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Doward V. Kilasi

Characteristics and Development of Students' Mathematical Identities

The Case of a Tanzanian Classroom

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Abstract

Students' mathematical identity, referring to students' context-based narratives about their mathematical self-perceptions, has recently received researchers' increased attention in mathematics education because, as a construct, it offers a broader socially engaging perspective for analysing the role of these perceptions and socio-cultural factors that shape them. While previous studies have mostly examined students in 'Western' schools who do not vary greatly in their mathematical and socio-economic backgrounds compared to students in Tanzanian schools, this study focused on a Tanzanian mathematics classroom whose students varied greatly in these backgrounds. The study applied socio-cultural and socio-psychological perspectives to examine the features and development of these students' mathematical identity. An ethnographic approach was used to collect and analyse data on the students' mathematical identity and conditions affecting its development at home, in school, and in the classroom. Students' narratives provided insights into context-specific features of mathematical identity and patterns of identity development. Also, observations of the school and mathematics classroom, review of official documents, and open-ended questionnaires generated data for contextualising students' identity narratives.

Data analysis resulted in multiple mathematical identities. While positive identities of *Innate ability*, *Persistent effort*, and *Image- maintenance* characterised students' engagement in mathematical activities, the negative mathematical identity of *Oppositional identity* was accompanied by the students' tendency to refrain from these activities. The study further showed that each type of mathematical identity had a distinct pattern of mathematical experiences. Overall, positive mathematical identities were associated with more supportive previous mathematical experiences compared to the negative identity. *Contextual factors* such as teachers and parents positively or negatively shaped these experiences. The study suggests that teaching strategies that enable students to exercise their agency may not be enough to promote students' mathematical identities. It is also important to understand how students have experienced mathematics and how they perceive their future relationship with mathematics, and support them accordingly.

Keywords: mathematical identity, positive mathematical identity, negative mathematical identity, mathematical experiencing, contextual factors

Helsingin yliopisto, Kasvatustieteellinen tiedekunta
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Doward V. Kilasi

Matemaattisen identiteetin tyypit ja niiden rakentuminen

Tapaustutkimus tansanialaisen luokan oppilaista

Abstrakti

Tämä tutkimus käsittelee oppilaiden *matemaattista identiteettiä*, jolla tarkoitetaan oppilaiden kertomuksellisia havaintoja itsestä suhteessa matematiikkaan. Matemaattista identiteettiä käsitellään tutkimuksessa sosiokulttuurisista ja sosiaalipsykologisista näkökulmista käsin. Käsitettä käytetään työssä analyyttisenä välineenä, jonka avulla oppilaiden havaintoja itsestä matematiikan oppijana sekä näiden merkitystä matematiikan oppimisessa tarkastellaan suhteessa sosiokulttuurisiin tekijöihin. Toisin kuin aiemmat matemaattisen identiteetin tutkimukset tämä tutkimus kohdistui tansanialaisen luokan oppilaisiin, joiden matemaattiset ja sosio-ekonomiset taustat vaihtelivat suuresti. Tutkimuksessa tarkasteltiin matemaattisen identiteetin tyyppejä sekä niiden kehittymistä kodin, koulun ja luokan konteksteissa käyttäen sosiokulttuurisia ja sosiaalipsykologisia näkökulmia. Tutkimusaineiston hankinnassa ja analysoinnissa käytettiin tulkinnallista etnografista lähestymistapaa. Oppilaiden narratiivien lisäksi tutkimusaineisto pohjautui koulun ja luokan havainnointiin, virallisiin dokumentteihin sekä opettajien haastatteluihin ja kyselyihin.

Tutkimustuloksina saatiin useita erilaisia matemaattisia identiteettejä. *Kyvykkyyden*, *Sinnikkään työskentelyn* ja *Minäkuvan säilyttämisen* positiiviset identiteetit kuvastivat oppilaiden sitoutumista matematiikan oppimiseen, kun taas negatiivinen matematiikan identiteetti, *Vastustava identiteetti,* yhdistyi pyrkimykseen päästä eroon matematiikasta. Tutkimus osoitti, että jokaisella identiteettityypillä oli toisista poikkeava matematiikan kokemustausta. Positiiviset identiteetit yhdistyivät negatiivista identiteettiä useammin aikaisempiin kannustaviin matematiikan kokemuksiin. Opettajat ja vanhemmat osana *oppimiskontekstia* vaikuttivat näihin kokemuksiin joko positiivisesti tai negatiivisesti. Tämän tutkimuksen tulokset näyttävät, että opetustavat jotka tukevat omaehtoista oppimista eivät välttämättä riitä edistämään matemaattisen identiteetin rakentumista. Matematiikan opiskelun ja matemaattisen identiteetin rakentumisen tukemiseksi on ymmärrettävä my ös oppilaiden aiempia matematiikan kokemuksia sekä heidän käsityksiä tarpeista opiskella matematiikkaa jatkossa.

Avainsanat: matemaattinen identiteetti, positiivinen matemaattinen identiteetti, negatiivinen matemaattinen identiteetti, matematiikan kokeminen, kontekstitekijät

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Helsinki, 10.05.2017
Doward V. Kilasi

Contents

1 Introduction

1.1 Background

The construct of identity began to appear in developmental psychology literature in 1950 (Erikson, 1968; Sokol, 2009). In this literature, identity has been central to studying self-perceptions of individuals as they experience identity-related crises and develop psychologically from childhood to adolescence (Erikson, 1950, 1968; Sokol, 2009; Tsang, Hui, & Law, 2015). With time, the conception of identity has become more complex, consisting of psychological, social psychological, sociological, and social cultural aspects, for example (Bosma, 1995; Cote & Levine, 2002; Kroger, 2007; Tajfel, 1978; Wenger, 1998). Identity can thus be conceptualised and approached from different theoretical perspectives.

Although this construct has a long-standing use in other fields, it is a recent arrival in mathematics education (Allen & Schnell, 2016). Here it is often termed *mathematical identity* not to refer to a mathematical expression equating one quantity with another (e.g., Kanel-Belov & Rowen, 2006), but to an individual's perception of "who he or she is mathematically" in a socio-cultural context (Allen & Schnell, 2016: 279) or the "narratives" students give about how they view themselves in relation to mathematics (Sfard & Prusak, 2005: 16-17; also see Larnell, 2016). It has become a central construct in studies that employ the social cultural perspective to emphasise the relationship between students' engagement in learning mathematics and social contexts of mathematics learning (Boaler, 2002c; Boaler & Greeno, 2000; Wang, 2007).

In this perspective, mathematical activities and interactions constitute mathematics learning experiences responsible for the development of students' mathematical identity (Bishop, 2012; Larnell, 2016). Larnell (2016), for example, views this link between mathematical identity construction and mathematics learning experiences as "strong" (p. 237). The effectiveness of these mathematical activities and interactions in developing mathematical identity has been suggested to depend strongly on the extent to which students exercise their agency. For example, students in classrooms where opportunities to exercise their agency exist are more likely to develop positive mathematical identity than in classrooms in which such opportunities are lacking (Cobb, Gresalfi & Hodge, 2009). Moreover, the teacher represents a key contextual factor in shaping students' mathematical identity when employing teaching approaches that enhance learning and allow students to exercise their agency. In turn, students' positive mathematical identity can foster mathematical participation while negative mathematical identity can impede such participation (Boaler, 1997; Boaler & Greeno, 2000; Cobb et al., 2009; Eccles, 2009). Furthermore, a link between students' mathematical identity and their view of their future in relation to mathematics is featured in the literature on mathematical identity. Students with positive mathematical identity are more likely to perceive themselves as individuals who will study mathematics in the future or who will be involved in mathematics-related careers, compared to students with negative mathematical self-perceptions (Anderson, 2007; Boaler & Staples, 2008; Larnell, 2016).

In short, students' mathematical identity offers a broader socially engaging perspective for analysing important features and the role of students' mathematical self-perceptions in mathematics learning as connected with social contexts that shape them (Eccles, 2009; Nasir, 2002). However, students' mathematical identity has for nearly two decades—from Boaler's work (1997) to, for instance, Allen & Schnell's work (2016)—received researchers' attention mostly in Europe, Australia and North America. Extending this research to mathematics classrooms in Africa where secondary school students vary enormously in their socio-economic and mathematical backgrounds can broaden the scope of research on students' mathematical identity and factors that shape it. This study focuses on the characteristics and development of students' mathematical identity in a Tanzanian secondary school mathematics classroom.

1.2 Rationale for the study

When students in a mathematics classroom vary in their mathematical backgrounds and previous experiences, they are also likely to vary in their mathematical identity (Latterell & Wilson, 2016; Sfard & Prusak, 2005). In Tanzanian secondary school mathematics classrooms, variations in students' mathematical backgrounds and experiences are great (Center for Economic Prosperity, 2012). Most children who have parents with formal education begin to learn basic mathematical skills before primary school due to being taught by their parents or hired teachers. But children whose parents lack formal education begin to learn these skills in primary school. Additionally, unlike other parents, parents with formal education tend to support their children's work at school (Uwezo, 2010, 2011). In Tanzanian primary schools, usually characterised by overcrowded classes and a shortage of mathematics teachers, children with basic mathematical skills gained before school are more likely to score higher on mathematics tests than children lacking these skills (Uwezo, 2011). Tanzanian students thus begin secondary school with great variation in their mathematical backgrounds, suggesting further variations in secondary school students' mathematical identity. This variation in students' mathematical backgrounds and experiences motivated this study. The primary focus was on students' mathematical identity, conceptualised in this study as consisting of "narratives" told by individuals about themselves (Sfard and Prusak, 2005: 16-17; also see Kaasila, 2007). Analysis of these narratives led to different categories of mathematical identity.

In the narratives on mathematical identity, students especially narrated their mathematics learning experiences, which indicated the essentiality of these experiences to the development of their mathematical identity. A detailed examination of these experiences and their impact on mathematical identity was thus considered necessary for broadening the scope of mathematical identity. A specific conceptual framework for analysing these experiences and contexts that shaped them was developed. In developing the framework, the term "experience" represented the central idea. This idea, besides being implied in students' narratives, is frequently mentioned in the literature on mathematical identity, signifying its close relationship with mathematical identity (e.g., Gee, 2001; Larnell, 2016; Latterell & Wilson, 2016; Martin, 2000; Seligman, Relivich, Jaycox & Gillham, 1995). As shown in the literature and suggested by data on mathematical identity, mathematics learning experiences are gained through a complex process of mathematical participation and interactions shaped by contextual factors such as the teacher (e.g., Allen & Schnell, 2016; McGee, 2015; Walker, 2012). In this thesis, I refer to this process as *Mathematical experiencing* and I illustrate it in Chapter 2 as a cyclic pattern of events necessary for mathematical identity to develop (the data-based evolvement of the term is shown in Appendix K). While experiencing the events of mathematics learning, students reflect on the events and on themselves, reflect on mathematics, make decisions and choices, recall their past experiences, imagine their future relationship with mathematics, and react emotionally to all this (Anderson, 2007; Walker, 2012; Sfard & Prusak, 2005). These aspects of *Mathematical experiencing* are in this study considered essential for the development of students' mathematical identity.

In turn, a developed mathematical identity, that is, when a student is clearly conscious of who he or she is in relation to mathematics, is characterised by factors that foster mathematical participation such as agency, mathematical commitment and ambition (cf. Cobb et al., 2009; McGee, 2015). These *Fostering factors* support the repetition of the cycles of *Mathematical experiencing*. Moreover, *Mathematical experiencing* is shaped by the environments where mathematics learning takes place. Teachers' interactions with students in mathematics learning, institutional assessment criteria used in schools, peer influences during mathematics learning and mathematical content are examples of such factors. They are denoted in this study as *Contextual factors* that enhance or inhibit *Mathematical experiencing* and the impact of *Fostering factors.* This conceptual framework, presented in detail in Chapter 2, was developed on the basis of data analysis (see Appendix K) and ideas from the literature on identity. In turn, it guided subsequent data analysis and interpretation.

1.3 The context of the study

The dominant teaching approach in Tanzanian schools is teacher-centred, that is, the teacher determines the learning process (Vavrus, Thomas & Bartlett, 2011: 76-77). This approach also characterised mathematics teaching in the secondary school mathematics classroom studied here. The teacher planned and controlled most of the events in the classroom including students' participation in lessons and their behaviour towards the teacher. Previous studies suggest that this approach limits opportunities for students to exercise their agency, and can impede the development of positive mathematical identity (e.g., Cobb et al*.,* 2009). These studies further suggest that students with previously developed positive mathematical identity tend to maintain their positive mathematical identity while resisting or even protesting against being positioned by the teacher as mere receivers, instead of being perceived as constructors of knowledge or individuals who can decide and plan their learning (Boaler, 2002c; Boaler & Greeno, 2000; McGee, 2015). Similarly, for students in the mathematics classroom studied here, the students' opportunities to develop and exercise their agency in the classroom were limited. In response, some students created such opportunities outside the classroom, for example, by forming discussion groups and participating freely in such groups.

Moreover, the mathematics classroom was part of a broader context that may have influenced events in the classroom and students' mathematical self-perceptions. First, since the school was a boarding type school (i.e., accommodating students during the four years of secondary school), students interacted (e.g., through self-organised peer teaching and exchange of views related to mathematics) outside the mathematics classroom with students in other grades. Second, students in the studied classroom were influenced by a government policy of subject specialisation that was enforced by the school administration. The policy required students in the beginning of the third grade to choose and specialise in either Arts or Science subjects. At the time of choosing subjects for specialisation, students had developed the perception that mathematics was part of science. As a result, students who had chosen physical sciences were more willing to participate in mathematical activities compared to those who had chosen arts subjects. Finally, the classroom consisted of students with different mathematical backgrounds. Some students had been exposed to mathematics by their parents at home before they began school. But other students had only begun learning mathematics in primary school.

Thus, although the mathematics classroom was characterised by a traditional teaching approach, the students were diverse in terms of their mathematical experiences during and before secondary school. The students also perceived themselves differently with respect to knowing and learning mathematics. This diversity of students' mathematical backgrounds and experiences motivated an in-depth investigation of the characteristics and development of students' mathematical identity among third grade students in a secondary school in Tanzania.

1.4 Methodological aspects of the study

Proper elicitation and understanding of students' narratives on their mathematical self-perceptions and experiences required an appropriate theoretical perspective to guide interactions with research participants in the study field. The social constructivist perspective was considered appropriate. It posits that 'reality' (i.e., who we think we are or what we think we know) consists of mental constructions based on our experiences in specific situations (Denzin & Lincoln, 1994). It is thus subjective and contextually situated (Atkinson & Hammersley, 1994; Creswell, 1998; Tesch, 1990) and is seen as part of our existence rather than an objective phenomenon existing outside us. Since we experience the world differently, we also construct meanings of our experiences differently, though to some extent, these meanings can be socially shared in a given social context (Cote & Levine, 2002). With this perspective, it was possible to more consciously consider the mathematics students of this study as individuals who had personal ways of viewing themselves in relation to mathematics and who subjectively constructed meanings of their mathematical experiences.

More specifically, the research perspective of this study can be characterised as interpretive ethnography, useful for interpreting the insider's view of self in a specific cultural context (Brewer, 2000; Denzin, 1997; Silverman, 2005). It helped make the decisions on data collection and analysis needed to gain an in-depth and context-based understanding of students' mathematical identity and its development. Within this methodological framework, a diary method was applied to collect data on students' day-to-day thoughts on how they perceived themselves with respect to mathematics and how they experienced mathematics at home, in school and in the classroom. Contextual information was gathered through participatory and non participatory observations and field notes, open-ended questionnaires, documentary evidence, and conversations with key selected students and teachers. Such information was useful for understanding the social cultural context in which the students learned mathematics (cf. Silverman, 2005). Furthermore, thematic analysis was employed in analysing the data on students' narratives. Themes were constructed on the basis of codes that were identified while interpreting the data. Thus, whereas the social constructivist perspective provided a broad interpretive framework to guide interactions with mathematics students and teachers, the interpretive ethnographic perspective provided practical guidance in data collection, analysis and interpretation.

1.5 Structure of the study

This first chapter introduces the main concepts of the study, the rationale for the thesis and the methodological framework applied in the study. To provide a more detailed account of these theoretical and methodological aspects and to present interpretations and discussion of data clearly, the thesis is organised into six additional chapters. The theory and concepts framing the thesis are elaborated in the second chapter, and in the third chapter, four main research questions and their context are presented. The methodological issues and framework are discussed in the fourth chapter in which the ethnographic approach adopted in the thesis is contextualised within the broader social constructivist perspective of conducting research. Findings of the study are reported in two separate chapters—chapters five and six. While findings on characteristics of students' mathematical identity are presented in the fifth chapter, findings on the nature of *Mathematical experiencing* behind students' mathematical identity are reported in the sixth chapter. Finally, patterns and issues arising in the fifth and sixth chapters are discussed and concluded in the seventh chapter.

2 Characteristics and development of mathematical identity

2.1 Conceptualisations of mathematical identity

In developmental psychology, identity is understood as an individual's internal structure of cognitions about who the individual is (e.g., Erikson, 1968, 1974; Wang, 2007). The most distinguishing characteristic of the developmental perspective is the emphasis on the individual when analysing the development and location of identity (Tsang, Hui, & Law, 2012; Wang, 2007). That is, although social factors are considered important in identity development, the process of identity development is largely viewed as essentially self-determined (Erikson, 1974; Cote & Levine, 2002). Moreover, identity, which sometimes appears in literature as a synonym for *self-concept*, suggests a relatively fixed or stable phenomenon that exists within individuals and influences their behaviour (Stentoft & Valero, 2009).

The social cultural perspective of identity is somewhat different, viewing identity as developing in social cultural settings when individuals act and interact in these settings (Boaler, 2002a; Wenger, 1998). In particular, the influence of social cultural factors is emphasised in views on the development of identity. Even when individuals have developed the capacity to control their actions and interactions and to make decisions related to learning, this capacity is viewed as being exercised within and shaped by cultural or social contexts (Cote & Levine, 2002; Wenger, 1998). When conceptualising identity, the emphasis is placed on interactions between the individual and the social cultural context in which the individual acts and interacts (Cote & Levine, 2002). During analysis, researchers regard identity as located both within the individual (how one views oneself with respect to a quality) and external to the individual (how others view the individual with respect to the same quality). Consistent with these ideas, students' mathematics-related identity is seen as embedded in and shaped by social cultural contexts in which individual students exist, act and interact and not as phenomena isolated from these contexts (Anderson, 2007; Cobb et al., 2009; Latterel & Wilson, 2016; Nasir, 2002; Sfard, 2002). With this contextual significance in mind, researchers have emphasised the role of the classroom and teaching/learning processes that take place in it (e.g., Boaler, 2000; Boaler & Greeno, 2000; Cobb et al., 2009).

Identity has been studied in mathematics education for nearly two decades. It was introduced into the field when social cultural perspectives of learning began to receive more attention (Boaler, 1997; Stentoft & Valero, 2009). These perspectives were (and are still) viewed as necessary for providing a broader understanding of the process of learning by focusing not only on the individual learner but also on the role of social cultural contexts that shape the way the individual learns mathematics. Thus identity, as a social cultural phenomenon, is important in broadening the understanding of mathematics learning through analysing the "dialectic relationship between the individual and social dimensions of learning" (Stentoft & Valero, 2009, p. 56).

According to Sfard and Prusak (2005), for narratives to be interpreted as identity, they need to have certain characteristics. First, they should be reifying; that is, they should be associated with the use of *be*, *can* or *have*, for example, in expressions of *I am good at mathematics* or *I can succeed in mathematics* (p. 16). Adverbs such as *always, never*, and *usually*, that indicate repetition of action can also indicate reification. Second, narratives should be endorsable. This 'endorsability' is reflected in a narrative when narrators indicate (e.g., by telling) that the stories they present faithfully represent the 'reality' as the narrators perceive it (p.16). Finally, narratives should be significant; that is, any change in the narrative affects the narrator's feelings about the change (p.16). In short, reification, endorsability, and significance can portray students' mathematical perceptions related to their mathematical identity.

Students can perceive themselves as certain kinds of individuals with respect to a certain aspect of mathematics learning, for example, as doers of mathematics, as belonging to the mathematics community, as individuals committed to mathematics, or as mathematically competent students (Anderson, 2007; Larnell, 2016; Latterel & Wilson, 2016). This thesis focuses on self-perceptions of mathematical competence, mathematical participation, mathematical commitment and mathematical ambition because they are examples of important motivational aspects in mathematics learning (e.g., Cobb et al., 2009; McGee, 2015; Nasir, 2002) and they were salient in the students' narratives on their mathematical identity and its development. The thesis also integrates aspects from the social cultural perspectives of learning (e.g., Anderson, 2007; Wenger, 1998) with those from social psychological perspectives (e.g., Bandura, 1997; Eccles, 2009) to understand more clearly the relationship between psychological aspects of behaviour (e.g., emotions) and contextual factors in the nature and development of students' mathematical identity.

2.2 Applied components of mathematical identity

Self-perceptions of mathematical competence

The central component of mathematical identity consists of students' self-perceptions of mathematical competence, which can be positive or negative (Anderson, 2007; Malmivuori, 2001; Owens, 2008). Self-perceptions of mathematical competence can enhance or impede mathematical participation, commitment, and ambition depending on whether they are positive or negative (cf. Anderson, 2007; Bandura, 1997; Walker, 2012). Thinking in terms of mathematical self-competence also accompanies views on the nature of mathematical competence one believes to have. For example, some students view mathematical competence or incompetence as essentially genetically inherited (Anderson, 2007; McLeod, 1992). This perception has a background in such students' previous mathematical experiences or cultural socialisation (Kordi & Baharudin, 2010; Larnell, 2016; Malmivuori, 2001; McLeod, 1992; Yackel & Cobb, 1996). It accompanies previous experiences of more frequent success than failure among students who perceive themselves as born with a genetically inherited mathematical competence. In contrast, the mathematical background among students who perceive themselves as lacking this kind of mathematical competence consists of more frequent failure than success in understanding mathematical concepts and performance in mathematics tests (cf. Anderson, 2007; McLeod, 1992). Other students tend to link their self-perceptions of mathematical competence to their effort in learning mathematics (Anderson, 2007; also see Bandura, 1997; Weiner, 1986). Students who have personally experienced success in mathematics as a result of increasing effort or failure as a result of spending less effort often develop the perception that success is closely associated with effort (Latterell & Wilson, 2016). These students often regard themselves as competent as long as they are able to spend their effort and succeed.

Self-perceptions of mathematical participation

Self-perceptions of mathematical participation form another important component of students' mathematical identity (Anderson, 2007; Cob et al, 2009; Walker, 2012; Wenger, 1998). These self-perceptions develop as a result of students' participation in mathematical activities. In this thesis, 'mathematical participation' refers to students' involvement in mathematical activities (cf. Nasir, 2002; Walker, 2012). Performing a task individually that is self-assigned or given by the teacher is an instance of this involvement. Mathematical participation can also mean students' interactions with other students in the classroom (peers) and between students and teachers in learning mathematics. Responding to questions posed by the teacher or being praised by the teacher constitutes part of this teacher-student interaction. During the process of learning and self-evaluation students eventually become aware of themselves as individuals with a certain degree of participation in mathematical activities (Anderson, 2007; Owens, 2008).

Self-perceptions of mathematical commitment and ambition

Like self-perceptions of mathematical competence, self-perceptions of mathematical commitment develop in the process of learning mathematics (Cobb et al, 2009). These self-perceptions are linked to the degree of students' mathematical commitment and self-evaluations of such commitment. The term 'commitment', as used in social psychology and sociology, refers to the persistence of goal-directed behaviour for a long time (Becker, 1960; Burke & Reitzes, 1991; Ford, 1973). Thus 'mathematical commitment' in this thesis means the degree to which students persist in mathematical participation. As a result of mathematical participation and commitment and self-evaluations based on such participation and commitment, students can develop various self-perceptions of their degree of mathematical commitment. Some students may consider themselves as highly committed to mathematics while other students may view themselves as less committed.

Additionally, students can perceive themselves in terms of their ambition in learning mathematics. Mathematical ambition can be understood as students' eagerness to succeed in mathematics at the moment of learning mathematics. This eagerness can be reflected in the extent to which students set achievement goals and the amount of effort they spend in achieving them (cf. Bandura, 1997). Seeing oneself as having high ambition to succeed in mathematics means regarding oneself as one who sets challenging targets (or levels of achievement) in the learning process and who strives to achieve them (cf. Bandura, 1997; Eccles, 2009). In contrast, perceiving oneself as having low ambition means viewing oneself as one who sets less challenging targets and who feels satisfied or indifferent upon achieving them. Persistence in mathematical participation (i.e., mathematical commitment) can be explicated by the ambitiousness of goals the students set and the extent of their effort in achieving them. Mathematical ambition is thus a central indicator of mathematical commitment.

Finally, self-perceptions of mathematical commitment and ambition tend to accompany self-perceptions of mathematical performance (cf. Eccles, 2009). While participating in mathematical activities, students do not only develop self-perceptions of mathematical commitment and ambition, but through continued self-appraisal based on their performance results (e.g., test scores), they also come to learn about themselves as performers in mathematics (Cobb et al., 2009; Malmivuori, 2001). As a result of this self-evaluation, while some students may view themselves as high performers, others may perceive themselves as moderate or low performers.

Summary

The components of students' mathematical identity applied in this study are students' self-perceptions of mathematical competence, participation, commitment and ambition. These self-perceptions are shaped while students participate in mathematical activities and evaluate themselves in relation to these activities. Additionally, self-perceptions of mathematical competence constitute a central component; it can enhance or impede other mathematical self-perceptions.

2.3 Characteristics of mathematical identity

Analysing characteristics of mathematical identity furthers the understanding of the nature of mathematical identity. In this thesis, mathematical identity, consisting of the components discussed previously, is here considered to have three main characteristics: it can be positive or negative, it can influence students to think about how others (e.g., peer or teacher) perceive them with respect to their competence, and it is associated with students' thoughts about the usefulness of mathematics to their future lives.

Positive and negative mathematical identity

Mathematical identity can be positive or negative depending on students' previous mathematical experiences (MacGee, 2015; Walker, 2012). After students have developed a positive mathematical identity, they view themselves as having characteristics for success in mathematics. Often, these learners are those who have previously succeeded in learning mathematics and have learned mathematics in social environments (e.g., classrooms) that promote the sense of autonomy and active learning (Allen & Schnell, 2016; Boaler & Greeno, 2000). Drawing on Weiner's Attribution Theory (Weiner, 1986), positive mathematical identity can further be characterised by students' ascriptions of success in mathematics learning either to their inborn ability or to their effort. These ascriptions are linked to individual students' previous experiences of success and their evaluation of these. Mathematical success that comes after students' increased effort is associated with ascriptions of such success to effort while success that consistently (over time) comes after less effort expenditure is associated with ascriptions of success to innate ability.

On the other hand, students' negative mathematical identity is accompanied by experiencing negatively the process of learning mathematics (Latterell & Wilson, 2016; Nasir, 2002). Such negative experiences may include parental, teacher or peer disapproval or failure to meet institutionally set standards such as a good grade (Aunola et al., 2003; Walker, 2012). In addition, how teachers organise their teaching seems to affect students' mathematical self-perceptions. For example, according to Cobb et al (2009), students in mathematical contexts where teachers dominate learning-related activities and do not encourage their students to take responsibilities for their learning are more likely to develop a negative view of themselves as compared to students in classes in which student autonomy is encouraged. They view mathematics as a domain that belongs to the teacher. According to the authors, this view often co-occurs with a lack of a sense of obligation and responsibility and a lack of commitment to learning mathematics. Moreover, having negative mathematical identity is associated with students' tendency to view themselves as those who do not belong to the category of mathematics achievers or those who cannot succeed in mathematics (Allen & Schnell, 2016). Applying Weiner's Attribution Theory (Weiner, 1986), it can be argued that negative mathematical identity can also be characterised by students' ascriptions of failure to their low innate ability in learning mathematics. These ascriptions result from students' evaluations of their previous experiences of failure in learning mathematics despite their effort.

In short, mathematical identity can be categorised as positive when students perceive themselves as having characteristics (e.g., competence) for success in mathematics. Identity can be categorised as negative when students view themselves as lacking the characteristics that enable them to succeed in mathematics. While positive identity is associated with positive experiences of success in learning mathematics, negative identity accompanies negative or unsuccessful experiences in mathematics learning situations. Finally, mathematical identity can be associated with students' ascriptions of success or failure in learning mathematics to a cause (innate ability or effort).

Discrepancy between self-perceptions and others' perceptions

Discrepancy between students' mathematical self-perceptions and how others view them with respect to mathematics is another important feature of mathematical identity. In particular, students with positive mathematical identity are often concerned with knowing whether there is a difference between how they view themselves and how others view them in relation to mathematics (McGee, 2015; also see Bohl & Van Zoest, 2002; Burke & Reitzes, 1991). In this process of self-evaluation, a discrepancy can occur between how individual students perceive themselves and how they think they are perceived by others such as peers or teachers. When a discrepancy is perceived to exist (i.e., when students think they are viewed negatively), students question or doubt their positive self-perceptions. This process of questioning and doubting (i.e., reflection) can accompany negative emotions such as feelings of hostility or even hostile behaviour (Stets & Burke, 2003; Turner & Stets, 2005). The questioning and doubting can also motivate students to reduce the experienced discrepancy, for example, through engaging in behaviour (increasing effort or using alternative strategies to achieve better performance results) that could make others interpret the students in ways that are positive, consistent with how they view themselves (McGee, 2015). In contrast, when there is consistence between how students view themselves and how others view them (i.e., when they are viewed as positively as they view themselves), the students experience positive emotional arousal and positive evaluations of self-worth (Op't Eynde, 2004; Turner & Stets, 2005).

Students' imaginations of their future lives

Imaginations of the future in relation to mathematics constitute another characteristic of mathematical identity. As students take part in mathematical activities, they imagine their future relationship with mathematics (Allen & Schnell, 2016; Latterell & Wilson, 2016). Students with positive mathematical identities often view themselves as individuals who will continue learning mathematics and will succeed in it in the future (Anderson, 2007). Positive self-perceptions of mathematical competence are also associated with thoughts about a future mathematics-related career, and these thoughts give students a sense of direction in terms of career-related goals (Latterell & Wilson, 2016). Thinking in terms of a future mathematics-related career also provides or enhances the meaning of being involved in mathematical activities, which in turn strengthens the students' sense of relationship with mathematics, enhances their commitment to mathematics, and increases the likelihood of performing better in mathematics (Anderson, 2007; Boaler & Greeno, 2000). In contrast, students with negative mathematical identity often view themselves as individuals who will not continue learning mathematics in the future (Allen & Schenell, 2016). Negative identities are also associated with preference to seek a future career that is unrelated to mathematics (Anderson, 2007).

Conclusion

Explicating mathematical identity by making salient its components and characteristics allows a detailed understanding of the nature of mathematical identity. This explication also provides a basis for developing criteria for analysing different mathematical identities.

2.4 The *Mathematical experiencing* conceptual framework and identity development

Experience is a subject of discussion in various fields of study including philosophy and education (e.g., Dewey, 1938; Smith & Smith, 1995). In education, experience is considered essential for learning. Kolb (1984), for example, argues that "learning is the process whereby knowledge is created through the transformation of experience" (p. 41). According to the author, this transformation occurs through observation, reflection, and abstract conceptualization of the experienced phenomenon. This conceptualisation of experience underlines the complexity of experience. However, the experience responsible for mathematical identity development requires a different way of thinking. For example, terms such as "concrete experience", "reflective observation" and "abstract conceptualization" as used in Kolb's work may be important for thinking about experience with respect to learning, but a different way of thinking about these concepts can increase their relevance to the experience necessary for the development of students' mathematical identity.

The starting point is to view "experience" as an outcome of a certain process or encounter. This process or encounter can be termed *experiencing*. Since the experiencing relevant to this study is mathematical, it can be termed *Mathematical experiencing*. In this experiencing, consistent with students' narratives and observation data (see Appendix K), students are involved in concrete mathematical situations with their sense organs (e.g., seeing, hearing and touching) activated in mathematics-related interactions at home or school. This initial form of *Mathematical experiencing* can be referred to as *Concrete experiencing*. However, *Concrete experiencing* is not sufficient for mathematical identity to develop. As students engage in mathematical activities and interactions (i.e., participate in mathematical activities), they evaluate themselves based on their progress, performance and others' (e.g., parent, peers or teacher) remarks (Latterell & Wilson, 2016; Sfard & Prusak, 2005). This more reflective aspect of *Mathematical experiencing* is in this study referred to as *Conceptual experiencing* and can be stimulated by *Concrete experiencing.* Thus these two processes are intertwined during mathematical participation (e.g., students solve a mathematical problem involving eyes, ears and hands, and reflect on this activity). They are the two processes of mathematical experiencing and thus of the development of mathematical identity.

Moreover, participation in *Concrete experiencing* cannot occur without being *fostered* internally (e.g., through students' liking of mathematics or willingness to learn it) or externally (e.g., through parental pressure). At initial stages when children begin to learn mathematics, this fostering is *elemental s*ince a coherent sense of who they are with regard to mathematics (which reflects mathematical identity) has not yet been developed and thus has no influence on children's participation in mathematical activities. Accordingly, the elemental *fostering factors* take an important role in the children's learning and the initial stages of their mathematical identity development. I term these elemental fostering factors as *liking* of mathematics *or willingness* to learn mathematics. When willingness or liking of mathematics is not sufficient to support children's engagement in mathematics, parents may exert pressure on their children so that *Mathematical experiencing* continues and children gain the mathematical knowledge desired by their parents. This pressure—which can also be exerted by teachers or school requirements (e.g., compulsoriness of mathematics learning for all students)—is here termed *coercion*. Coercion, as used in this thesis, refers to external pressure, for example, from parents or teachers during *Mathematical experiencing*. Sometimes children or students do not currently experience coercion but feel compelled to learn mathematics as a result of experiencing coercion in the past. This feeling of being compelled is here referred to as *felt coercion.*

During *Mathematical experiencing*, students continually evaluate themselves based on interpretations of their performances, others' performances, and remarks or behaviour of peers, parents or teachers about students' competence in mathematics (Goodwin, 2008; Allen & Schnell, 2016). These self-evaluations are not purely cognitive; they involve emotional reactions (Malmivuori, 2001; 2004). For example, reflections on perceived failure on a mathematics test can arouse negative emotional reactions such as embarrassment or shame, as opposed to reflections on perceived success in which students may experience positive emotions such as joy or pride (cf. Bandura, 1997). This *emotional experiencing* (as it is referred to in this study), is characteristic of students' self-evaluations in mathematics learning situations.

Importantly, mathematical identity developing in this *Mathematical experiencing* process has characteristics that reflect how students, over time, have undergone *Concrete*, *Conceptual* and *Emotional experiencing*. For example, *Mathematical experiencing* associated with frequent success is likely to lead to the development of positive mathematical identity, while *Mathematical experiencing* associated with frequent failure is likely to lead to negative mathematical identity development. In *Mathematical experiencing*, there are more elaborate *Fostering factors* apart from willingness or liking of mathematics, namely, the exercise of agency, commitment and ambition (cf. Cobb et al., 2009; Bandura, 2001; Boaler, 1997). These factors are important in that they sustain students' participation in mathematical activities or their withdrawal from these activities. After students have developed a more coherent mathematical identity (when students have become more conscious of who they are in relation to mathematics), their activities are stimulated more by the exercise of agency, ambition and commitment rather than by only liking mathematics or willingness to learn it. Consequently, while liking of mathematics or willingness have a more important role in *Mathematical experiencing* before the development of a coherent mathematical identity, they cease to be a key factor after mathematical identity is fully developed.

2.4.1 The framework of *Mathematical experiencing* and identity development

The idea of *Mathematical experiencing* can be clarified through a discussion of a conceptual framework that I developed based on data (see Appendix K) in order to illustrate the importance of *Mathematical experiencing* in the development of mathematical identity. I conceive *Mathematical experiencing* as occurring in a cycle that develops from initial (simple) to complex form.

The cycle in its initial form

The cycle occurs in a simple form at initial stages of mathematics learning when students' mathematical identity is only beginning to develop and thus has no or negligible fostering effect. At this stage, the cycle, summarised diagrammatically in Figure 1, is responsible for the development of mathematical identity and skills.

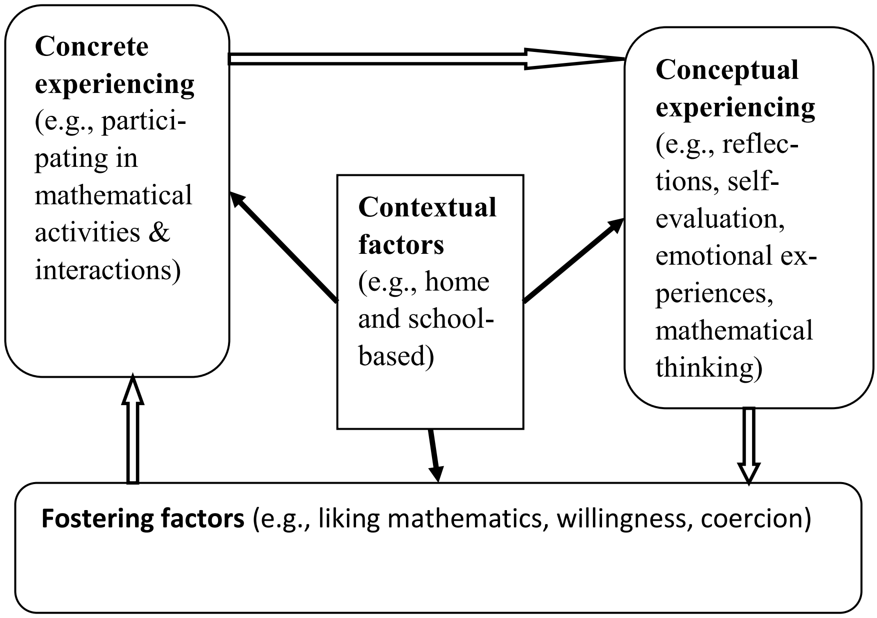

Figure 1. The cycle of *Mathematical experiencing in its initial form*

The cycle begins when students individually participate in mathematical activities, that is, when they become involved in mathematical activities (e.g., problem solving or doing tests) or when they take part in interactions to gain mathematical knowledge (e.g., listening, observing, discussing, answering questions, reading, or asking questions). As shown in Figure 1, this part of the cycle is termed *Concrete experiencing* because it involves students' sense organs. During *Concrete experiencing*, students also engage in reflections and evaluations of what they experience (e.g., how they interact with the teacher or peers) and of themselves (self-evaluation), construct meanings of these experiences (e.g., what a teacher's comment means), and think mathematically (e.g., how 20 + 30 is the same as 30 + 20) (Goodwin, 2008; Sfard & Prusak, 2005). This second part of the cycle is here termed *Conceptual experiencing.*

In the classroom or at home, students take part in concrete situations of learning, which stimulate these students' engagement in conceptual thought (Goodwin, 2008). This means that *Concrete* and *Conceptual experiencing* are closely related processes when students take part in mathematics learning activities and related interactions. Moreover, *Conceptual experiencing* may continue even after *Concrete experiencing* has ended. An instance of this is when students currently reflect on how they solved a mathematical problem hours or days in the past. In addition, *Conceptual experiencing* is partly emotional (cf. Lazarus, 1991; Parkinson & Manstead, 1992). Construction of meanings or evaluation of events, objects or self during *Mathematical experiencing* can generate positive or negative emotions (also see, Hannula, 2006a; Lazarus, 1991; Malmivuori, 2001). These emotions are important in this cycle. Positive *Conceptual experiencing* (e.g., evaluating oneself as good at mathematics) and positive emotional reactions (e.g., joy) can lead to the development of *Fostering factors*, namely, liking mathematics or willingness to continue participating in mathematical activities. Thus students, fostered by liking mathematics or willingness to participate in mathematical activities, attempt new tasks or take part in new episodes of interaction and in this way the cycle continues repeating. On the other hand, negative *Conceptual experiencing* (e.g., evaluating oneself as of low competence) and negative emotions (e.g., embarrassment) can lead to the development of willingness to withdraw from learning mathematics. However, this withdrawal may not be possible in homes and schools in which there is coercion or felt coercion. In this case, coercion can also be an important factor for students' continuation with *Concrete* and *Conceptual experiencing* (cf. Lerman, 2001).

Another important feature of this cycle is its *context.* Drawing ideas from social cultural perspectives and students' narratives, the term *context* can be understood as referring to actions (e.g., problem solving) and interactions (e.g., dialogical engagement) around mathematics occurring in and affected by social/cultural settings (Wenger, 1998; Yackel & Cobb, 1996). Students experience the cycle in its initial form when they are at the early stages of learning mathematics. They engage in *Concrete* and *Conceptual experiencing* at home or in the classroom. Homes or classrooms provide contexts that influence these processes positively (e.g., encouraging students to maintain their mathematical participation) or negatively, for example, by denying students opportunities to participate in mathematics. Subsection 2.4.3 details the influence of contexts on *Mathematical experiencing* and identity development

The cycle in its complex form

While self-evaluation (e.g., based on peer comparison) is necessary for the development of mathematical identity (Anderson, 2007; Sfard & Prusak, 2005; Wenger, 1998), the process of reflecting and constructing knowledge is necessary for students to gain mathematical knowledge (Godwin, 2008; Vygotsky, 1978; Wenger, 1998). Mathematical identity and gained mathematical knowledge are again necessary for the cycle to become complex as illustrated in Figure 2.

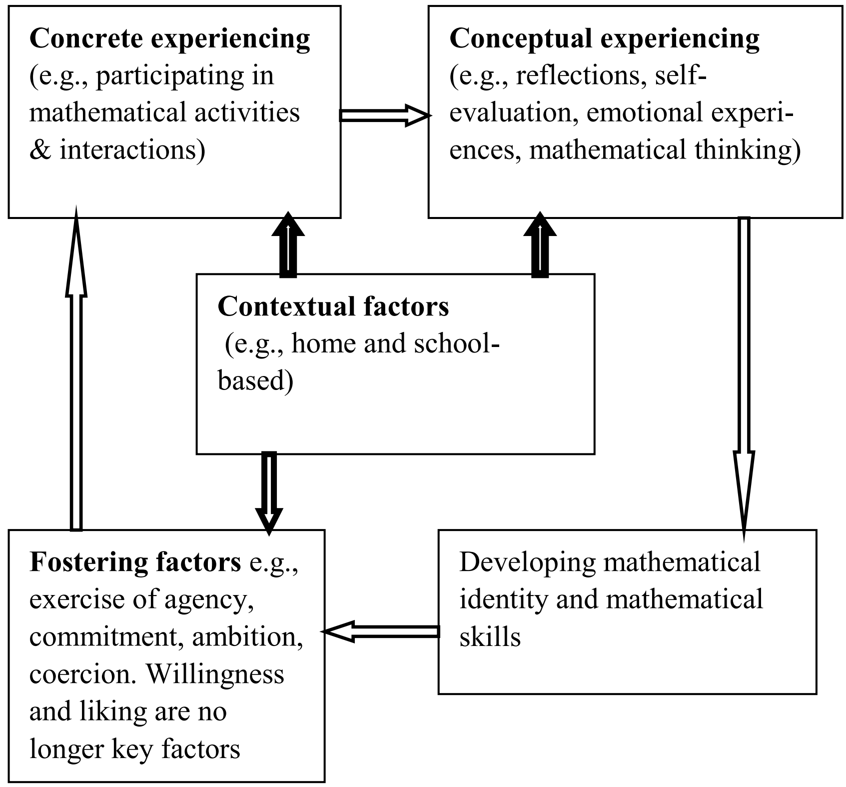

Figure 2. The cycle of *Mathematical experiencing* in its complex form

As shown in Figure 2, the cycle begins to be complex when mathematical identity and gained mathematical skills begin to be more coherent. Like in the simple form of the cycle, *Concrete experiencing* in its complex form stimulates (or is associated with) *Conceptual experiencing*. However, *Conceptual experiencing* at this stage is more complex compared to the *Conceptual experiencing* when cycle is in its simple form. It involves reflections and self-evaluations based on not only *Concrete experiencing* (why did I fail in that task?) but also on the evolving mathematical identity (am I really good at mathematics?) accompanied by mathematical thinking (how do I prove that 10 + 10 is the same as 8 + 12?) (cf. Goodwin, 2008) and emotional reactions associated with self-evaluations (Hannula, 2006b; Lazarus, 1991; Malmivuori, 2001). *Mathematical experiencing* can thus more directly generate mathematical skills. Reflections on gained mathematical skills are important in the process of mathematical identity development. Students' awareness of their mathematical skills, which is sometimes expressed in terms of achieved mathematics test scores, also forms a basis for justifying their mathematical identity.

On the other hand, the role of mathematical identity is to foster students to maintain the repetitiveness of the cycle through its associated *Fostering factors*, that is, through students' exercise of their agency (i.e., exercising their capacity to negotiate and make decisions and choices in the process of mathematics learning) (cf. Bandura, 1997; Malmivuori, 2001), commitment (consistent sense of obligation to succeed in mathematics) (Cobb, et al., 2009; Owens, 2008) and ambition (e.g., setting and pursuing ambitious achievement targets). If students are unwilling to study mathematics in schools in which mathematics is compulsory, the cycle may be maintained through coercion or this may lead to the breaking of the cycle (i.e., when students no longer take part in mathematical activities).

This complex cycle, like the simple one, is influenced by *context***.** Home or classroom contexts can encourage students' participation in mathematical activities. One instance of this is parental involvement in children's learning of mathematics or the teacher's use of a teaching method that allows students to exercise their agency. Contexts can also act as obstacles to children's participation in mathematical activities, for example, when the teacher is too authoritarian. The role of context in *Mathematical experiencing* and development of mathematical identity is discussed in the following section.

2.4.2 Contexts for *Mathematical experiencing* and development of mathematical identity

As illustrated in Figure 1 and 2, *Mathematical experiencing* and identity development are processes influenced or shaped by context, particularly by *Contextual factors* such as parents, teachers, the mathematical subject matter, peers , learning materials, and institutional arrangements such as formal evaluation criteria in schools (Anderson, 2007; Cobb et al., 2009; Lefevre et al., 2009). In this study, these *Contextual factors* are categorised as home-based and classroom-based.

Mathematical experiencing and identity development in home contexts

Studies have shown that children's mathematical experiences at home "form the foundation for mathematics learning in school" (Lefevre et al*.,* 2009: 55). This "foundation" does not only consist of children's mathematical skills, but also how children view themselves (particularly their competence) in relation to mathematics (Kordi & Baharudin, 2010; Walker, 2011). This is because homes can provide space for children to begin to learn not only mathematical skills but also about themselves in relation to mathematics (Aunola*,* Nurmi, Lerkkanen, & Rasku-Puttonen, 2003; LeFevre et al., 2009). In these homes, parents can determine the extent to which their children should engage in *Concrete* and *Conceptual experiencing*. For example, in homes where parents exercise authoritarian parenting style (i.e., characterised by excessive parental strictness, emotional detachment and punitive behaviour), children are forced to participate in mathematics learning at home under strict or punitive conditions (Baumrind, 1971; Darling & Steinberg, 1993). Yet, when mathematical knowledge is gained through this kind of experiencing, children may evaluate themselves positively based on their good performances and positive parental evaluations of children's mathematical competence (Kordi & Baharudin, 2010). With these experiences, children may become willing to continue participating in mathematics learning even without parental pressure. But experiences of failure and discouraging parental remarks can influence children to form negative self-perceptions in relation to mathematics which can impede their mathematical participation (Aunola, et al*,* 2003).

In another instance, there are homes characterised by authoritative parenting style, that is, by moderate parental strictness associated with warmth, flexibility and 'directiveness' based on reasoning (Baumrind, 1971; Darling & Steinberg, 1993). In home-based mathematical interactions, these parents can teach or guide their children to develop a sense of liking mathematics and willingness to engage in mathematical activities. But sustenance of this sense requires that mathematical participation is associated with children's successful performance, positive feedback from parents, and children's self-evaluation in response to their performances and parental feedback. Apart from homes with authoritarian and authoritative parental styles, there are homes with a permissive parenting style (Baumrind, 1971). This style is characterised by a lower degree of parental restriction compared to the other two styles. Children are given a higher degree of freedom to make their own choices and decisions based on their preferences. It can thus be argued that in homes with this parenting style, children may not be forced to learn mathematics if they do not prefer learning it.

However, in many homes, especially in developing countries, pre-school *Mathematical experiencing* is nonexistent. One reason is that some parents do not have the formal mathematical knowledge that they could pass on to their children. Second, other parents may have formal mathematical knowledge, but are drawn back by the perception that providing conditions for children to learn mathematics is not the responsibility of parents but of schools. In these homes, children cannot develop a sense of who they are or what they can do in relation to mathematics before they start school.

In homes where parents are actively involved in their children's learning of mathematics, important developments of children's mathematics learning may occur. Children gain elementary mathematical skills (e.g., counting, adding or multiplying). Apart from gaining these skills, they learn about themselves (e.g., their competences) in relation to mathematics based on evaluations of their performances and parental feedback during mathematical participation (Bleeker & Jacobs, 2004). Moreover, during child-parent interactions parents impose their beliefs on the children (Aunola et al, 2003), for example, the perception that success in mathematics depends on innate characteristics or that success in mathematics is determined by one's effort (Anderson, 2007). These aspects of *Mathematical experiencing* are then internalised and can serve as a basis for children's mathematical self-evaluations of competence, evaluations of mathematics as a subject of study, and further learning and understanding of mathematics.

Conclusively, parents constitute a key *Contextual factor* that affects children's pre-school *Mathematical experiencing* and development of their mathematical identity. How this factor affects the processes of development depends on parenting styles at home. Children in homes where authoritarian style is practised may participate in mathematical activities through parental coercion and in highly controlled environments, while children in homes where authoritative style is dominant may experience warm and flexible interactions with parents. Regardless of any parenting style, parents influence children's mathematical self-evaluations. Children also appraise themselves based on their performance in mathematical activities. How children ultimately perceive themselves in relation to mathematics depends on these experiences.

Mathematical experiencing and identity development in school contexts

The processes of *Mathematical experiencing* and identity development in school contexts are shaped by more complex *Contextual factors* as compared to home contexts. The most salient factor is the mathematics teacher, particularly the teaching approach he or she employs when teaching mathematics (Anderson, 2007; Boaler, 2002a; Cobb et al., 2009). Students and institutional arrangements represent other *Contextual factors* considered in this section. In analysing these factors and their influences, I focus mainly on the mathematics classroom.

The teacher

Teachers can play the greatest role in the development of students' mathematical identity (Anthony & Walshaw, 2009; Cobb & Hodge, 2002; Walshaw, 2004). They can create conditions in which students can experience mathematics negatively (e.g., when students are treated by their teachers as only receivers of mathematical knowledge) (Boaler & Greeno, 2000; Cobb et al., 2009; Lopez & Allal, 2007) or positively, for instance, when students are given opportunities to construct mathematical knowledge in their own way. Studies have shown that the use of a mostly teacher-dominated teaching approach (i.e., in which students are not given opportunities to exercise their agency) can impede the development of students' positive mathematical identity (Boaler & Greeno, 2000; Cobb et al., 2009). This means that, in the process of being taught and reflecting on this experience, students come to view themselves as merely receivers of knowledge from the teacher. As suggested in the conceptual framework (Figure 2), this negative view may impede, rather than foster, mathematical participation. In contrast, a more positive mathematical identity forms or develops in classes that provide opportunities for students to learn more actively and autonomously and in which students evaluate themselves positively based on their previous experiences of success. Students who have developed positive mathematical identity are also likely to be fostered by their sense of agency, commitment and ambition (i.e., *Fostering factors*) to maintain their participation in mathematics. The teacher is thus a key individual whose responsibility is to create classroom conditions that allow or encourage students to participate actively and autonomously in learning activities and to learn as well as develop positive mathematical identities (Anderson, 2007; Boaler, 1997; Owens, 2008).

However, teachers' efforts to create conditions to promote students' mathematical participation and development of mathematical identity can be affected by how these teachers perceive their students in terms of mathematical competence. For example, the teachers' perception that there are certain kinds of students who are naturally more competent than other kinds of students can cause teachers to interact more positively with students they regard as competent than with those viewed as incompetent (Dee, 2007; Massanja, 1997, 2004). On the other hand, when students learn of being positively perceived by their teachers, they are also likely to perceive themselves positively, which can foster these students to continue participating in mathematical activities (Massanja, 2004). In contrast, students are likely to view themselves negatively in response to teachers' negative perceptions (as expressed in teachers' behaviour, for example) about their competence. This in turn can negate students' view of themselves in relation to mathematics and impede their commitment to learning mathematics (Cobb et al., 2009; Massanja, 2004).

Another obstacle to teachers' efforts to develop students' mathematical identity through the application of more student-centred teaching methods is the negative view of mathematics as a subject matter. Students often view school mathematics in upper grades as highly abstract, consisting of complex mathematical symbols and expressions. In some countries (e.g., Tanzania) this problem is compounded by the use of a foreign language (e.g., English), which makes mathematics incomprehensible particularly to students with inadequate language skills. These obstacles—students' negative view of mathematics and inadequate language skills—can prevent students from participating in mathematical activities (Mungure, 2009). The role of teachers in these circumstances is to pay attention to how students view mathematics and whether students are skilled enough in the language used in teaching mathematics. Teaching methods need to help students understand mathematical concepts as an important condition for fostering mathematical participation, promoting experiences of success in mathematical activities and developing positive mathematical identity.

Finally, how successful mathematics teachers can be in creating classroom conditions for developing positive students' mathematical identity through the use of a more student-centred teaching approach depends on the teaching tradition of the schools where teachers teach (Boaler & Greeno, 2000). Previous research has shown that there are schools where the teaching tradition is characterised by teacher-dominance in classrooms (e.g., Massanja, 2004; Vavrus, Thomas, & Bartlett, 2011). In other schools the teaching tradition emphasises students' more active and autonomous participation in mathematical activities (Boaler, 1997). While it can be easier for teachers who teach in schools in the latter category to create classroom conditions for enhancing students' mathematical identity, teachers who teach in schools in the former category (e.g., in the school on which this thesis is based) may face the challenge of having to convince school authorities that using teaching methods that develop positive mathematical identity is a better way to promote mathematics learning (cf. Vavrus, Thomas, & Bartlett, 2011: 71-72).

Other important contextual factors

Mathematical experiencing and the development of mathematical identity are also affected by *contextual factors* other than teachers. Students represent another important determinant of *Mathematical experiencing* in the classroom. Through dialogical engagement in peer interactions, students gain new ways or patterns of thinking in relation to mathematics (Holton, Anderson & Thomas, 1997; Tudge, 1990). In addition, according to Bandura (1997), peers form relationships in which, through interactions, they "broaden and particularise knowledge of their capabilities" (p. 173). In mathematics classrooms, one or more students become reference points to which other students compare their mathematical competences (cf. Bandura, 1997; Damon, 1984). Specifically, students evaluate themselves relative to mathematics based on observations of other students' (reference points) mathematical performances. When students evaluate themselves as mathematically competent compared to other students or as students who can become as good as those students they compare themselves to, over time, they develop a positive mathematical view of themselves (e.g., McGee, 2015). In contrast, when students evaluate themselves as mathematically incompetent compared to other students or as students who cannot be as competent as the students they compare themselves to, they can develop a negative mathematical view of themselves (Larnell, 2016).

Moreover, peer comparison in school can also be associated with students' differences in their mathematical backgrounds. In the beginning of schooling, some students may have elementary mathematical skills gained at home, while other students may lack these skills. As a result, students with home-gained mathematical skills tend to evaluate themselves as more capable compared to their counterparts who lack these skills. Similarly, students without this background can appraise themselves as mathematically incompetent compared to students with mathematical skills. As these students continue participating in mathematical activities, these differences in students' comparison-based evaluations of themselves relative to mathematics may continue towards upper grades in their schooling until the differences in the skills gained in school disappear, at least as shown in test scores. Students' positive mathematical view of themselves develops when peer comparisons and self-evaluations are positive but when these comparisons and self-evaluations are negative, students can develop a negative view of themselves relative to mathematics.

Apart from these background factors, the role of parents is still important when students are already in school (LeFevre et al., 2009; Walker, 2012). Parents give their children the support that they need to succeed in mathematics in school, such as books, supportive home environment for self-study, encouragement, and home-based tutorials. Parental support can enhance students' mathematical participation and skills acquisition, resulting in students' positive self-evaluation and positive view of themselves relative to mathematics. Students without this parental support may experience mathematics negatively if, for example, teacher support, peer-support, and ability to study independently and succeed are lacking (Anthony & Walshaw, 2009; LeFevre et al., 2009).

Another *Contextual factor* affecting *Mathematical experiencing* and the development of students' mathematical identity consists of *institutional arrangements* (Anderson, 2007; Wenger, 1998). These are standards or regulations developed in a school or imposed by an external agency such as a government for the purpose of enabling schools to meet their educational goals. These institutional arrangements do not only influence the patterns of *Mathematical experiencing* in classrooms, but also influence students' perceptional patterns (Fordham & Ogbu, 1986; Nasir, 2002; Sfard & Prusak, 2005). One form of institutional arrangements is a mathematics curriculum. Often, curricula provide parameters within which lessons should be planned, taught and assessed (Mungure, 2009). However, although schools or governments consider these curricula as appropriate or even compulsory for every student as was the case in the investigated school, some students may evaluate or perceive them as irrelevant to their lives (Lerman, 2001; Mungure, 2008). Such evaluations or perceptions can impede students from participating in mathematical activities, leading students to view themselves as not belonging to the category of mathematics learners (Allen & Schnell, 2016).

Assessment and grading scales constitute another important aspect of institutional arrangement. They form a basis for students and teachers to evaluate progress in mathematics learning (Anderson, 2007; Stentoft, 2007). Students evaluate their mathematical progress and competence in mathematics learning based on their mathematics test scores. Test score measures also represent an important basis for students' comparison of current performances with previous performances as well as for comparing themselves with other students in terms of mathematical competence (cf. Reay & Wiliam, 1999; Weiner, 1986). These evaluations and comparisons are important for the development of students' mathematical self-perceptions and identity (McGee, 2015; Latterell & Wilson, 2016).

Lastly, subject specialisation policies in schools constitute another form of institutional arrangements. At a certain level or grade of schooling, students are required to choose a set of subjects and continue studying them. When choosing preferred subjects, there are two important processes related to *Mathematical experiencing* and identity development. First, students appraise the importance of subjects to their personal lives at present and in the future (Martin, 2000; Malmivuori, 2001). For example, students may consider mathematics important due to its application to physical sciences (e.g., physics, astronomy and geology). Consequently, mathematics becomes more important to students who pursue physical sciences than to students who prefer studying other subjects (e.g., languages) not related to mathematics. The former students are then more likely to sustain their participation in mathematical activities than the latter students. Thus, students in the former category are more likely to develop positive mathematical identify than students in the latter.

Moreover, mathematical subject specialisation influences students' thinking about their future and other subjects to which mathematics is applicable. Studying subjects that require knowledge of mathematics and reflecting on them enhances students' perceived value of mathematics and fosters students' mathematical participation (Martin, 2000; Nasir, 2002). Students' awareness of the application of mathematics to their anticipated future career also fosters their participation (Anderson, 2006). In contrast, mathematical participation can be weakened by students' view of mathematics as irrelevant to their future career and lives. In short, "the ways students see mathematics in relation to the broader context can contribute either positively or negatively to their identity as mathematics learners" (Anderson, 2007: 9).

2.4.3 Summary

In this chapter, I discuss important features of students' mathematical identity and its development. I first suggest that mathematical identity is reflected in students mathematical self-perceptions which, when narrated, are reifying (i.e., associated with the use of, for example, *can, be, have* or words indicating repetition of actions), endorsable (i.e., indicate faithfulness in story telling), and significant (i.e., if any change in a narrative, for example, by investigator, affects respondents emotionally). Second, mathematical identity is here considered to have analytical components: self-perceptions of mathematical competence, of mathematical participation, of commitment and of ambition. Third, mathematical identity can be positive or negative; it can make students reflect on how they are viewed by other students and think about their future lives in relation to mathematics. Fourth, *Mathematical experiencing* is a necessary process for the development of mathematical identity. *Mathematical experiencing* occurs in a cycle and is influenced by *Contextual factors*. The cycle in its initial form is fostered by students' liking of mathematics and willingness to learn mathematics and it is necessary for the development of mathematical identity. In its complex form, the cycle is mainly fostered by features of mathematical identity (i.e., agency, commitment and ambition), necessary for sustenance of *Mathematical experiencing* and further development of mathematical identity. The cycle also influences students' construction of mathematical knowledge, thereby sustaining their self-evaluation of mathematical competence and thus further promoting their mathematical identity development. While mathematical identity is an essential concept for characterising students' mathematical self-perceptions, *Mathematical experiencing* is used in this study to analyze mechanisms and processes (i.e., the cycle of *Mathematical experiencing*) in the development of mathematical identity among students in a Tanzanian mathematics classroom.

3 Research questions

Research questions constitute a critical part of an inquiry. They keep a research process in focus and guide methodological decisions and choices (Cohen, Manion, & Morrison, 2007; Corbin & Strauss, 2008). But for these questions to be meaningful, they need to be stated together with their contexts. In this chapter, the meaningfulness of these questions is enhanced by situating them within two contexts: the mathematical identity literature and the Tanzanian mathematics classroom and school. In both cases, the appropriateness of these questions within such contexts is indicated.

3.1 Context of research questions

The aims of this thesis, which evolved during the process of data collection and analysis, were to examine and describe students' mathematical identity and its development. The thesis is contextualised within studies that examine the link between mathematical identity development and mathematics teaching approaches employed in mathematics learning classrooms (Boaler, 1997; 2000; Cobb et al., 2009). These studies suggest that in classes where teacher-dominant approaches to teaching are frequently used, students have conflicts within themselves arising from a contradiction between their self-perceptions as mathematically competent students and their role in the classroom as passive receivers of knowledge from the teacher (Boaler, 2002c; Boaler & Greeno, 2000). Traditional approaches to teaching are further found to accompany students' views of themselves that tend to impede the development of a positive mathematical identity. For instance, students in classes where such approaches are applied often perceive themselves as receivers of knowledge, not competent enough to construct their own understanding (Cobb et al., 2009).

In particular, this thesis examined mathematical identity characteristics and development among students who varied greatly in their socio-economic and previous mathematical backgrounds and attended a teacher-dominated mathematics class in a Tanzanian secondary school classroom. In this classroom, the most interesting observation was the students' self-categorisation as students of Science or of Arts. Also, their seating preferences in the classroom reflected this self-categorisation. This classroom, consisting of students with different mathematical backgrounds, was part of a broader and complex context (Appendix B). The mathematics-related actions and interactions in the classroom were influenced by the school's institutional arrangements such as policies and evaluation criteria and fostered by the mathematics teacher in the classroom.

Moreover, like mathematics classes preliminarily observed in other classrooms in the school, the mathematics classes within the focus of this thesis were characterised by a traditional teaching approach. In this approach, teachers were the sole providers of knowledge, the only planners, organisers, presenters and evaluators of lessons. They were also the key disciplinarians, ensuring 'order' in the classrooms. Opportunities for students to exercise their agency in creating their own mathematics learning and understanding were limited or nonexistent. Consequently, students mostly took the role of passive receivers of knowledge. This kind of teacher-student relationship in mathematics learning was not unique to the classroom and school of the study; it was a predominant way of teaching in Tanzanian schools and was generally culturally accepted (Kamugisha, 2010; Vavrus, Thomas, & Bartlett, 2011). Teachers were often likened to parents in that they were seen as not only dispensers of knowledge but also in that they had a parental role of nurturing students in ways acceptable by the wider society (Mafumiko, 2006). These characteristics of the mathematics classroom—teacher dominance, students' self-categorisation based on subject specialisation, differences in students' mathematical backgrounds, and the complexity of the mathematics learning context—formed the basis for considering the classroom as appropriate for examining the characteristics of students' mathematical identity and features of mathematical identity development.

3.2 Emergence of research questions

As mentioned in Section 3.1, the most conspicuous characteristic of the mathematics classes during the preliminary investigations was the tendency among the students to categorise themselves as arts or science students. This self-categorisation was related to students' seating preferences in the mathematics classroom. While most of the arts students preferred to sit at the back, the science students tended to sit in front, closer to the mathematics teacher. Whereas the students who sat in front were actively involved in the classroom-based mathematical activities, students sitting at the back were mostly preoccupied with non mathematical activities. Moreover, the students perceived their mathematical competence differently. Regardless of their subject specialisation, they perceived mathematics as more relevant to science than arts. But they differed in their self-perceptions of mathematical competence. While students who perceived themselves as mathematically incompetent tended to sit at the back, students with positive self-perceptions of mathematical competence took the front seats. These variations in students' self-categorisation, seating preferences, activeness in mathematics classes, differences in their socio-economic and mathematical backgrounds, and self-perceptions of mathematical competence suggested a complexity to the students' mathematical identity, meaning that mathematical identity encompassed not only students' mathematical self-perceptions but also behavioural tendencies associated with such self-perceptions, and background experiences. Thus two broad research questions based on preliminary data collection and analysis (described in detail in Chapter 4) were formulated, and the aim was to identify and characterise students' mathematical identity:

1. What features characterise students' positive mathematical identities?
2. What features characterise students' negative mathematical identities?

Furthermore, the importance of *Mathematical experiencing* in mathematical identity development was noted during the preliminary data collection and analysis resulting in the criteria for analysing mathematical identity (see Subsection 4.3.3) and during the analysis of the identified mathematical identities. This was not a surprise; the importance of mathematical experiences to mathematical identity development is generally discussed in the literature on mathematical identity (e.g., Latterell & Wilson, 2016; LeFerre et al., 2010; Martin, 2000; Nasir, 2002; Seligman *et al.,* 1995). In these discussions, the development of mathematical identity occurs when students take part in actions and interactions related to mathematics learning. In the preliminarily observed mathematics classes, students had mathematical experiences likely to have resulted in their mathematical identity. They had been exposed to mathematics for at least nine years (i.e., seven in primary school and two in lower secondary school). Few students had learned mathematics in nursery school before they began their primary school. The students had learned mathematics in different primary schools and had been taught by different teachers in primary and secondary school (see Appendix D). Thus, the variation of mathematical identity among the students in this classroom seemed to depend on how they had previously experienced mathematics. The data on features of mathematical identities also gave a similar impression. This likely dependence further underlined the importance of *Mathematical experiencing* in the development of mathematical identity. Thus two broad research questions were formulated, the aim being to analyse the characteristics of *Mathematical experiencing* for each mathematical identity:

3. What kind of Mathematical experiencing characterises students' positive mathematical identity?
4. What kind of Mathematical experiencing characterises students' negative mathematical identity?

These research questions about *Mathematical experiencing* formed the basis for formulation of specific questions for gathering and analysing additional data from the students. In doing this, different periods of students' *Mathematical experiencing* were covered: home, primary school, and secondary school (To view examples of the specific research questions, see Appendix I.)

In sum, addressing the four main research questions contributed to the understanding of the different ways in which students perceived themselves in relation to mathematics and the nature of mathematical experiences associated with these perceptions. The discussion of the methodology applied for addressing these questions is presented next.

4 Research methodology

Methodological choices, decisions, and procedures are necessary in any social research project (Hammersley & Atkinson, 1995; Punch, 2005). These require a basis in the form of the purpose of the research and the researcher's assumptions about how that purpose can be methodologically realised (Denzin & Lincoln, 1994; Lincoln & Guba, 2000; Punch, 2005). The motives of this study are to characterise students' mathematical identity in a Tanzanian mathematics classroom in which students varied greatly in their socio-economic backgrounds and previous mathematical experiences and to explore the nature of *Mathematical experiencing* behind mathematical identity among these students. Contextualising the motives of the study within a broader paradigmatic perspective produces the basis for justifying methodological choices, decisions and procedures for this study (Lincoln & Guba, 2000). Social constructivism is the general methodological perspective (or research paradigm) that can best frame the approach of this study and lead to the realization of the study aim (cf. Denzin & Lincoln, 1994; Lincoln & Guba, 2000; Punch, 2005). Ethnography, at a more practical level, has been chosen as a suitable methodological framework to guide data collection and analysis, and is also compatible with the assumptions of social constructivism (Silverman, 2005). One key instance of this compatibility is that both these approaches share the idea that individuals, through interactions with others, construct their own understandings relevant to their contexts and that these understandings can be qualitatively studied (Lincoln & Guba, 2000). This chapter introduces the methodological choices, decisions and procedures of the study based on social constructivist and ethnographic assumptions.

4.1 Basic assumptions of scientific inquiry in the study

In broad terms, how an investigation is conducted depends on a set of basic assumptions, often referred to as research paradigm, that guide the research process (Denzin & Lincoln, 1994; Lincoln & Guba, 2000; Mertens, 2005). According to Denzin and Lincoln (1994), a research paradigm can be characterised as having three major aspects. The first consists of assumptions about the nature and form of 'reality' (ontology) and *what* can be known about this reality. The second aspect is epistemological, concerned with questions of *how* the reality can be known (Lincoln & Guba, 1994). This expresses views about how the relationship between the investigator and the investigated phenomenon should be. The third aspect is methodology, consisting of a set of assumptions about how we gain knowledge of what is being investigated. It provides methodological guidance for practical and more specific decisions during the process of investigation (Cohen et al., 2007; Denzin & Lincoln, 1994). In practice, these ontological, epistemological and methodological assumptions intertwine. For instance, when making choices and decisions, these paradigmatic assumptions interplay in the researcher's thinking during the process of investigation (Denzin & Lincoln, 1994; Lincoln & Guba, 2000). However, their collective role provides useful guidance to research.

The choice of social constructivism as the perspective for this study was made after considering the relevance of other perspectives such as positivism, post-positivism, and critical theory in social inquiry (Denzin & Lincoln,1994; Guba & Lincoln,1994, 2005). Characteristics of these paradigms are summarised in Appendix E. There were three reasons for choosing social constructivism. The first was associated with the nature of students' mathematical identity (ontological assumptions) as a 'reality' to be investigated. From the social constructivist perspective, mathematical identity can be viewed as a feature within students themselves (Guba & Lincoln, 1994; Sfard & Prusak, 2005). Students construct the 'reality' of themselves with respect to mathematics based on social interactions and other forms of personal experience in mathematical contexts. Students are also considered able to perceive themselves based on constructions of who they are in relation to mathematics (Wenger, 1998). Based on this understanding, the study did not intend to verify a theory or body of knowledge of mathematical identity, but the intention was to present an in-depth account of students' mathematical identity and associated experiences in their contexts of mathematics learning.

The second reason was epistemological. Constructivist thinking guides decisions about the relationship between the researcher and data sources (or phenomena being studied) in the process of investigation (Cohen et al., 2007; Denzin & Lincoln, 1994). This means that it was necessary to decide how I would relate with students (and teachers) in order to obtain the right information consistent with the purpose of the study. According to the constructivist perspective, there should be an interactive link between the investigator and research participants, and in this link, participants' views (i.e., data) are qualitatively constructed as the investigation proceeds (Cohen et al., 2007; Denzin & Lincoln, 1994; Guba & Lincoln, 1994). Thus, instead of detaching myself from the students as would be the case in a positivist study to ensure objectivity (Guba & Lincoln, 1994, 2005; Denzin & Lincoln, 1994), a rapport with students was established and maintained for one year with a focus on their mathematical self-perceptions and associated experiences.

Finally, the reason for choosing social constructivism was methodological. The more specific decisions about techniques and procedures of data collection and analysis were based on the methodological assumption that such techniques and procedures need to be chosen (or developed) depending on the ontological and epistemological assumptions that the researcher has chosen (Guba & Lincoln, 2005; Denzin & Lincoln, 1994). Thus, techniques and procedures of data collection and analysis as presented in this chapter are consistent with social constructivist assumptions. That is, the qualitative data was gathered using open-ended and exploratory techniques (mostly the diary method) in a process in which the researcher interacted with students to obtain the data and further interpreted the data in a thematic procedure of data analysis (Guba & Lincoln, 1994; Silverman, 2005).

4.2 Ethnography as the methodological framework for the study

Although the social constructivist paradigm provides a broad perspective within which the researcher can justifiably make general choices and decisions, it does not suggest a specific methodological framework for a given study (Guba & Lincoln, 2005; Denzin & Lincoln, 1994). The specific methodological framework chosen for this study is ethnographic. It has been chosen based on the following reasons. First, ethnography, commonly used in fields such as education, anthropology and sociology, is regarded as an appropriate approach to gaining in-depth information on research participants in their social and cultural contexts (Creswell, 1998; Mertens, 2005; Silverman, 2005; Tesch, 1990). Second, this framework allows the researcher to combine several techniques and procedures of data collection and analysis when necessary (Brewer, 2000; Creswell, 1998). Third, in using ethnography, a researcher can interact with participants in their day-to-day lives within their contexts and can thus gain first hand subjective information (Mertens, 2005; Tedlock, 2000). Moreover, this approach is in line with the social constructivist assumptions of investigation and thus also with the paradigm and aims of the present study.

However, ethnography is not a clear-cut framework. It is here considered necessary to briefly clarify this complexity in order to make specific choices for the present study. The complexity of ethnography indicates several strands that vary, for instance, in research focuses (Atkinson, 2001; Atkinson & Hammersley, 1994; Brewer, 2000; Eisenhart, 1988; Hammersley, 1992a, 1992b; Kleine, 1990). Interpretive ethnography, ethnography of communication, biographical ethnography, and life historical ethnography are examples of these strands (Brewer, 2000; Denzin, 1997; Littlejohn & Foss, 2005; Mason, 2004). While they differ from each other, they share a number of similarities as well. For example:

> "They are grounded in a commitment to the first hand experience and exploration of a particular social setting on the basis of (though not exclusively by) participant observation. Observation and participation (according to circumstance and the analytic purpose at hand) remain the characteristic features of the ethnographic approach. In many cases, of course, fieldwork entails the use of other methods too" (Atkinson, 2001: 4-5)

The ethnographic approach adopted for this study can be characterised as interpretive in the sense that it focuses on "people, and their interpretations, perceptions, meanings and understandings..." which are regarded "as primary data sources" (Mason, 2004: 56), and the main concern is to seek the "insider view" at a given time to try to understand it through interpretation and to document it (Atkinson & Hammersley, 1994; Denzin, 1997; Gilbert, 2008; Mertens, 2005).

Relevance of ethnographic research to mathematics education

Choosing ethnography as a framework for the present study also derives from previous use of such an approach in mathematics education research (Eisenhart, 1988, 2001). Like in other fields of education, the need for in-depth understanding of mundane and authentic experiences and the behaviour of learners and teachers in their specific mathematics education contexts has called for this kind of methodological framework (Corey, Peterson, Lewis, & Bukarau, 2010; Eisenhart, 1988, 2001; Harel & Rabin, 2010; LeCompte & Goetz, 1993). Specifically, students' mathematical identity has been studied using approaches that have ethnographic characteristics though often not explicitly mentioned as such (e.g., Cobb et al., 2009; Nzuki, 2007; Sfard & Prusak, 2005; Terry, 2009). These studies have applied methods such as direct observations, interviews and analysis of mathematical identity in specific classrooms or schools that have revealed the influence of teacher behaviour and teaching traditions on students' mathematical identity, for example. This study is positioned in this kind of methodological framework and use of techniques consistent with this technique.

4.3 Techniques and procedures of data collection and analysis

4.3.1 Preliminary investigations

Preliminary investigations form a crucial stage in qualitative field research because they familiarise the researcher with the field and give a direction for the investigation process in the field (Silverman, 2005; Strauss & Corbin, 1990). Preliminary observations and group discussions with thirty seven third-grade students (between 16 and 17 years of age) in a northern Tanzanian secondary school mathematics classroom enabled me to gain a general understanding of the mathematics-related social and cultural context of the school (Braun & Clarke, 2006) and of the students' constructions of mathematical self-perceptions. To be certain that these constructions reflected their mathematical identity, the criteria for identifying identity suggested by Sfard and Prusak (2005, p. 6-7) were applied. According to these authors, one's identity can be made explicit by his or her stories that are, for example, 'reifiable' and 'endorsable'. Based on reifiability as a criterion, only data on students' perceptions that included students' references to themselves with expressions such as *I am*, *I have*, and *I can* (e.g., *I am* or *have been* good at mathematics, *I can* do maths) and expressions suggesting repetition such as *always*, *never* or *often* (e.g., *many times* I've thought *I'm* good in maths, *sometimes* I do maths) were gathered, analysed, and considered as reflections of students' mathematical identity. Endorsability of students 'perceptions constituted another criterion. Reifiable data were considered endorsable if it consisted of stories as told by students themselves to represent 'reality' as they perceived it (Sfard & Prusak, 2005). Thus, while students with positive mathematical self-perceptions confirmed their self-perceptions by referring to their high performances in mathematics tests, students with negative self-perceptions justified their self-perceptions based on their previous low mathematics test scores.

After preliminary observations and discussions in the school and developing a picture of the issues or aspects to be studied further, the need to focus more on students' mathematical self-perceptions arose. As a result, a diary method was applied to gain detailed data from individual students and to achieve a clear differentiation of the data (Corbin & Strauss, 2008; Silverman, 2005). This method was chosen also because students wanted to have their identities protected during the data gathering process. Accordingly, the diary method was viewed as more protective than the interview method. The data were necessary for identifying students' views and establishing criteria for further collection of information to characterise these views. Individual students offered their views or perceptions while being guided by a series of exploratory questions (Corbin & Strauss, 2008; Strauss & Corbin, 1990). At this point, it appeared necessary to organise data by identifying students with generally similar views and grouping them together (as shown in Subsection 4.3.3) to allow a relatively quick access to individual students' information. Collection and analysis of data continued until saturation was reached, that is, until diaries yielded no new information, leading only to repeated information from students (Corbin & Strauss, 2008; Silverman, 2005).

In addition, since data from the students seemed to emphasise the role of broader contextual factors of the school and other institutions, data were gathered through classroom observations, review of official documents related to mathematics, conversations with mathematics teachers, and administering open-ended questionnaires to two teachers and officials in the school administration.

4.3.2 Specific techniques and procedures of data collection

An important distinguishing characteristic of ethnographic studies is the incorporation of contextual information related to participants being investigated (Eisenhart, 2001; Silverman, 2005). Two kinds of data were sought based on this characteristic. The first kind of data focused on students' mathematical identity and experiences. The second kind of data related to the context (i.e., system of education, school, and mathematics classroom) in which students learned mathematics. While data on student's identity and experiences was collected using the diary method, data on the school and classroom context derived from general documentary information, questionnaires administered to mathematics teachers and school administrators, and direct observations of the mathematics classroom and school.

The diary method and procedure applied

The diary method was used for gathering data on how individual students perceived themselves in relation to mathematics and how they had experienced mathematics. In acknowledging that there are different kinds of diaries, an appropriate choice of diary method was needed. Memoirs are diaries that are often written with the intention of publishing them (Allport, 1943) whereas intimate journals as personal records are intended to be kept as private documents (Allport, 1943; Lida, Shrout, Laurenceau, & Bolger, 2012). Logs also represent private records consisting of a list of events without detailed commentary (cf. Allport, 1943; Lida et al. 2012). The diary method used in this study is in the category of intimate journals. It was useful in gathering detailed data about students' mathematical identity (cf. Robson, 1993) since it was considered as a "powerful way for individuals to give their accounts of their experiences" and thoughts about their experiences and themselves (Clandinin & Connelly, 1994, p. 421). Open-ended questions were designed to guide students' writing of their diaries.

The diary method is useful particularly when data cannot be accessed through other methods such as interviews (Clandinin & Connelly, 1994). For this study, the diary method was considered the most appropriate one. In a school where teachers had immense power and authority over their students, students did not accept being tape-recorded. They were highly concerned about preserving their anonymity and security during and after the research process. This fear of being tape-recorded meant that the interview method would not succeed. In consequence, the diary method was chosen as an alternative method and was also accepted by students on condition that their personal data would be hidden.

However, like many other methods of data collection in social research, the diary method has weaknesses. For example, a great deal of responsibility is placed on the student, who has to record information according to the researcher's instruction (Robson, 1993). Also, there are possibilities of misreporting for various reasons, such as trying to please the researcher (Robson, 1993). To address the first problem, participants were asked to write diaries when they had free time. Many of them chose to write their diaries after classes and during weekends. The possibility of misreporting was difficult to detect. However, students did not need to please the researcher who was an outsider and not one of their teachers or other school staff. Also, students' willingness to reveal 'risky' information about their 'difficult' mathematics teacher reflected their trust in the researcher.

The diary procedure was based on a common pattern of interaction between students and the teacher using notebooks as a medium of communication. In the school, notebooks were sometimes used as tools for more individualised teacher-student communication related to mathematics learning. First, teachers provided assignments and asked students to do the assignments in their notebooks. The notebooks were then brought to the teachers after the assignments were completed. The teachers marked the assignments and wrote comments or provided other forms of feedback in the notebooks, including asking students to come to their offices for extra tutorials. The teachers then brought the notebooks back to students so that each could read the teachers' feedback.

I applied a similar approach during the fieldwork of the study. I wrote open-ended questions (one question at a time) in the notebooks that I had bought and issued to students only for research purposes. Students responded to the questions by writing in the notebooks. In response to what they had written, they were asked more specific questions to let them elaborate on what they had previously written. This procedure was maintained during the entire period of the fieldwork until the stages at which further questioning yielded no new information (Corbin & Strauss, 2008).

Other methods of data collection

In order to gain understanding of the context in which students learned mathematics, methods other than the diary method were applied. Documentary sources and their analysis represented such data. The value of this method in research is summarised by Mason (2004):

> "The analysis of documentary sources is a major method of social research, and one which many qualitative researchers see as meaningful and appropriate in the context of their research strategy. The idea of documentary research used to conjure up a mental image of a researcher digging around in a dusty archive among historical documents, but in

> fact there are many different ways of generating data through documents" (p. 103)

Documents for this study consisted of records of the Tanzanian mathematics curriculum for secondary schools and students' mathematics test scores. With the consent of students and the school's academic officer, the scores from school's official records were obtained. They were useful in understanding the possible implications of students' mathematical identity for their academic performance. Media texts related to education in Tanzania and ministerial documents (e.g., circulars, school inspectorate reports, Tanzania education policy, and educational programmes) also were an important source of contextual information and helped in contextualizing students' thoughts about themselves in relation to mathematics (cf. Mason, 2004; Pink, 2001; Platt, 1981). The documents provided information about the broader social, political and economic aspects related to mathematics education in a Tanzanian classroom. They specifically provided data on both the macro (i.e., broader, systemic and cultural setting) and micro (i.e., the classroom/school) context in which students learned mathematics. Some of these documents were available at the school and some were in the main libraries of Tumaini University Makumira and University of Dar es Salaam.

Additional data were gathered through open-ended, self-made questionnaires constructed by the researcher on the basis of preliminary observations (see Appendices C and D). The questionnaires sought to explore teachers' and administrators' views and feelings about the school students and their progress in mathematics learning. Two mathematics teachers—a third grade teacher whose class was the main focus of the study, and a second and fourth grade teacher—filled these questionnaires. In addition, two school administrators (i.e., deputy principal and academic officer) filled another questionnaire. While their views provided valuable contextual insights for the study, the most important data derived from the conversations with the grade three mathematics teacher when observing his class, teaching activities and behaviour. Relevant parts of these conversations were hand recorded immediately after each conversation and later typed.

The researcher's observations of the mathematics classroom provided information on events and practices in the classroom of the study. The classroom was observed eleven times in total and field notes were written each time. The time interval between the observations ranged from three days to two weeks. Each observation took about 40 minutes (i.e., the whole lesson) and the class was observed once for each topic being taught during the period in which observations were done. The observations focused on students' attendance and characteristics of the physical environment of the classroom. Other observations targeted teacher-student interactions, particularly during teacher's lesson presentations, when asking questions to students, assigning tasks to students, and when students responded to this teacher behaviour. In addition, observations were made of student-student interactions while participating in the class (e.g., in "pair discussions") and of students' free talk, particularly in the absence of the teacher. Furthermore, group discussions with the third grade students were conducted during the first two weeks of classroom observations. These took place outside the classroom (in the school library building) and were selectively recorded by hand and later typed. The data were used in identifying and characterising students' mathematical identity and experiences.

4.3.3 Techniques and procedures of data analysis

In ethnographic research, like in any social research, data analysis is an integral part of investigation (Baker, 2008; Fetterman, 1989, 1998). The meaning of data is understood particularly during, and as a result of, data analysis (Baker, 2008; Corbin & Strauss, 2008). There are different techniques for analysing ethnographic data. One of these is thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006). Braun and Clarke (2006) define thematic analysis as a qualitative analytic technique for:

> "...identifying, analysing and reporting patterns (themes) within data. It minimally organises and describes your dataset in rich detail. However, frequently it goes further than this, and interprets various aspects of the research topic" (p. 79)

According to Braun & Clarke (2006, p. 82), each of the themes "captures something important about the data" and presents its meaning in relation to data and research questions. Furthermore, thematic analysis is a complex activity. Coding of data, which means assigning meaning in terms of words or phrases to sections of data (Boyatzis, 1998), is central to this technique. These assigned meanings or codes then become basic units for developing sub-themes and themes. For this study, data within two broader frameworks were thematically analysed. The first related to contextual aspects of the fieldwork school and classroom in regard to mathematics learning. The second framework consisted of how students perceived themselves in relation to mathematics and their mathematical experiences. The analysis applied within these two broader frameworks is illustrated below.

Analysing sub-themes and themes related to the context

The contextual data were analysed thematically based on Braun and Clarke's (2006) ideas. Initial codes were generated during the collection and analysis of initial data, leading to the emergence of sub-themes. Additional data and coding resulted in a review of the emerging sub-themes and themes. When the sub-themes and themes were considered fully developed (i.e., when new data did not add new meanings), collection and analysis of data on the themes and sub-themes were ended. The themes, sub-themes and codes constructed are summarised in Appendix J.

The contextual data related to the mathematics classroom were mostly in the form of notes resulting from direct observations of events in the classroom. But the notes also consisted of records written during conversations with the students and the mathematics teacher. Moreover, the data for interpreting the context were based on extracts from documents that guided teaching and assessment of mathematics in the classroom and on the questionnaires filled by the mathematics teacher. To analyse these data, a thematic analytic approach similar to the one used for analysing data about school context, was employed. As a result, the theme *Mathematics Learning Context* emerged as a result of these analyses. Its sub-themes and codes are presented in Appendix J.

Initial analysis of data on students' mathematical self-perceptions and experiences

Data gathered through classroom observations and group discussions with students were analysed thematically to initiate the process of identifying and characterising students' mathematical identity and experiences associated with their identity. However, this analytical process was more complex than when analysing contextual data. This was because students viewed themselves in diverse ways, and there were great variations in the ways they had experienced mathematics. Consequently, the analysis of this data was done by taking into account this diversity. During initial data analysis, codes began to suggest certain sub-themes and themes (cf. Boyatzis, 1998; Braun & Clarke, 2006). The emergence of the sub-themes and themes in students' self-perceptions was associated with a complication that needed to be resolved. In the group discussions, there seemed to be a close link between the emerging sub-themes and certain categories of students who participated in the study. That is, specific groups of students seemed to identify themselves with certain evolving sub-themes. Moreover, students who perceived mathematics as a useful subject to them came to be in conflict with those who felt mathematics was not a useful subject to them. This was the case even when all students who were involved in this conflict perceived themselves as competent in mathematics.

It was considered necessary to divide students into separate groups on the basis of such views. Based on these views as well as emerging themes, students were divided into three groups for further analysis based on two key criteria: self-perceptions of mathematical competence and perceptions of mathematical usefulness. These two factors were frequently mentioned in the discussions, signifying their importance in students' thoughts and feelings in relation to mathematics. Moreover, views on the value of mathematics were important because of their implications for students' imagined future concerning their relationship with mathematics (cf. Anderson, 2007). The procedure for grouping students was as follows: First, after familiarisation with students and their learning context, particularly through the observations made in the classroom, all the thirty seven students were invited to a meeting in the school library. Second, students who perceived themselves as mathematically competent and mathematics as useful to them personally were asked to form a separate group. Third, students who perceived themselves as mathematically competent but who thought mathematics was not useful to them personally were asked to get together in another group. Fourth, students who viewed themselves as mathematically incompetent and mathematics as a useless subject to them personally formed a third group. These initial student groups are shown in Table 1.

Table 1. Initial categorization of students based on shared views on mathematics

Criteria	Group members
High perceived competence/maths is useful	16(11 male, 5 female)
High perceived competence/maths not useful	10 (5 male, 5 female
Perceived incompetence/maths not useful	11 (7 male, 4 female)

Fifth, students' names were recorded in each group and each name was assigned a number (1 to 37). Sixth, on the following day, the meeting continued in the same venue and numbers that had been assigned to students' names were given to students so that each knew his or her number. Consistent with students' wishes, these numbers were then used in their notebooks for diary writing instead of their names to keep their personal information hidden from anyone else except the researcher. At this stage, it was also necessary to ensure that students' real names were not revealed to other persons.

However, during the process of further analysis, the sixteen students who perceived themselves as highly competent in mathematics and mathematics as useful to their personal lives differed in how they viewed the nature of their mathematical competence. While some students thought their mathematical competence was essentially innate, requiring only little effort to succeed in solving mathematical problems, other students believed that they had become good at mathematics because they had worked hard and could tolerate difficult situations in the process of learning mathematics. Thus, based on the students' perceived nature of mathematical competence, this group was further subdivided into two groups as shown in Table 2. This subdivision made the process of both data collection and thematic analysis less complicated since the four subgroups were then focused separately to obtain more detailed information from each.

Table 2. Final categorization of students based on views on mathematics and mathematical competence

Criteria	**Group members**
High maths competence is innate/maths is useful	6 (4 male, 2 female)
High maths competence is gained through effort plus tolerance/maths is useful	10 (5 male, 5 female)
High maths competence/maths is not useful	10 (5 male, 5 female)
Low maths competence/maths is not useful	11 (7 male, 4 female)

After categorising students into these four groups, thematic analysis, along with collection of more diary data and students' mathematical test scores, proceeded. Sets of codes that seemed to have a broader and shared meaning were drawn together to form initial sub-themes and their facets (Corbin & Strauss, 2008; Strauss & Corbin, 1990), which were later reorganised into a set of criteria used as a basis for gathering additional data and analysing them according to student categories. The criteria are shown in Table 3.

Table 3. Criteria for analyzing characteristics of students' mathematical self-perceptions

Self-perceptions of: -Mathematical competence -Mathematical participation (participation in mathematical tasks and interactions in mathematics learning) -Ambition -Commitment to learning mathematics

The focus then was on how students' self-perceptions varied between the groups in Table 2 as related to the criteria in Table 3. For answering this question, more detailed data analysis was conducted in addition to a review existing literature in order to find theoretical ideas for meaningfully capturing the emerging themes and subthemes against the criteria in Table 3.

Data analysis on students' mathematical identity and its development

The process of data collection and analysis yielded information on the variation in students' self-perceptions, including polarity (i.e., positive and negative patterns). Thus, positive perceptions were reorganised under the theme of positive mathematical identity and negative perceptions under the theme of negative mathematical identity. At this stage, I made a decision to only focus on these major themes in the subsequent data collection and analysis. In addition, the subthemes under the major themes were renamed (see Table 4). In this, the first three groups presented in Table 2 represented positive mathematical identity and the fourth group denoted students with negative mathematical identity.

Students in the first group of positive mathematical identity viewed themselves as mathematically gifted, regarded themselves as highly engaged in mathematical activities, felt ambitious and committed to mathematics, and had the highest mathematics test scores. Since the perception of being mathematically gifted was more salient among students in this group compared to the other groups, the sub-theme describing their views was named *Innate ability identity*. Students in the second category perceived themselves as mathematically competent, highly committed and ambitious in learning mathematics. They also considered themselves as frequently individually engaged in mathematical activities and as those who regularly interacted with others in mathematics learning situations. Furthermore, they had high mathematics test scores. Due to persistent effort being salient in their competence-related views, the subtheme describing their perceptions was named *Persistent effort identity*.

Finally, students in the third category perceived themselves as able to succeed in mathematics depending on their effort in mathematical activities. However, their performance had been declining over time, and at the time of the fieldwork, it was lower than it had been previously. Students in this category perceived mathematics as not relevant to their imagined future studies or career and had given priority to other subjects seen to define their future lives. A salient characteristic associated with students in this category was their preoccupation with the desire to be viewed as individuals who were able to succeed in mathematics and consequently striving to avoid failure in order to maintain this positive image. Thus, the subtheme for these perceptions and concerns was named *Image-maintenance identity*.

Students in the fourth group (Table 2) had a negative view of themselves in relation to mathematics. They considered their mathematical competence to be low, and their ambition and commitment to mathematics to be low (or even none). They viewed themselves as individuals who did not regularly take part in mathematical activities or engage in interactions while learning mathematics. Moreover, students in this group perceived mathematics as useless to their lives. They were preoccupied with learning other subjects and had the lowest average level of performance in mathematics tests compared to students in other groups. The subtheme for describing these characteristics was thus named *Oppositional identity* under the theme of *Negative identity*. Originally, "Oppositional identity" refers to an identity of resistance of individuals belonging to minority groups in USA against mathematical participation due to its perceived representation of the values of the majority white people (Fordham & Ogbu, 1986). In this thesis, *Oppositional identity* refers to students who resisted mathematical participation due to their perceived low mathematical competence and the perceived uselessness of mathematics to them (cf. Cobb et al., 2009).

Furthermore, the process of data analysis suggested that students' mathematical identity was closely associated with their previous mathematical experiences and that these experiences varied depending on the kind of identity students had. Under the evolving theme of *Recalled mathematical experiencing*, more data was collected and analysed to understand how students with different mathematical identities had previously experienced mathematics. The sub-themes of this theme—*Mathematical experiencing* for students with *Innate ability identity*, with *Persistent effort identity*, with *Image-maintenance identity*, and with *Oppositional identity*—were named based on interpretation of the data. Although the influence of theories, for example, of mathematical identity and motivation may be reflected in these subthemes, the naming process of the subthemes did not make reference to specific theories. In addition, a coherent interpretation of *Mathematical experiencing* among students in the four categories of mathematical identity required a cohesive conceptual framework. This framework, discussed in detail in Chapter 2, was developed separately through open and axial coding of data on students' *Mathematical experiencing*. Selected memos in Appendix K show how the framework evolved.

Table 4 presents the final themes and subthemes of students' mathematical identities and previous *Mathematical experiencing* related to these identity categories.

Table 4. Identity types and *Mathematical experiencing*

Themes	Sub-themes
STUDENTS' POSITIVE MATHEMATICAL IDENTITIES	-*Innate ability identity* - *Persistent effort identity* -*Image-maintenance identity*
NEGATIVE MATHEMATICAL IDENTITIES	*Oppositional identity*
RECALLED MATHEMATICAL EXPERIENCING	- *Mathematical experiencing* with *Innate ability identity* -*Mathematical experiencing* with *Persistent effort identity* -*Mathematical experiencing* with *Image-maintenance identity* -*Mathematical experiencing* with *Oppositional identity*

The coding scheme providing detail on these different types of identity and *Mathematical experiencing* is presented in Appendix J. A deep understanding of these was achieved through collection and analysis of additional data.

4.4 Validity issues

Different validity criteria have been proposed by different authors in the field of qualitative research methods including ethnography. Some criteria reflect the influence of the post positivist research perspective (e.g., Lincoln & Guba, 1985; Morrow, 2005), while other criteria, consisting of notions such as creativity, reflexivity, and congruence (Marshall, 1990; Popay et al., 1998) indicate a departure from this framework, aligning with interpretive perspectives. There is a variation also in how individual researchers select or develop validity criteria in specific research projects (Henry, 2015). Due to a lack of commonly shared criteria for ensuring validity of qualitative research projects, Henry (2005) and Maxwell (1996) argue that researchers should have discretion to creatively select and/or develop criteria consistent with the purpose of a specific research project and circumstances in which the project is conducted. In keeping with this argument, the criteria considered suitable for this study were: credibility, transferability, reflexivity, sensitivity, creativity, thoroughness, and congruence (Henry, 2015; Lincoln & Guba, 1985, 1994; Marshall, 1990; Maxwell, 1996; Popay et al., 1998).

Credibility is the extent to which the research findings reliably reflect the research participants' experiences, meanings, and social context (Lincoln & Guba, 1994; Maxwell, 1996). In the present study, credibility was enhanced by prolonging the fieldwork period to one year to allow an in-depth study and understanding of the research participants, their mathematics learning context, mathematical identities and experiences. Different kinds of data (i.e., in the form of students' narratives, observation field notes, official documents, and questionnaire-based data) collected and analyzed during the fieldwork, aimed at ensuring consistence between research findings and students' experiences, meanings, and the mathematics learning context. In addition, the notebook-based correspondence between the researcher and students allowed the researcher to ask additional questions to let the students clarify what they had previously written.

Transferability, which refers to the applicability of the research findings to other contexts with similar characteristics (Lincoln & Guba, 1985), was enhanced by presenting a thick description of the context in which the students learned mathematics, their mathematical identities and experiences, and by clearly describing the patterns defining the variation of mathematical identity and experiencing across the participants. These patterns were accurately described with a view to increasing the likelihood of their applicability to other mathematics learning contexts in Tanzania.

Reflexivity, a conscious process of self-criticism, can help researchers minimize the influence of their preconceptions or bias that may reduce the validity of the research process and outcome (Maxwell, 1996; Patton, 1990). In this study, self-criticism of stereotypical thoughts and seeking context-based evidence to prove or disprove pre-conceived ideas constituted strategies for minimizing the influence of these ideas especially in the beginning of the fieldwork. In addition, sensitivity refers to the researcher's consciousness and considerateness of research participants' views, culture, and context (Marshall, 1990). Based on this criterion, I built a rapport with students in the beginning of the fieldwork using a shared language (Swahili) to easily understand students' concerns and feelings during the research process. Moreover, consistent with the local cultural expectations, I acknowledged the students' help by thanking them and presenting each student with a notebook and a pen.

Creativity, another validity criterion, requires researchers to adapt and use methods, ideas, and principles appropriate to the circumstances of a specific research project to help them achieve their research goals without undermining the principles of scientific inquiry (Patton, 1990). In the present study, creativity was instrumental particularly during the fieldwork. For example, creativity was employed when determining a data collection method (the diary method) based on students' preference and adapting it to the school's tradition in which teachers communicated with students by writing in students' notebooks. The other example of creativity was the development of a conceptual framework grounded in data for use in the interpretation of students' narratives.

The thoroughness validity criterion generally refers to the attentiveness to detail and accuracy in the selection of research participants, data collection, and analysis (Morrow, 2005; Propay et al., 1998). Consistent with this criterion, the number of research participants was considered adequate because the data given by the participants addressed fully the purpose of the research, which was to describe and explain the characteristics and development of students' mathematical identity. Also, data collection and analysis proceeded together, employing methods relevant to interpretive ethnography.

Finally, congruence is a rather complex validity criterion. On the one hand, it refers to the harmonious relationship between research purpose, design, questions, methods, procedures, and findings, but on the other, it refers to the relevance of research results to previous research findings and practice (Marshall, 1990; Morse & Richards, 2002). After establishing the purpose of research through preliminary data collection and analysis, congruence in this study was enhanced by developing a research design (interpretive ethnography), formulating research questions, and selecting research methods and procedures, consistent with the research purpose. Congruence was also enhanced by evaluating the findings against the research purpose to ensure there was consistence between them. Moreover, this study extends the previous research scope by focusing on a classroom in which students varied greatly in their mathematical backgrounds (see Chapter 7). Also, since the study was grounded in data, it has evidence-based practical implications. For example, it stresses the use of pedagogical methods that promote positive mathematical identity development.

These identity criteria—credibility, transferability, reflexivity, sensitivity, creativity, thoroughness, and congruence—constituted an important basis for enhancing the validity of the study. An evaluation of the trustworthiness of some of these criteria is detailed in section 7.5.1 of this dissertation.

4.5 Ethical issues

Ethics are an important issue in research. As a result of increased commitment of research to the autonomy of individuals, the rights of subjects in research are increasingly being recognised and respected by researchers (Christians, 2005; Soble, 1978; Veatch, 1996). For example, participants should agree voluntarily to participate in a study (Christians, 2005). The participants of this study (i.e., students, teachers and school administrators) chose to participate voluntarily. Students had a chance to opt out of the study if they wished. As a result, during the early stages of data collection through diaries, a few students dropped out (Appendix D); the main reason was that they had lost interest in the study. Moreover, it is stated in the articles of the Nuremberg Tribunal and the Declaration of Helsinki that individuals who participate in research must be informed about the period of the study, the methods used, risks that are likely to occur, and the goal of research (Christians, 2005; also see Soble, 1978; Veatch, 1996). These issues were relevant to the present study. In the beginning of the fieldwork and during the initial meetings participants (both students and teachers) expressed their desire to know the reasons for conducting this study in their school. That the reason was to gain knowledge of students' experiences and thoughts about themselves in relation to mathematics was explained to the students. They were also informed that such knowledge, gained through the use of data collection methods, would enable the researcher to interact with students, teachers and school administrators.

Most importantly, students were concerned about possible risks due to their participation in the study. They feared that some of the views might be interpreted by teachers as offensive and might thus put them at the risk of corporal punishment. On this basis, students preferred not to have their views tape- or video-recorded. They also did not like to have their names written on their diary notebooks. The use of numbers instead of names was viewed as a way of preserving their anonymity. In an attempt to reduce students' worry and increase chances for obtaining dependable and sufficient data (Creswell, 1994; Silverman, 2005), these preferences were incorporated into the study plan. The diary method (instead of interviews) was used, and numbers instead of names were labelled on the covers of students' notebooks. Later, the numbers were changed into pseudo names to be used in the research report (the pseudo names appear in Appendix D). In addition, confidentiality was ensured, that is, data that were considered somewhat risky to students (e.g., details about specific teachers) were kept confidential.

However, teachers and school administrators who participated in the study did not seem to be concerned about risks associated with their views even when blaming the National Examinations Council of Tanzania for its "inefficiency" in setting mathematics examination questions. But the anonymity of teachers, administrators and school was preserved by not mentioning their real names in the thesis. Toward the end of the fieldwork, mathematics teachers and administrators wished to "learn something" from the findings of the fieldwork. In response, general thematic descriptions of the study were presented to them. These emphasised the need for teachers to understand individual students' mathematics-related concerns, aspirations and future plans and take them into account when teaching as a way of improving students' willingness to participate in mathematics.

4.6 Summary

Broadly speaking, the methodological choices, decisions, and procedures in this study were framed within the constructivist assumptions of inquiry (Hammersley & Atkinson, 1995; Lincoln & Guba, 2000), which provide a general perspective for the nature of knowledge (or understanding) and how this knowledge could be gained. In this perspective, knowledge is subjective, resulting from the individual's interpretations of phenomena (Lincoln & Guba, 1994). The perspective thus provides general guidance for approaching mathematics students and teachers as subjective individuals in the social context of their school. Interpretive ethnography was chosen as a methodological framework to guide choices of data collection and analysis techniques and decisions about procedures of collecting and analysing data while taking the role of context (the school and classroom) into account (Eisenhart, 2001; Silverman, 2005). Within this framework, the major source of data was the third grade mathematics students in a secondary school in Northern Tanzania. The next two chapters present findings of the study. Chapter 5 presents results regarding characteristics of students' mathematical identity. Chapter 6 reports findings on the role of *Mathematical experiencing* in the development of students' mathematical identity. Names of students associated with the quoted data are pseudonyms used to ensure their anonymity.

5 Results of the study on features of mathematical identities

In this chapter, I present results regarding features that characterised mathematical identities among secondary school students in a Tanzanian mathematics classroom. Due to the excessive amount of data drawn from 37 students with positive and negative identities, I report quotations of data from the 24 most representative students. Mathematics test scores are however presented for all 37 students of the study. Specifically, Section 5.1 consists of features of positive mathematical identities and Section 5.2 consists of negative identity features. These results are summarised in Section 5.3.

5.1 Features of positive mathematical identities

Thematic analysis of students' current and positive mathematical identities was based on the research question: *What features characterise students' positive mathematical identities?* The answer to this question is related to the first main theme of the results. To begin with, three types of positive mathematical identities were identified using the procedure as presented in Chapter 4. Although all these three identities were positive in the sense that students with these identities perceived themselves positively relative to mathematics, there were specific features that distinguished one type from the other. Figure 3 introduces the identities named *Innate ability identity, Persistent effort identity,* and *Image-maintenance identity*.

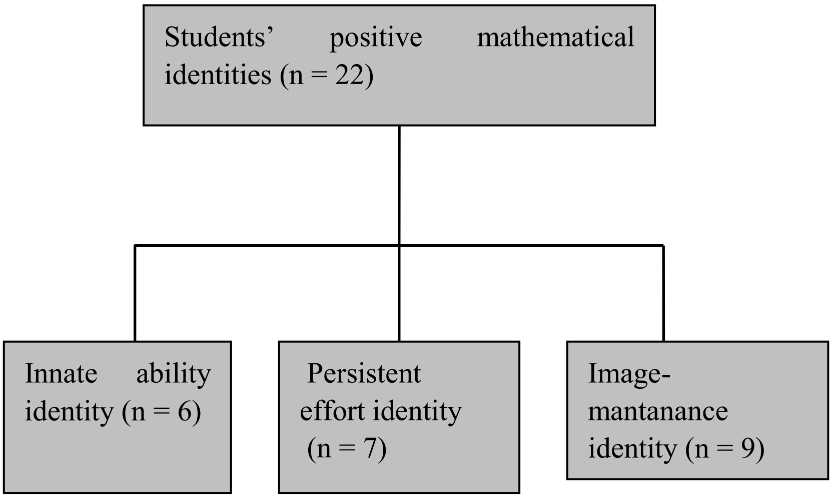

Figure 3. Students' positive mathematical identities

The central characteristic in *Innate ability identity* was the students' perception that they had innate qualities that enabled them to succeed in mathematics. In contrast, the key feature in *Persistent effort identity* was the students' perception that they were capable of succeeding in mathematics through persistent effort. Finally, *Image-maintenance identity* was characterised by the concern among students to maintain their image as individuals who could succeed in mathematics although mathematics was viewed as not important for their future studies or careers. Thus for students with this identity, effort was spent mostly to avoid failure in mathematics tests. These identities and their characteristics are summarised in Table 5. Because of the excessive amount of data drawn from 22 students with positive identity, in the following sections in this chapter I present quotations of data from 18 students with the most representative data except mathematics test scores which I present for all 22 students.

Table 5. Characterization of students' positive mathematical identity

Identity type	Characteristics
Innate ability identity	-Strong self-perceptions of mathematical competence -Mathematical competence viewed as nature-based -Some interaction with others but mostly independent involvement in tasks -Strong ambition for success -Highly committed to learning mathematics
Persistent effort identity	-Strong self-perceptions of mathematical competence -Mathematical competence viewed as resulting from effort -Highly interactive and personally involved in tasks -Strong ambition for success -Highly committed to learning mathematics
Image-maintenance identity	-Strong self-perceptions of mathematical competence -Mathematical competence viewed as resulting from effort -Weakly interactive and less involved in tasks -Ambition mostly to avoid failure -Committed to learning mathematics only to avoid failure

5.1.1 Innate ability identity

Innate ability identity was characterised by students' positive self-perceptions of their competence, independent involvement in mathematical activities with only limited interaction with others in the course of learning mathematics, strong commitment, and strong ambition. As shown in Appendix D, the students had an exceptionally advantaged mathematical background compared to students with other positive identities in that before primary school, all had been taught basic mathematical skills by their parents under strict conditions and had been nurtured by parents who were highly educated and lived in urban or industrial areas of Tanzania. These parents continued to support their children financially and materially in primary and secondary school.

Self-perceptions of mathematical competence

Students' perceptions of the innateness of their capabilities in solving complex mathematical problems were common among students with *Innate ability identity*. Katanga, for example, illustrates the perception that his high mathematical competence was an inheritance.

I really feel that I've great ability in math even the difficult ones. We are mathematicians in my family. My father is a land surveyor and my brother is studying mathematics and physics at university and my sister is an accountant. So I got it from them (Katanga)

As a way of confirming or justifying the 'truth' of having innate mathematical competences, students cited their previous mathematical achievements in which less effort was spent. Edward, for example, referred to his pattern of success from primary to secondary school, which to him indicated nature-based mathematical competence:

I was doing very well in mathematics when I was in primary school and I still do well even now. I don't use too much effort but I usually succeed in examinations. (Edward)

Other students with *Innate ability identity* were more explicit (compared to Edward) about the relationship between mathematical competence and effort. For example, in Kilolo's view, excessive effort in solving mathematical problems was an indication of lack of giftedness in mathematics:

Things like geometry are tough…so you can't just do it without some hard work…I need more time to do it but not too much. I know the principle or how to do it so it should take a short time to get the answer. If you do it for a long time then you're normal person. You've got no talent… (Kilolo)

When more effort and time was needed to solve a mathematical problem, and particularly when mathematical problem solving yielded wrong solutions, students' perceptions of being mathematically gifted were temporarily challenged but relieved after finding a quicker way of solving the problems as described by Katanga:

…sometimes I feel I've a problem because I try to do maths but I don't get correct answers even if I use long time to do that...then I feel I have no gift or have I lost it?...but then I know I'm yet gifted but I do maths in a wrong way or I use too long method...I find the best way then I get the correct answer quickly (Katanga)

In short, the perception of mathematical competence as innate and excessive effort in doing complex mathematics as an indication of a lack of mathematical giftedness was common among students with *Innate ability identity*. Also, previous success in mathematics tests was cited to justify their perceived giftedness.

Self-perceptions of mathematical participation

Students with *Innate ability identity* perceived themselves as less interactive with fellow students but as individually highly involved in mathematical activities. Perceptions of independence formed a distinguishing characteristic of students in this category. For example, for John, studying independently was a way of learning quickly and avoiding boredom.

> *…I can study with someone but much of the time I do maths alone. I can then do much more than when I'm studying in a group…in groups you can talk lots of things and do little maths…I don't like that…sometimes it's boring when some people don't understand fast enough (John)*

These students had previously interacted with peers but had become positioned as providers of mathematical knowledge while receiving not much from their peers, particularly when they paired with students who had lower performance records or seemed unable to understand tasks. Studying independently was seen as a better option.

> *I discuss with someone who don't seem to understand well and asks me what can we do? It means he needs help, so I help…I know more so I need to tell another person about it (Katanga)*

> *They get so much from you and you get nothing at all from them. Last term when I joined I joined a group they keep asking me to teach them something and at the end they only say thank you, nothing else. They depended much on me. Of course I felt good about it somehow but then I gained nothing more…(John)*

However, these students were not completely independent learners of mathematics. For example, when they encountered a problem, they sought support from other 'more capable' students, mostly in higher grades. Many students in this category perceived themselves as less successful participants in teacher-determined pair discussions as they preferred leadership in the discussions. The extreme case was John, who justified his dominance by the perception that as the teacher failed to organise the pairs, it was his (John's) responsibility to manage the discussions. The sense of authority also gave him pleasure.

> *The teacher just asks us to sit in pairs and discuss an exercise but does not say how we need to discuss it so one person must decide how to discuss. When I get a chance to make things happen I feel good... because if you can tell others what to do, you know that you can say something and other people agree (John)*

Lastly, as Edward illustrates, students in this category saw themselves as individuals who most actively interacted with the teacher, that is, as individuals who asked questions to the teacher and responded to the teacher's questions more frequently than other students.

> *Each time if I don't understand something, I ask the teacher...I ask him everyday...if the teacher asks something I answer him quickly...I'm not afraid. Many students just sit back and ignore the teacher but I don't do that…(Edward)*

Students' self-perception as highly engaged and interactive in mathematical activities characterised mathematical participation among students with *Innate ability identity*. However, they preferred studying independently and asked for tutorial support from more competent persons (i.e., the teacher or higher grade students) only when they saw it necessary.

Self-perceptions of commitment to learning mathematics

The students with *Innate ability identity* viewed themselves as having a strong mathematical commitment, that is, a general sense of obligation to learn mathematics. This applied not only to their mathematics activities during school time, but also when they studied mathematics at home or in tutorial classes during holidays, as Kilolo states:

> *…I love maths so I study even in holidays…its just normal at home that so many people get tuition…I paid 1000 shillings [50 cents of the Euro] for one hour last month and they teach for three or four hours in a day (Kilolo)*

Moreover, these students' commitment to mathematics increased as the complexity of mathematical problems increased. For example, when a complex task was left unaccomplished, Edward found it difficult to sleep because of his strong desire to get the problem solved.

> *If I solve an equation correctly, I feel like doing a more difficult one, and if I do but don't get a correct answer or I get a wrong solution I do it again…I do until it's solved well. If I go to sleep without finishing a task I think about it at night and sometimes I wake up early in morning and try to solve it again (Edward*)

In short, students with *Innate ability identity* had self-perceptions of strong mathematical commitment that further were associated with their strong desire to accomplish tasks after getting them.

Self-perceptions of ambition in learning mathematics

The students' self-perceptions of mathematical commitment can be further clarified by analysing the specific aspect of mathematical commitment called *ambition*. Students with *Innate ability identity* described themselves as ambitious in the sense that they set higher achievement goals and strived to achieve them. Edward illustrates this in the following quotation:

> *…I always think about getting a good grade like A, but if I don't get that, I feel that I've failed, then I try to change how to do maths (Edward)*

These students' awareness of their high competence seemed to affect how they perceived themselves in terms of their capability to achieve their achievement goals. They saw themselves as capable of achieving their ambitious goals. For example, although sometimes John failed to realise his highest goals, he continued to set these goals because he perceived himself as capable of realising them:

> *I like to get A even if I know the test is going to be tough…Like last week the teacher asked only tough questions in the test…but I still need A…yes, I know I can get it if I really want but sometimes I don't get it... (John)*

Students also viewed themselves as individuals who could surmount obstacles to succeed in achieving their goals. Such obstacles were, for instance, shortage of books or difficulties in understanding mathematics teachers. Buying books and attending private tutorial classes were some of the ways of tackling these obstacles.

Moreover, these students perceived themselves as highly reactive to their achievement outcomes. They experienced mixed reactions when receiving a worse-than-expected feedback. On the one hand, they viewed themselves as individuals who could be overwhelmed by negative feelings such as experiencing a "shock". Self-perceptions of embarrassment and sadness were also commonly reported among students with *Innate ability identity*, as illustrated by Asha:

> *It's terrible if you fail…I feel difficult if I fail. Sometimes I feel sorry for myself. All my happiness just go away in a short time. It gets bad if you know how badly you did it. I don't like to know it because it makes me feel bad…(Asha)*

On the other hand, these students perceived themselves as individuals who could think about possible causes of their failure in mathematics tests. For example, Edward regarded himself as not the primary cause of failure; he directed his thoughts to the teacher and was suspicious of how the teacher had marked his test papers: In contrast, Asha perceived herself as the primary cause of failure, pointing to her lack of accuracy in working on mathematics tests:

> *I feel very bad of course. I think about it maybe I wasn't careful enough in doing the test or maybe I got it wrong…I thought I knew it but didn't know the correct way to do it…So yes, I think about it (Asha)*

In contrast, students with *Innate ability identity* perceived themselves as experiencing positive emotions after gaining high scores in mathematics tests and recognition by other students after such successes. In particular, joy was the most common of these reported emotions. Katanga describes his case:

> *When I get A, I become happy if the exam was really tough…I feel like showing my results around for all to see… I feel it's ok if marks are pinned on the wall for others to see as well. It's a normal thing to be happy with friends, when others see your good grade…(Katanga)*

These students did not only perceive themselves as individuals who experienced intense positive emotions after achieving good test results, but also as individuals who thought about reasons for gaining their high scores. The students saw themselves as often carefully selecting procedures during a mathematics test and being familiar with mathematical concepts used in the tests. Such aspects were described as reasons for success in mathematics tests. This reasoning is reflected in John's account:

> *I think about what the questions are really asking…then I think about which questions to do...and the way I can solve the problem and to try to get used to them and solve them quickly... (John)*

On the whole, students with *Innate ability identity* perceived themselves as highly ambitious. They described themselves as individuals who set higher achievement goals, pursued the goals, surmounted obstacles, and reacted emotionally but also rationally (i.e., by searching for reasons associated with success or failure) to their achievements in mathematics. These self-perceptions of ambition were consistent with their mathematics test scores that surpassed the average test scores of the students with other identity types. Table 6 presents average test scores for the six students with *Innate ability identity*.

Table 6. Test scores for students with Innate ability identity

Type of test	Average score (in %)
Mid-term test	83.6%
Terminal test	80%
Annual (final) test	78.7
Average score (annually)	78.7

Note: The number of students in this category was 6 (assessment scale ranged from 0% to 100%. **Data source**: School files of mathematics tests scores.

Conclusion

The salient feature of the students with *Innate ability identity* was their overall positive self-perceptions of themselves as successful learners of mathematics. These students cited their previous and consistent successes in mathematics tests to justify their perceived giftedness. They viewed themselves as mathematically gifted, mostly independent learners of mathematics, strongly committed to mathematics, and highly ambitious. These students had the highest mathematics test scores, which further were consistent with their reports of high ambition.

5.1.2 Persistent effort identity

Persistent effort identity represents students' positive self-perceptions of competence, high degree of participation in mathematical activities, high mathematical commitment, and strong ambition. Unlike the students with Innate ability identity, these students perceived themselves as persistently working hard to achieve their mathematics achievement goals. Moreover, the common feature in their background was a limited or lack of mathematical skills prior to primary school. Most of them had lived in rural areas with parents who lacked formal education, and they began learning the basic mathematical skills in primary school. With this disadvantaged background and their strong desire to learn mathematics and other subjects, they learned to spend effort from the beginning of primary school. However, there were variations between these students. For example, before school, Molero learned from his parents how to count cattle in the Maasai language, but Ambrose did not learn anything about counting before school. These similarities and differences are detailed in Appendix D.

Self-perceptions of mathematical competence

Like students with *Innate ability identity*, students with *Persistent effort identity* perceived themselves as mathematically competent. However, instead of narrating innate qualities for high mathematical competence, these students perceived their gains in their mathematics as resulting from their persistent hard work. Rehema, for example, perceived herself as one who always practiced mathematics to increase her mathematical skills. These students also perceived themselves as capable of adjusting their effort depending on the complexity of a mathematical problem. They did not view special innate ability as necessary to solve complex problems but viewed themselves as capable of solving such problems with an increased effort (i.e., more exercises, discussions and seeking assistance from the teacher). Such self-perceptions are illustrated by the quotations from Mariam and Joseph:

> *...people who believe that they were born with ability to do maths, they are wrong. If I believed as they believe I could not be learning maths by now...(Mariam)*

> *If I find say a very hard equation I try myself first, but if it's still hard to get the answer I ask somebody or teacher to help me...or I can take it to my group and then we discuss together. We learn about it together and decide how to work on it. If we get it right, I will never fail to solve equations like this in the future (Joseph)*

Some of these students, apart from perceiving themselves as mathematically competent and as able to increase their competence through increased effort, considered themselves as lacking a home-based mathematical background and parental support. Thus, effort (i.e., individually and asking support from peers and the teacher) was for them the only way to maintain or increase their mathematical competence. Ambrose presented an example of such perceptions:

> *Some [students] are so good because they have been learning mathematics since their childhood. I'm different. My parents are poor. I began to learn maths in primary school...I do a lot of studying and sometimes I ask my fellow students or teacher to help me. I can do a lot of maths and I know I'll be better in the future...(Ambrose)*

In short, students with *Persistent effort identity* perceived themselves as mathematically competent, and their competence, evident in their success in mathematics tests, was the result of their previous effort. They also viewed themselves as capable of becoming even more competent through increased effort and participation in self-organised study groups.

Self-perceptions of mathematical participation

While students with *Innate ability identity* perceived themselves as individuals who studied independently, students with *Persistent effort identity* viewed themselves as those who preferred interdependence. The latter students saw themselves as persons who frequently interacted with others in order to learn mathematics. These self-perceptions correspond to my observations of these students' study behaviour as follows:

> *Unlike the isolated individuals who believe they are naturally gifted, and who can also be seen in classrooms, the school library, or in dormitory rooms during free time, students with equally strong relation with mathematics are very often seen in their study groups of three, five or seven, sometimes more. Each group has a leader—so called "group leader". The leader proposes time and venue for the next meeting and waits for members to agree or disagree. Sharing mathematical knowledge and "teaching" each other are at the core of these groups. Such groups can mostly be seen on campus when there are no formal school sessions—mostly in the afternoons. They are seen in open spaces, under trees, and in classrooms. The groups are permeable—everyone is welcome, including "guests" from the upper grades. These guests are often seen "teaching" in some groups (Field notes based on observations)*

Each student in this category was a member of a self-organised discussion group. The main purpose for joining these groups was to learn from others, share knowledge with them, and work together in solving mathematical problems. The groups were organised, often without teachers' influence, to serve this purpose.

Apart from studying in groups, these students also perceived themselves as persons who sometimes studied individually, and this individual effort was viewed as important. For example, Mariam strongly felt that success in mathematics was not possible without increasing her effort.

> *…anything I do, I do it seriously. Maths is hard and I have to I work harder more than other subjects. If I don't try hard, I can't do well in maths (Mariam)*

Moreover, these students viewed themselves as individuals who shared mathematical knowledge with peers. They viewed sharing of knowledge as important since a variation existed among the students in terms of their mathematical knowledge. For example, students coming from wealthier families attended private tutorials and had to share their mathematical skills with students who could not afford to pay for private tutorials. Rehema illustrates this sharing behaviour in the following quotation.

> *When I come to school I take all papers and books which I get in tuition classes and I give them to my friends in our group. So we discuss them and I tell them how to solve some problems…(Rehema)*

Furthermore, students with Persistent effort identity viewed themselves as active in mathematics classes and as students who often occupied the front space in the room. They described themselves as proactive in asking the teacher some questions and responding to questions posed by the teacher. For example, Rehema stated that:

> *I like to sit in front because I like to hear the teacher better. Students who sit in front are serious. So it's a good place. Sometimes I miss my place so I have to sit maybe in the centre or behind the class, but then I can't hear well the teacher...and it's difficult to ask the teacher…(Rehema)*

In short, students with *Persistent effort identity* perceived themselves as highly involved in mathematical activities and those who during regular classes, actively participated in mathematical activities. Outside the classroom and during free hours, these students viewed themselves as preferring to discuss mathematics in their self-organised groups in which they also shared their mathematical skills.

Self-perceptions of commitment to learning mathematics

Students with *Persistent effort identity* perceived themselves as strongly committed to learning mathematics. In particular, they viewed themselves as individuals who actively engaged in solving problems, mostly in study groups, even after regular classes. Molero exemplifies such a strong commitment in the quotation below.

> *We can do maths in class, but I feel I still want to do more even when we're outside the classroom. So I do maths. I choose a topic which I like then I work on exercises, and feel yes now I've done something... (Molero)*

Second, these students saw themselves as individuals who became more engaged in mathematics, both individually and in study groups, when the complexity of mathematical problems increased, as Mariam states:

> *It is easy for me to do easy mathematics tasks myself first. Then I try more difficult maths like algebra or something like that. Sometimes I cannot do tough maths alone, so I go to my group and we solve together... (Mariam)*

Finally, students in this category saw themselves as not only committed to mathematics at school, but also during their vacation in home environments. For example, as a result of this commitment, Molero had to surmount obstacles in her rural home (e.g., limited time due to too much work) in order to learn mathematics.

> *I'm from a village not a city or town so you may know it's hard to get time and do maths in holidays…I get the feeling to do maths…exercise maths at home so I find time to do it…I get time after work or when others go to sleep…then I can do maths. So yes I do maths even in holiday…I feel that I have to do it during holiday (Molero)*

In sum, *Persistent effort identity* was characterised by students' positive perceptions of high commitment to mathematics both in and out of school.

Perceptions of ambition in learning mathematics

Students with *Persistent effort identity* perceived themselves as ambitious, with a strong desire to attain high achievements in mathematics. This ambition was reflected in their specific mathematics achievement goals. Unlike fixed goals set by the students with *Innate ability identity* (i.e., aiming at an A grade), these students' goals were often flexible, set in terms of ranges. For example, Joseph, being certain of attaining B, aimed to have scores between A and B. Scores below B were an indication of failure for him:

> *I want to get A of course. But many times I don't get it even if I work hard. But if it's possible, B is ok and if it's still possible, I look for A. I won't be happy to get below But… (Joseph)*

These students perceived themselves as individuals who continue setting ambitious achievement goals to increase their mathematical knowledge and who would continue studying mathematics in the upper grades of schooling. Because mathematics in upper grades was perceived to be more complex than in the third grade, the students were determined to gain sufficient knowledge to lay a good 'foundation' for success in the more complex mathematics in the future. Rehema illustrated this concern:

> *At A level, it is very difficult to solve math problems, but I will do it...I know if I work hard now in O level I will have good foundation to succeed in A level... (Rehema)*

Moreover, these students viewed themselves as willing to surmount obstacles likely to impede their efforts to realise their goals. The most cited obstacle was shortage of textbooks, which was tackled through sharing the few books available in the study groups.

> *In our group, everyone likes to share the mathematics knowledge he has…we're like family in our group. After discussion I ask them to let me take a book with me like until tomorrow then I use it…when it's ready I bring it back… (Molero)*

Like students with *Innate ability identity*, students with *Persistent effort identity* perceived themselves as individuals who reacted emotionally and rationally (e.g., searching for reasons) to mathematics achievements. They narrated experiencing joy when mathematics scores had been consistent with their (students') expectations of success, as Rehema narrated below:

> *I feel very happy…it's something nice to get such scores…that's what I worked hard for, so it's like you get the result of your sweat and feel you can do maths. So I really become happy and like more the people who helped me (Rehema)*

This joy was often associated with thoughts searching for possible reasons for the score (e.g., hard work) and the willingness to maintain or improve their future mathematics test scores through increased effort. On the other hand, the students described themselves as persons who experienced sadness and worry and had self-evaluative thoughts after receiving low scores in mathematics tests. Joseph illustrates such experiences as follows:

> *If I get a low mark like 40 or less, I don't like to see it. I feel like oh what have I done? Of course this has happened to me and each time it happens I feel really sad and think much about it, like what to do to avoid it in the future.... (Joseph)*

Despite experiences of sadness or worry after attaining a low score in mathematics, students maintained their self-perception as individuals who did not give up learning mathematics but who instead increased their effort in learning mathematics. They also considered themselves as individuals who sought strategies to improve future mathematics performances and discussed them 'communally' in self-organised study groups as Mariam describes below:

> *When a score is low, it means I have to work harder in order to get a better grade. We discuss this in our group when some of us fail, even if only one person in our group fails we discuss it and always we decide that we need to be more serious and do more work in our groups. We should not waste time talking about other things, we should be more serious in our work... (Mariam)*

In short, *Persistent effort identity* was characterised by students' positive self-perceptions of ambition in learning mathematics. Key features charactering these perceptions included students' perceptions of themselves as individuals who set ambitious but flexible achievement goals in mathematics, who surmounted obstacles, who were able to succeed in mathematics, and who had strong emotional (e.g., joy or sadness) and rational (e.g., reasoning or self-evaluations) reactions to mathematics test scores. These features of ambition—particularly the students' tendency to set ambitious goals—were reflected in their mathematics test scores which on average were higher than those for students with *Image-maintenance identity* but lower than scores for students with *Innate ability identity*. Table 7 presents average test scores among the seven students with *Persistent effort identity.*

Table 7. Mathematics test scores for students with *Persistent effort identity*

Type of test	Average score (in %)
Mid-term test	68.5
Terminal test	64.6
Annual (final) test	63.6
Average score (annually)	67

Note: The number of students in this category was 7 (assessment scale ranged from 0% to 100%). **Data source**: school files of mathematics test scores.

Conclusion

The central feature in the *Persistent effort identity* category consisted of students' self-perceptions of being individuals capable of increasing their mathematical skills and having competence through persistent effort. The self-perception of having innate qualities for solving complex mathematical problems, which was characteristic of students with *Innate ability identity*, was not shared by students with *Persistent effort identity*. Instead they viewed mathematical competence as incremental relative to effort expenditure. In addition, students with *Persistent effort identity* perceived themselves as students who always participated in mathematical activities and who were highly ambitious and strongly committed to learning mathematics. Moreover, they cited their incremental effort-based success in mathematics tests when confirming their positive self-perceptions of mathematical competence.

5.1.3 Image-maintenance identity

Students with *Image-maintenance identity* varied greatly in their pre-school mathematical background. While Agnes, Anna, Kibasa and Rajabu had some experiences of mathematics, Godfrey, Sikitu and Shukuru did not have any mathematical background at the beginning of their primary school. The parents of the former students had formal education and had taught their children basic mathematical skills before primary school. (Appendix D presents background data for each student in this identity category). Additionally, these students had high mathematical commitment and high scores in mathematics tests in primary school and during the first two secondary school years. Although they maintained their positive self-perceptions of mathematical competence in the third secondary school grade, they perceived mathematical skills then as useless to them, in particular, after specialising in arts. Furthermore, their weak mathematical commitment in the third grade (of secondary school) was closely associated with their avoidance of failure. Accordingly, they set their achievement goals mainly for avoiding failure in mathematics tests.

Self-perceptions of mathematical competence

One key feature charactering *Image-maintenance identity* was the students' perception of themselves as capable of solving any kind of school mathematical problem. This mathematical capability was understood as a consequence of effort rather than an innate quality as Anna, for example, remarks:

> *Some people [fellow students] think it's a gift but I don't know why they think like that. I've been good in maths and I can do maths if I want to, but I've no gift. If I do nothing I can't pass any test or exam. So, I must do something, like trying to solve problems, just practise. (Anna)*

Another key feature that distinguished students with *Image-maintenance identity* from students with other positive identities (*Innate ability* and *Persistent effort* identities) was the students' expectation of being perceived by their peers as mathematically competent, even if these students' mathematics test scores had become lower compared to their scores in previous school grades. For example, Kibasa was concerned about how his fellow students, especially those who did not know his background as a higher performer in mathematics tests, viewed him based on his current low scores. Unfortunately, students outside his class (who judged Kibasa's mathematical competence based on test results which, were often pinned on the school notice board) perceived him as a student with low mathematical competence. Only students in his own class knew about his high scores in previous math classes. They also knew that the reason for Kibasa's low scores in the third grade was his concentration on arts. However, Kibasa was not comfortable being viewed by others as a student with low mathematical competence:

> *It's nice if they know I'm good at maths. But students in our school just check how you perform in exams and say like 'she is great or she is stupid'…I usually get D or a bit more because that's what I work for. If I work harder I achieve more, but they don't know that. However, my class knows much about me because I got a lot of high scores in form one, sometimes I was the first or the second best in exams.… They know that I can do maths but am not learning much now because I do Arts.(Kibasa)*

Because of the wish of students with *Image-maintenance identity* to be perceived as mathematically competent, these students were prone to put their effort into mathematics in order to at least pass the mathematics tests and present themselves as mathematically competent persons. Avoidance of a failure in mathematics tests was their primary aim.

Self-perceptions of mathematical participation

Image-maintenance identity was associated with students' perception of themselves as individuals who actively took part in mathematical activities and interacted with others in mathematics learning contexts. However, this applied to them to a lesser degree compared to students with other kinds of positive identity. In practice, based on reports in their diaries, these students' involvement in mathematical activities and interaction varied depending on how close the mathematics examination day was. When the day was near, they increased their effort in learning mathematics. But when the examination day was not close, students selected only the material that was interesting and easy for them to understand. They also were more concerned with copying the teacher's notes than learning the material. Rajabu, for example, focused on topics he liked and could easily understand but used the teacher's notes more intensively when the examination day approached. Such approaches are illustrated in the following quotation.

> *I don't mean I do nothing if there is no test. I go to class because I should keep teacher's notes since I'll have to prepare for exams later. I do then anything the teacher tells to do, like homework or discussion. It's true…I don't struggle if there is no test near. I have learnt what I can learn and leave out anything I don't understand or maybe don't like. (Rajabu)*

Similarly, these students reported having devoted more time for participating in self-organised discussion groups close to a mathematics examination. Anna's discussion group, for example, concentrated on mathematics "a few days" before the test. Otherwise, mathematics was not a priority in the discussion groups.

> *In my group we don't discuss maths all the time, but when the exam is near, yes, we discuss. It's may be a week or just a few days before that we discuss. We try to guess the topics to be included in the test. We look at past mathematics tests and think that those questions cannot be asked again, and we don't practise them.(Anna)*

Moreover, students with *Image-maintenance identity* perceived themselves as students who often selected topics about which they had the teacher's notes. They tended to select mostly easy topics. They repeated the exercises that they had previously done in class, and they read textbooks for revision. Deep understanding of the mathematical content was not the main purpose for these students but rather to gain a minimum pass grade at least. Sikitu illustrates such behaviour in the following quotation.

> *We do many things like we discuss what we copied in class. We practice exercises again, we repeat questions we did in class… Books must be there also because we use them.…there are exercises in the book and we work on them too (Sikitu)*

These students viewed themselves as selective even in doing mathematics tests and also as students who tried to work carefully on the easier items they had selected. For instance, Rajabu, having noticed how examination papers consisted of simple and difficult items, tended to direct his attention to simple items and make sure he did them carefully. That would increase his chances of scoring above F.

> *I do the maths that is simple enough for me. I don't do difficult tasks because I know I can't do them well enough...I use much time in this so that I am able to do them well and pass. It's because I don't like to get F (Rajabu)*

Although students with *Image-maintenance identity* perceived themselves as mathematically competent they considered themselves to be individuals who participated less in mathematical activities and interactions as compared to the students with other positive mathematical identities. Their low mathematical participation was much due to their expenditure of increased effort on arts that in their view would determine their future career and did not require advanced knowledge of mathematics. Even if these students liked mathematics, mathematics was not perceived as having such career-related value among them. Yet, performing sufficiently well in mathematics was necessary for being viewed by other students positively.

Self-perceptions of commitment to learning mathematics

When describing how strongly students with *Image maintenance identity* saw themselves as committed to learning mathematics, they predominantly used words and phrases such as "to some extent" and "less than I was" to describe the degree of their commitment. For example, although Shukuru still liked mathematics, she did not feel as committed as she had been in previous grades. She was more committed to 'arts' subjects:

> *Somehow I think I feel like doing maths but it...in form one…I didn't wait for an exam. I still like mathematics, but I don't have enough time for it. I am in arts, so I study it when I have time, and also when exams are getting close, I do practice more. I spend more time in arts like history and English.(Shukuru)*

When describing self-perceptions related to mathematical commitment, all students with *Image-maintenance identity* compared their present mathematical commitment to that in their past, particularly in the first grade. This pointed to mathematical commitment that had diminished with time. Sikitu, for example, described this pattern in the following way:

> *I strongly felt that I must do this problem or that one. That occurred without having a test or homework. It was just myself who felt it. No one was thinking about arts or science in form one. We were new in the school and we took everything very seriously. In or at the end of form two, we talked much about arts and science…which one is better and which is not… Everyone in class was talking about it, also teachers, and sisters and brothers tried to advise us… I knew I wanted to study arts. So, I no longer like doing maths so strongly… It just changed somehow. (Sikitu)*

Moreover, these students' self-perceptions of mathematical commitment were associated with a strong desire to maintain their image as students who could still succeed in mathematics despite focusing on arts. Agnes' case provided an illustration of such tendency. She also was aware that her commitment to arts meant that she had insufficient time for mathematics. Yet, her eagerness to keep her positive image as an individual who succeed in mathematics persisted as described next.

> *Some people think that if you study arts, it's because you can't do well in maths. I want everybody to know that I am still good in maths…I know it's not possible to get high scores, but it's possible to pass the exams. I don't want to get F, because it means you don't know math at all (Agnes)*

Generally, students with *Image-maintenance identity* reported weak mathematical commitment. Even if they found themselves liking mathematics, they were mostly motivated by their desire to demonstrate to others that they were still competent in mathematics, and they tried to maintain this image over time. Such weakening of commitment was due to their focus on arts and the fact that mathematics was not part of their long-term academic and career plans.

Self-perceptions of ambition in learning mathematics

Image-maintenance identity was characterised by perceptions of ambition in learning mathematics which weakened due to such students' preoccupation with arts. They set less ambitious achievement goals in mathematics aimed at avoiding a mathematical failure. Kibasa provides an example of such views:

> *I thought whether to ignore maths or not, but I chose to also do maths. No, I like it…but I knew that if I abandon maths, I would continue to get F, F, F in all exams. Everybody would think 'Kibasa is so stupid, now he isn't like in the past.' I didn't like that, so I continue to do maths…The bad thing is F, I don't like it (Kibasa)*

These students seemed to collectively think that "a pass" in mathematics, however minimal, in the school leaving certificate would increase the value of the certificate in other people's eyes. This was because mathematics was widely perceived in the school as the most difficult subject, and passing it was indicative of competence in other subjects as well.

Despite the less ambitious mathematics achievement goals, the students perceived themselves as individuals who reacted strongly (emotionally and rationally) to their mathematics test scores. Scoring slightly above F (i.e., above 20%) was associated with feelings of satisfaction as this level of performance was generally within the students' expectations. For example, Shukuru was satisfied with her performance and regarded it as corresponding to the amount of effort she had spent preparing for mathematics tests as described below:

> *I don't need much. I only want to pass the exams. If I get any grade above F, it's ok for me…because I get what I prepared myself for (Shukuru)*

However, this sense of satisfaction did not seem to be associated with any evident reasoning related to the performance. The most expected and targeted grade among these students was D, which corresponded with the amount of their effort and expectation. Scores above D (if achieved) were most frequently associated with surprise rather than satisfaction as those were beyond the students' expectations or did not correspond to their low effort spent in preparing for the examinations. Surprise, sometimes referred to by students as a "shock", was typically accompanied by self-evaluation. Such scores were attributed either to good luck, the teacher's lenience, or the teacher's failure to assess the papers carefully. For example, when Agnes got a C, she reported an experience of "shock" followed by wondering how she got it:

> *That shock has happened to me also. In the beginning of last term, we did a test and I got C. I don't know how I got it… I was lucky or maybe the teacher had not graded my test carefully (Agnes)*

On the other hand, these students perceived themselves as persons who became dissatisfied, disappointed, and embarrassed when they scored F (i.e., between 0 and 20%), particularly when examination results were displayed in public (i.e., on the school's notice board) as Shukuru describes below:

> *I don't like F. If I get it I feel like stupid... It is a shame if my friends see it, because they think I can't do maths at all... Sometimes I feel like I don't want to do maths at all, but then I say, no, I have to study it... (Shukuru)*

These students did not only perceive themselves as reacting emotionally to mathematics test scores but also rationally. In particular, their thinking was directed toward finding out reasons that might have led to a failure and how to avoid that in the future. Rajabu presented an example of such self-evaluation:

> *I think about how I prepared for the exam…or when working on an exam…I think it all happens in the exam... Some questions are tricky, so maybe I wasn't careful enough. I'll become more careful…Yes, when you fail, you, learn something about yourself and you do better in another exam. (Rajabu)*

Generally, *Image-maintenance identity* was characterised by students' perceptions of their limited ambition in learning mathematics. Specifically, these students viewed their mathematics achievement goals as lower compared to the goals they set in previous school grades, and they aimed mostly at avoiding failure in mathematics tests. These self-perceptions of low ambition were, in practice, reflected in their declining pattern of mathematical performances which at the end of the fieldwork were the lowest among students with positive mathematical identity. Table 8 presents average mathematics test scores for the nine students with *Image-maintenance identity*.

Table 8. Mathematics test scores for students with Image-maintenance identity

Type of test	Average score (in %)
Mid-term test	53
Terminal test	38.6
Annual (final) test	32
Average score (annually)	41

Note: The number of students in this category was 9 (assessment scale ranged from 0% to 100%). **Data source**: school files of mathematics test scores.

Conclusion

Image-maintenance identity was characterised by students' positive self-perceptions of mathematical competence. They justified these perceptions by referring to high mathematics test scores in previous primary and secondary school grades. But at the same time, these students perceived themselves as individuals who participated less often in mathematical activities, who had limited mathematical commitment and ambition, and who were mostly concerned with avoidance of failure in mathematics tests in order to be viewed by other students as mathematically competent. These self-perceptions were reflected by a declining pattern of mathematics test scores. In consequence, these findings suggest that positive mathematical identity is not always associated with high mathematical performances. What is additionally needed is students' positive view of the importance of mathematics to their future lives.

5.2 Features of negative mathematical identity

In this section, I present findings to address the research question: *What features characterise students' negative mathematical identity?* Analysis of negative mathematical self-perceptions among students with regard to their mathematical competence, mathematical participation, mathematical commitment, and mathematical ambition pointed to the presence of one type of mathematical identity, which I named *Oppositional identity*. This naming was based on students' views strongly indicating an oppositional attitude toward taking part in mathematics learning.

5.2.1 Characteristics of Oppositional identity

Students with *Oppositional identity,* to some extent, varied among themselves in their mathematical backgrounds. For example, whereas Zuberi, Daudi, and Mapunda had occasionally been taught arithmetic or counting by their parents before primary school, Edwin, Ema, and Mary had not learned such skills (see

Appendix D for more detail). Also, in primary and secondary school, their effort at learning mathematics resulted in little or no success, and ultimately they gave up learning mathematics in the secondary school third grade after specialising in arts. Although they were opposed to learning mathematics at this stage, they nonetheless attended classes because such classes were compulsory. Other features associated with these students’ *Oppositional identity* are outlined in Table 9 and elaborated in the following subsections. The quotations presented in this section are drawn from the 6 (of 9) most representative students with *Oppositional identity*.

Table 9. Characteristics of mathematical *Oppositional identity*

-Negative perceptions of mathematical competence
-Limited interactions and rare or no personal involvement in mathematical tasks
-Lack of ambition to succeed in mathematics
-Lack of commitment to learning mathematics

Self-perceptions of mathematical competence

Self-perceptions of mathematical competence among students with *Oppositional identity* were negative. That is, these students perceived themselves as having low mathematical competence and, more specifically, as lacking a gift in mathematics. Mapunda, for example, illustrates these perceptions:

> *I know you can’t be smart in maths in this school if you don’t have a special thing in your head. You must have it. Its’ not for everyone… People everywhere say maths is so difficult. I agree. I’ve seen it, but life is possible without maths. (Mapunda)[“you” refers to ‘I’]*

The students’ perception of their low mathematical competence due to lacking a gift in mathematics was supported by their parents. They had observed their children’s’ consistently low test scores, and they had explicitly concluded that their children lacked a mathematical gift. This applied, for example, to Mary. She was convinced that she consistently got poor test scores because she had no gift in mathematics as described below:

> *My parents, especially my father, saw my poor score in every report… But it is only in maths and maybe chemistry sometimes. They saw me trying to work hard in mathematics in holidays…and they looked at my exercise books and saw that I was not doing well. My father said that I have no gift in maths….in other subjects it was different… and he said that I should work hard in subjects I could do well… And, yes, I feel my father was saying the right thing because I feel the same way and I do very well in other subjects. (Mary)*

In addition, these students had frequently compared their mathematics test scores with those gained by other students in their class. They had found that their scores were much lower compared to the other students' scores. This further confirmed their perceptions of lack of innate qualities for succeeding in mathematics as Zuberi narrated:

> *I've no gift...Of course, each time I was feeling uncomfortable because my friends always got very high scores even if they did not really work hard like me (Zuberi)*

These students' consistent failures in previous mathematics tests despite their effort had led to their negative self-perceptions of mathematical competence. As a result of these experiences and perceptions, the students had given up mathematics and concentrated in arts subjects, perceiving themselves as being in school only for gaining knowledge in arts.

Self-perceptions of mathematical participation

Students with *Oppositional identity* perceived themselves as individuals who did not willingly take part in mathematical activities or interactions related to learning mathematics. Even though these students attended mathematics lessons as required by the school policy, they perceived themselves as individuals who only pretended to participate in mathematical activities when the teacher was close to them, for example, when he monitored their pair discussions. In practice, this involvement was not genuine but it resulted from students' fear of their teacher. Daudi illustrates such behaviour:

> *The teacher wants everyone to do his exercises. If you don't do it you get punished. So you pretend you're doing but in fact you're not doing it… When the teacher collects the exercise books for marking he sees nothing is done so he just writes a big zero in the exercise book and writes words like POOR or LAZY. But it's ok for me (Daudi)*

Observations of the mathematics class again revealed that often the teacher stood in front of the room when teaching. These were the moments when students' behaviour in relation to mathematics was expressed. As Ema stated, students with *Oppositional identity* used the time to engage in non-mathematical activities, whispered to one another, or remained quiet but without listening:

> *It's always good when he is far. I mean if he is teaching in front of us, we do anything to push time. We talk silently or do homework, or maybe just think about something. (Ema)*

Similarly, these students perceived themselves as individuals who did not really participate in teacher-organised pair discussions. They viewed themselves as persons who always took this time to discuss non-mathematical matters of interest as evidenced below:

> *We talk about anything we like, even if we look like we talk about a teacher's questions or exercises… We can talk about it if he walks near us, but if he's away we talk other things… We have to talk because the teacher wants everyone to talk at that time… So, you can't just keep quiet (Zuberi)*

The key reason why students did not genuinely engage in mathematical activities was the students' self-perception of mathematical incompetence, of not being part of those who can learn mathematics, and of the uselessness of mathematics to their personal lives. These perceptions are reflected in Edwin's remarks, for example:

> *I don't learn maths because I can't do it. But I know that I don't need it because I have Arts, not Science, and I will not choose subjects that have maths in them..I will study Arts like languages.(Edwin)*

In short, self-perceptions in relation to mathematical participation and interactions were negative among students with *Oppositional identity*. They viewed themselves as not individually engaged in mathematical tasks or in interactions related to learning mathematics although they perceived themselves as students who regularly attended classes as required by the school. These students had given up mathematics, and this explains their oppositional behaviour in the mathematics classroom.

Self-perceptions of commitment to learning mathematics

An important feature of *Oppositional identity* was the students' perceptions of themselves as not committed to learning mathematics. In the past (in the first grade), students in this category had experienced mathematical commitment and had perceived themselves as committed. However, with time, the commitment had faded away and their self-perceptions of commitment became negative as Edwin illustrated:

> *When the teacher teaches, I feel like nothing important is going on. I liked maths in form one and I thought of working hard to become good in maths or to be a maths person like Pius [Edwin's friend], but I failed.(Edwin)*

Instead, these students viewed themselves as often experiencing a feeling of resistance or an impulsive desire to refrain from mathematics classes. Daudi experienced this impulse but was required by the school policy to attend classes and remain in class until the classes ended.

> *I have to be in class. It's a must. So, I just sit there with the feeling that I want to go away from maths lessons. But, I must be there till the end of a lesson…I don't like being in maths class because I don't want to learn anything about it, but if you go out they punish you. (Daudi)["you" refers to 'I']*

Some students displayed unwillingness to think about mathematics or even to hear other people talk about it in or out of the classroom. Instead, these students turned their minds to subjects for which they had a stronger sense of commitment. Mary, for instance, often focused on English and History to avoid boredom due to the need to attend a mathematics class and to "learning nothing", as she narrated below:

> *I don't like those lessons or to have math in my head. But it is boring to be in class and learn nothing. What should I do? - I start doing things that make me feel good and not bored…I do English homework or maybe history. These are the significant subjects to me. (Mary)*

Generally, these students perceived themselves as not only lacking mathematical commitment, but also reported resistance toward being exposed to mathematics.

Self-perceptions of ambition in learning mathematics

Oppositional identity was also associated with students' perceived low or lack of ambition in learning mathematics. Clearly, these students viewed themselves as individuals who neither set goals for accomplishing certain mathematical tasks nor thought much about learning goals in mathematics. For example, Mary perceived herself as not one who set mathematics achievement goals or thought about those goals as shown below.

> *Since I became an Arts student I haven't thought like how high I should score in maths. I only thought of it in the past… Now, I only spend my effort in whatever I can do in the examinations. Sometimes I only write my name on the paper and take it back to the teacher. (Mary)*

Instead, students with *Oppositional identity* perceived themselves as individuals who set ambitious goals in other school subjects (Arts) in which they all wanted to excel.

Another feature of self-perceptions of mathematical ambition was the students' view of themselves as individuals who reacted to their low mathematics test scores with indifference (i.e., the "I don't care" reaction), as illustrated, for example, by Ema:

> *No, I don't do maths at all so if I get F it's just ok for me...I don't complain or feel bad...It's because I know I can't pass any math exam. After a maths test I just go out of the exam room and don't think about it.(Ema)*

Among these students, negative self-perceptions of mathematical ambition were accompanied by expectations of failure in mathematics tests and indifference about these expectations as Mapunda remarked in the following quotation:

> *I know I'll fail. Even if you give me a test now I'll get F. So, why should I worry about it? Maths is too tough and I've no gift for it…I don't even need it in my life. So, I don't worry about it. (Mapunda)*

In general, *Oppositional identity* was characterised by students' self-perceptions of being individuals who lacked ambition for learning mathematics, that is, as individuals who did not set mathematics learning goals for themselves. Their negative self-perceptions of ambition were consistent with the mathematics test scores they gained during the third grade. The scores were the lowest compared to students with all other identity types. Table 10 presents average mathematics test scores for the 10 students with *Oppositional identity*.

Table 10. Mathematics test scores for students with *Oppositional identity*

Type of test	Average score (in %)
Mid-term test	11.6
Terminal test	9.2
Annual (final) test	5
Average score (annually)	8.5

Note: The number of students in this category was 10 (assessment scale ranged from 0% to 100%). **Data source**: school files of mathematics test scores.

Conclusion

In the secondary school third grade, the students with *Oppositional identity* perceived themselves as individuals who had low mathematical competence. They confirmed or justified these negative self-perceptions by citing their consistently low scores in previous mathematics tests, which they had gained despite their effort. The students had given up learning mathematics and perceived themselves as not participating in mathematical activities, uncommitted to mathematics, and as students without mathematical ambition.

5.3 Summary on characteristics of mathematical identities

Summary on positive mathematical identities

The research question guiding analysis in this chapter was: *What features characterise students' positive mathematical identities?* The identity features were identified through analysing students' self-perceptions in relation to their mathematical competence, participation in mathematical activities and interactions, mathematical commitment, and ambition. Three different types of positive mathematical identities were identified: *Innate ability identity, Persistent effort identity*, and *Image-maintenance identity*. First, students with *Innate ability identity* perceived themselves as having high innate competence in mathematics. They also viewed themselves as individuals who mostly studied mathematics independently (except in the classroom in which they interacted mostly with the teacher) and who rarely sought support from peers but who helped others succeed in mathematics. In addition, these students viewed themselves as highly ambitious in learning mathematics. On average, their mathematics test scores were also the highest in their class. They viewed themselves as committed to mathematics and generally regarded excessive effort as an indicator of low mathematics competence. They described themselves as individuals who experienced strong positive emotions (e.g., joy) as a result of success and negative emotions (e.g., shame) as a result of perceived low performance.

The most distinguishing feature for students with *Persistent effort identity* was the rejection of the idea that inborn qualities are necessary for success in mathematics. Instead, they embraced the idea that mathematical competence can develop gradually through persistent effort. Thus, these students considered themselves to have mathematical competence that had developed through their own persistent effort. Moreover, they viewed themselves as individuals who frequently took part in mathematical activities and interacted with other students, mostly in self-organised study groups. Their self-perceptions of persistent effort were reflected in their average mathematics test scores, which were high, though not as high as scores for students with *Innate ability identity*. They also regarded themselves as highly ambitious and committed to mathematics, reacting to success with joy and to failure with embarrassment or sadness while thinking about possible reasons for their success or failure.

Image maintenance identity was most distinctly characterised by students' concern with maintaining a positive self-image relating to mathematics. That is, students with this identity viewed themselves as having competence for success in mathematics and they desired that other students perceive them in the same way. Thus despite commitment to arts, these students strived to avoid failure in mathematics tests to avoid being viewed as mathematically incompetent. Moreover, image maintenance identity was characterised by reports of a diminishing degree of involvement in mathematical activities and interactions, low ambition, lack of commitment to learning mathematics, and a decline in their mathematics test scores. However, these students reported emotional reactions such as embarrassment after a failure in a mathematics test.

Generally, these findings suggest the possibility of different kinds of positive mathematical identities, each consisting of distinctive features. This scenario applied especially in the classroom where the teaching approach was mostly teacher-dominated. The findings also reveal that students are able to accurately evaluate themselves with respect to mathematics. They can reflect on their learning and emotional experiences and are also capable of exercising their agency, for example in the form of making choices and decisions depending on specific features of their mathematical identity. More specifically, *Innate ability identity* and *Persistent effort identity* were associated with or even fostered by a future-oriented thinking, to continue learning mathematics in upper grades or colleges and then to seek a mathematics-related career. In contrast, *Image-maintenance identity* was not fostered by students' thoughts of their mathematical future but rather by avoidance of failure in mathematics tests. In particular, these features of *Image-maintenance identity* suggest the idea that positive mathematical identity is not directly associated with higher performances. Rather, perceptions of the importance of mathematics to one's future life acted as a mediator between students' positive identity and their mathematics achievements.

In conclusion, of all the studied mathematical identity components (i.e., self-perceptions of mathematical competence, participation, commitment, and ambition), positive self-perceptions of mathematical competence seemed to represent the core of positive mathematical identity and be a further link to the other identity components. Even when the students were asked to narrate how they perceived their mathematical participation, commitment and ambition, their responses often included perceptions of their mathematical competence (e.g., *I know maths*, *I help others*, *I can succeed in maths*). Especially students with *Image-maintenance identity* tended to perceive themselves as mathematically competent even if they did not view themselves as highly committed to learning mathematics or as mathematically highly ambitious students. Furthermore, the students justified their positive self-perceptions of mathematical competence by referring to their previous successes in mathematics tests. Positive self-perceptions of mathematical competence thus need to be drawn to the centre of analysis of students' positive mathematical identity.

Summary on Oppositional identity

The research question guiding analysis in this section was: *What features characterise students' negative mathematical identities?* Again, these features were identified through a thematic analysis of students' self-perceptions of mathematical competence, participation in mathematical activities and interactions, mathematical commitment, and ambition. Only one type of negative mathematical identity was identified, and it was named *Oppositional identity*. The key feature that made *Oppositional identity* different from other mathematical identities was the students' negative perceptions of themselves in relation to mathematics and their resistance toward school mathematics. Specifically, students with this identity considered themselves mathematically incompetent and unwilling to take part in mathematical activities or related interactions. They described themselves as individuals who attended mathematics classes due to coercion (i.e., compelled by school policy). These students further reported lack of ambition and commitment to learning mathematics. The basis for this was negative self-evaluations based on their previous mathematical performances that were consistently low despite their effort to try and improve them. They reacted to their low mathematics test scores with indifference. Instead, these students had positive perceptions in relation to arts, in which they excelled and were interested.

Lastly, negative self-perceptions of mathematical competence seemed to be the central component among all the studied components of the negative *Oppositional identity* (i.e., self-perceptions of mathematical competence, participation, commitment, and ambition), yet closely related to the other components of this identity. Students referred to their self-perceptions of low mathematical competence even when responding to questions that sought data on other components of mathematical identity. Instances of these responses were: *I know I won't get anything more than F*, *I can't do it*, and *I've no gift*. Moreover, there was no instance in which these students perceived themselves as having mathematical commitment or ambition while also perceiving low mathematical competence. Therefore, self-perceptions of low mathematical competence and a resistant attitude towards classroom mathematics constituted an essential feature of students' *Oppositional identity*.

Overall conclusion and the way forward

The analysis in this chapter demonstrates the existence of multiple student mathematical identities among third grade students in a Tanzanian secondary school. These students also varied enormously in their socio-economic and mathematical backgrounds (Appendix E). Their variation in their previous mathematical experiences is also reflected in the data on features of mathematical identity, in which students frequently referred to such experiences when narrating their mathematical self-perceptions. This reference underlines the need for more systematic analysis of the students' previous experiences to understand the role of such experiences in the development of mathematical identity. Chapter 6 presents such analysis, applying the *Mathematical experiencing* conceptual framework introduced in Chapter 2.

6 Results of the study on mathematical experiencing

In Chapter 5 I reported features that characterise the two identified categories of students' mathematical identities among the Tanzanian secondary school students, which were positive and negative. In this chapter, I focus on the nature (i.e., features) of *Mathematical experiencing* behind the development of positive and negative mathematical identity among the 22 students whose identities were analysed in Chapter 5. In doing this, I apply the term *Mathematical experiencing* as defined in Chapter 2.This term refers to the cycle in which students participate in mathematical activities by solving problems or learning new mathematical concepts individually or through interaction with others (*Concrete experiencing*), followed by reflections and self-evaluations in relation to these activities (*Conceptual experiencing*), and continuing(or discontinuing) with *Concrete experiencing* through the influence of *Fostering factors* (e.g., students' willingness or parental coercion). *Mathematical experiencing,* which causes the development of mathematical identity and generation of mathematical knowledge, also refers to how *Contextual factors* (e.g., teachers, peers, parents, or the nature of mathematical content) shape the cycles of *Mathematical experiencing*. First, I report results on *Mathematical experiencing* for students with positive mathematical identity (in Section 6.1), then for students with negative identity (in Section 6.2). For reasons of clarity, I use italics for the terms in the conceptual frame work of *Mathematical experiencing* as well as for the specific mathematical identities.

The research questions that guided the analysis and findings as presented in this section were:

3. What kind of Mathematical experiencing characterises students' positive mathematical identity?
4. What kind of Mathematical experiencing characterises students' negative mathematical identity?

The aim was to understand the characteristics of students' previous *Mathematical experiencing* and how this *experiencing* influenced the students' views about themselves in relation to mathematics. The findings in this chapter on the narratives of mathematical identity are organised under the three positive mathematical identities, namely: a) *Innate ability identity, b) Persistent effort identity, and c) Image-maintenance identity* and the negative mathematical identity of *Oppositional identity*. Reporting of the results covers three periods of previous mathematical experiences: 1) time before beginning primary school, 2) time during primary school, and 3) time during secondary school for each identified type of mathematical identity.

6.1 *Mathematical experiencing* behind Innate ability identity

As discussed in Chapter 5, *Innate ability identity* was characterised by positive self-perceptions of competence, independent involvement in mathematical activities, limited interaction with others in the course of learning mathematics, strong ambition, and strong commitment. But they also had perceptions of innate characteristics for success in mathematics. In this section, I examine how these features developed through the process of *Mathematical experiencing*.

6.1.1 *Mathematical experiencing* behind self-perceptions of mathematical competence

Home-based Mathematical experiencing behind self-perceptions of mathematical competence

Among students with *Innate ability identity*, the genesis of the sense of mathematical competence seemed to begin at home during their experiencing of basic mathematics. During home-based mathematical interactions between parents and children (*Concrete experiencing*), parents had much influence on their children's self-perceptions of competence in two main ways. First, they taught their children basic mathematics and ensured that these children gained the mathematical skills as intended by parents. Second, some of these parents believed that their children could learn mathematics and later become as mathematically competent as the parents themselves were, and they communicated this belief to their children, influencing them to believe in the same way. Katanga's remarks below represent these experiences.

> *My parents kept telling me that I was very intelligent. They taught me maths and gave me exercises to work on my own. They expected me to do well, but if I did not do well they became angry as they thought I was intelligent enough to do maths well...I was thinking about it. Yes, of course they were right when I think about them now. I see they were right. (Katanga)*

Katanga's narrative also illustrates parental use of coercion (e.g., when his parents shouted at him when he performed poorly) to foster their children's learning of mathematics. The narrative also gives an instance of *Conceptual experiencing*. That is, apart from experiencing parental coercion, Katanga reflected on what his parents told him (especially about his potentially high mathematical competence) and on his progress in learning mathematics. As a result, he began to "somehow" believe his parents.

When these children were in nursery school, they became more aware of their competence in basic mathematics as a result of two important factors. First, these students learned more about their mathematical competences (and other basic skills) through comparing themselves with peers in terms of their mathematical skills and reflecting on the differences. For example, through peer comparison, John came to learn that he was more competent than his peers in his nursery school:

> *In nursery, many children didn't know any writing…like multiplying two and two or three and three, they didn't know, but I knew it. The teacher didn't teach us this. So I could see that I was better than them because I knew how to multiply, divide, add and subtract small numbers. Somehow I felt like teaching them and I taught them just to show that I was better in arithmetic. (John)*

While interacting with peers (a form of *Concrete experiencing*), John observed his peers' performances in basic mathematics, reflected on them and, based on this comparison, evaluated himself as one who could perform better than his peers (*Conceptual experiencing*). This positive self-evaluation about competence in basic mathematics was associated with willingness (a *Fostering factor*) to demonstrate their mathematical skills to other children and to do basic mathematics (e.g., counting). This is also an instance of transition among these children from learning mathematics through parental coercion to learning mathematics through each child's own willingness. Edward gives an example of this experiencing:

> *I also taught other children but I was doing it just to show that I knew much better than them. I liked to count and write some vowels and alphabets and simple sentences and let them see what I was doing. (Edward)*

Parental influence continued to affect these children's thoughts about their competence in basic mathematics also in nursery school. Some parents told their children that they belonged to families that were mathematically talented, which meant that these parents expected their children to demonstrate this talent when learning mathematics. These children thought about their parental views, reflected on their higher mathematical performances in nursery schools compared to their peers, and became convinced that their parents were "right".

In short, home-based *Mathematical experiencing* for students with *Innate ability identity* was intensive enough to influence students to reflect on their mathematical competence and begin to develop positive self-perceptions of this competence. Three key features are noted here. One was the active and regular parental involvement in children's learning of mathematics. Another feature was the belief among parents that their children were mathematically gifted and the communication of these beliefs to their children during interactions. The final feature was the students' interactions with peers in nursery school where they evaluated their mathematical competence based on comparison with peers who lacked such competence. All these shaped the students' development of positive self-perceptions of mathematical competence.

Mathematical experiencing behind self-perceptions of mathematical competence in primary school

Self-perceptions of mathematical competence dominated these students' evaluations already in primary school. Again, one important factor in these developments was the role of parents in influencing their children to view their mathematical competence as innate as Katanga exemplifies in the following quotation:

> *Parents always talked about maths in our family. Even now they talk about it. Like my father said he had gift in maths and science, and he said we had gift in maths as well. I believed my parents because I was the best in class...I mean in maths and science (Katanga)*

In addition to parental influences, like in nursery schools, these students outperformed many of their peers, attaining the highest performance levels with limited expenditure of effort. Thus, students' self-evaluations based on parental remarks of giftedness in mathematics and students' own academic success in school seem to have strengthened their positive perceptions of mathematical competence.

These self-perceptions were also likely to be shaped by the schools' *Contextual factors* consisting of assessment criteria and other evaluation practices. In particular, ranking students in descending or ascending order had caused students to develop a tendency to easily compare themselves with others and reflect on this comparison based on how performances had been ranked. John's case illustrates this:

> *I was the best one in the class. In standard one I was the best in all tests except one when I was the second best. In this test, the problem was that I had overlooked two questions. (John)*

The parental role is again seen in the consolidation of students' perceptions of being gifted in mathematics, which parents did through attributing their children's outstanding mathematical success in school to giftedness as indicated in the next quotation.

> *When they saw I had done very well in science, maths and English they became very happy and said my gift was clearly seen in the reports…they began to say that I would pass the final exam in standard seven just when I was still in standard five…(Asha)*

In short, students in primary school developed strong self-perceptions of being mathematically competent and gifted. Continued parental influence and positive self-evaluations based on peer comparison and on students' high performance in mathematics tests were key factors contributing to this development. These students' *Mathematical experiencing* in primary school favoured the development of their positive self-perceptions of mathematical competence.

Mathematical experiencing behind self-perceptions of mathematical competence in secondary school

Overall, students with *Innate ability identity* had arrived at secondary school with positive perceptions of their mathematical ability and could justify these perceptions based on their high mathematical performances in primary school. This was the basis for students' positive *Mathematical experiencing*. However, students' academic life in the new school environment presented challenges to their mathematical self-perceptions. One of the most challenging *Contextual factors* they faced during the first secondary school grade concerned difficulties in understanding the mathematics content because it was presented (e.g., in books) and taught in English, which was the new language of instruction. Kilolo presented his experience in this as follows:

When I came here somehow I began doubting it…asking: am I really good? Maybe things were too simple in primary school. I thought things like this. The first day in form one the teacher talked English only and I got just few words. I didn't understand anything. After the class I was sad. I reminded myself that my father always says I'm smart…he is wrong. Then I thought again that maybe I don't know much English. I became sure that it was English not maths. (Kilolo)

The use of abstract mathematical concepts in class also contributed to the language-related challenges in the first grade, posing difficulties in understanding mathematics even after being elaborated in simple English by the teacher as John reported:

After completing primary school I thought I knew English very well, but when I came here [to secondary school] I didn't understand so many words, even when the teacher tried to explain them. They were new to me. It was not ordinary English but maybe mathematics English. It was really difficult to learn maths at first.(John)

As John illustrates in the quotation above, learning difficulties resulting from a new language and abstract mathematical expressions (i.e., *Contextual factors*) did not only impede learning of mathematics, but also challenged students with *Innate ability identity* to think more consciously about or even doubt their positive mathematical self-perceptions (i.e., *Conceptual experiencing*).

Another *Contextual factor* that challenged students' self-perceptions of mathematical competence was the teacher in the second grade (who taught all the students who participated in this study). The teacher had created classroom situations that had often complicated learning. For example, the teacher's delays in attending classes and her unwillingness to respond to students' questions constituted an impediment to learning among these students as described by Asha:

The teacher became angry at any time. If you asked a question in class, she became angry. Sometimes she answered a question just in short, but other times she didn't answer at all. If you go to her office and try to ask for more teaching, she just looked at you and said nothing, or she just said 'ask your friends. Sometimes she came to our classroom late and gave us homework and that's all. (Asha)

Despite these challenges, students maintained their positive mathematical self-perceptions through reflecting on their success in mathematics tests in previous school grades and on their parents' perceptions of their high mathematical competence. Based on these reflections, positive mathematical self-perceptions and willingness to succeed in mathematics, these students exercised their agency by withdrawing their reliance on the teacher as an important source of mathematical knowledge. They sought other alternative ways of learning mathematics such as attending private tutorials, studying independently and seeking assistance from students in upper grades. This applied, for example, to Edward:

> *I did a lot of math exercises on my own every day as I had my own books. I already knew the topic that the teacher taught. It was like a revision for me. Some problems were really difficult, so I asked A level students to show me how to do it.(Edward)*

In these alternative ways, the students continued to gain high scores in mathematics tests and maintained their positive mathematical self-perceptions.

Generally, for students with *Innate ability identity*—and also for those with other mathematical identities—*Mathematical experiencing* in secondary school was clearly more challenging compared to their *Mathematical experiencing* in primary school. Yet, due to these students' positive self-perceptions of their mathematical competence and optimism, accompanied by their exercise of agency to overcome the challenges by finding alternative ways of learning mathematics, enabled them to continue excelling in mathematics. Such experiences, together with continued parental support, consolidated these students' perceptions of being mathematically competent and gifted.

6.1.2 *Mathematical experiencing* behind self-perceptions of mathematical participation

Home-based Mathematical experiencing behind self-perceptions of mathematical participation

Innate ability identity was characterised by students' intensive involvement in concrete situations of mathematics learning at home where parents played a key role. Parents were the key contextual factor in these home environments. They initiated and maintained *concrete experiencing* (e.g., interacting with parents around mathematics) to help their children learn mathematics. This *concrete experiencing* was initially fostered mostly by parents' authoritarian behaviour, for instance, of coercing their children to learn mathematics. Asha presents an example of such experiences:

They [parents] wanted me to do all sums well and get them all. I tried hard to get everything correct before I sent my exercise book to them. If I got only one of them right, they didn't like it. It was hard sometimes when the sums were difficult. Dividing was my biggest problem. So it was hard if all exercises were about division. (Asha)

Although these children's initial and regular mathematical interactions in home contexts were fostered by parental strictness, they came to learn the benefit of such interactions later. They gained elementary mathematical skills and became aware of this knowledge. Because of this, they appreciated the interactions as Asha and Kilolo narrate:

Life was tough because they punished me if I didn't do well…but then, I knew a lot of things before I went to Mwenge primary (Asha)

I thank my parents for helping me so much when I was a little child. I was thinking they were not nice or just bad people but feel like this now. I do very well in maths and science now.(Kilolo)

Students with *Innate ability identity* entered nursery school at the age of five or six. Mathematics learning in these schools was not emphasised. Unlike parents who were strict and close to their children ensuring that their children learned elementary mathematics, nursery school teachers were not strict, nor did they interact with students closely during classes. Katanga illustrates this experience next:

The teacher at school was not strict like my parents. You could be wrong or right, but the teacher didn't shout at you if you did something wrong. I guess she didn't even know my name. But we played a lot because the teacher wanted everybody to play. We were many with only one teacher, so we didn't do much maths or reading. (Katanga)

On the whole, students with *Innate ability identity* had been exposed to mathematics from childhood. Parents had played a key role in orienting their children to mathematics and other school-related basic skills through creating home environments in which their children were taught mathematical skills, often under strict conditions. Even if students later attended nursery schools, home-based mathematical participation and learning continued.

Mathematical experiencing behind self-perceptions of mathematical participation in primary school

Mathematics related interactions and learning in the schools which students with *Innate ability identity* attended had been limited due to the size of classes. For example, in a class of over seventy students, Edward felt that he did not adequately learn because of limited interaction between the teacher and students.

> *Our class was very large. I think we were like 70 or maybe 80 and only one maths teacher… and the same teacher taught other subjects like English…so... I didn't learn much in class (Edward)*

Because of large classes and a shortage of teachers, teacher-centred approaches emphasising the teacher's authority and limiting peer interaction had dominated class instruction. In these circumstances, mathematics learning depended on students' own willingness to learn by listening to their teachers and trying to do assigned exercises. With parental support and a home environment that was conducive to learning, students maintained their high levels of performance as Asha illustrated:

> *I listened carefully to the teacher and it wasn't difficult for me to know what the teachers were teaching. So I did a lot of exercises at home and my parents were also teaching me. (Asha)*

In short, students with *Innate ability identity* had limited opportunities to engage in *Concrete experiencing* (i.e., to engage in mathematical activities and interact in mathematics learning) in primary school, yet they had already developed their own willingness to learn mathematics. These students maintained their higher levels of performance in mathematics because of their parental support and their own willingness (rather than parental coercion) that fostered their striving in mathematical activities.

Mathematical experiencing behind self-perceptions of mathematical participation in secondary school

In the first grade of secondary school, students with *Innate ability identity* (like other students in the third grade) experienced challenges in a new school environment which impeded their progress in learning mathematics. First, the problem of the strangeness of the language of instruction (English) and abstractness of mathematical concepts (as mentioned earlier in this section) motivated students to increase their language skills by learning English individually and practicing English language usage with upper grade students. An example of such strategy is exemplified by Kilolo:

> *In every class I wrote difficult words in my notebook, then after class I went to the library and used the Swahili/ English dictionary and I used to write meanings of the words in my notebook then I read again and again until I understood the meaning. I also tried to speak English with my roommate who was in form five. He was learning arts so he knew English very well. I was lucky he was there. We talked and he was teaching me new words. (Kilolo)*

In other words, *Mathematical experiencing* (both *Concrete* and *Conceptual experiencing*) was obstructed by incomprehensible mathematical expressions mostly due to insufficiency of English language skills. To succeed in mathematics, these students first surmounted these obstacles and then intensified their mathematical participation to gain mathematical knowledge.

Second, *Mathematical experiencing* among these students was set back in the first grade by lack of learning materials such as books, notebooks, and mathematical sets. Their schools had a shortage of these. To solve this problem, students sought help from their parents to buy the materials with the understanding that these materials would help them learn mathematics easily and enhance their mathematical skills. Katanga gave an example of such experiences:

> *The first time when I got problems in math, I began to think about what to do. I saw that the school had not enough books; there were no calculators; no mathematical sets. Only the teacher had his own maths set. I saw there were only four dictionaries in the library and I felt very bad. I told about this to my father and very soon I got them. (Katanga)*

Third, *Mathematical experiencing* for these students was mostly characterised by students' independent involvement in mathematical activities, attendance in private tutorial classes (during school holidays) and seeking assistance from parents or upper grade students to help them learn difficult mathematical problems. This learning behaviour was more intensive in the second grade (in secondary school) when these students lost their confidence in their mathematics teacher's ability to teach mathematics.

Another *Contextual factor* (apart from the grade two teacher) that influenced students to intensify their *Mathematical experiencing* was subject specialisation. At the end of the second grade, students were required to study either "science"(e.g., Physics, Mathematics, Chemistry and Biology) or "arts" (e.g., History, Civics, and languages) subjects. Specialising in science, which students in this category did, meant that students had to evaluate themselves regarding their competence in the specialised subjects, particularly competence in mathematics, which was generally perceived as a key subject because of its application to other science subjects. Asha illustrates this aspect:

> *When you choose to do science it meant that maths is part of it. So we knew that subjects like physics or chemistry, or even geography needs maths. You need to be good in maths if you want to do science. We all knew this because we talked about it. So, if you can't do maths, you can't do science. And if you can't do science you choose arts. ... I made my choice to study science. So I must study maths. (Asha)*

In short, these students as empowered by their positive mathematical self-perceptions, engaged in mathematical activities mostly independently (i.e., with limited interactions with peers in their mathematics class). When faced with complex mathematical problems that they could not solve on their own, they sought assistance from individuals they considered more capable than these students themselves were (e.g., upper grade students and teachers). The students also more independently sought ways to overcome *Contextual factors* that challenged their learning of mathematics. Because of these experiences, these students regarded themselves as individuals who mostly studied mathematics independently.

6.1.3 *Mathematical experiencing* behind self-perceptions of mathematical commitment

Home-based Mathematical experiencing behind self-perceptions of mathematical commitment

During home-based *Mathematical experiencing*, mathematical commitment (i.e., a general and rather long-term sense of obligation for learning mathematics) was not evident among students with *Innate ability identity.* At these initial stages of learning mathematics, the most important *fostering factor* was parental coercion, not children's mathematical commitment, as illustrated by Asha:

> *They forced me...I think I had no idea what maths is, but my parents forced me to learn everyday...I then began to know, bit by bit.(Asha)*

Later, these students began to like mathematics and wanted to learn mathematics even without parental coercion. Katanga recalls such experiences in the following quotation:

> *I felt good when I began to know how to add or subtract numbers. Yes, I liked maths and also other things like reading and writing, but I liked maths more. I wanted to do maths again and again. Parents made me know maths and taught me, but I did maths even when I was alone at home.(Katanga)*

This liking of mathematics and willingness to learn developed further as students engaged more in *Concrete experiencing* (learning mathematics often under parental pressure or coercion) and *Conceptual experiencing* (reflecting, self-evaluating and gaining mathematical knowledge) as Asha narrated:

> *Of course I wanted to learn. This was in my heart. But perhaps my parents wanted me to learn more quickly. (Asha)*

These students' mathematical engagement was initiated by their parents' coercion during home-based interactions. But, when they became familiar with mathematics and began to gain mathematical knowledge, they began to like mathematics and were willing to engage in mathematical activities even in the absence of parental coercion. This can be considered the beginning of their mathematical commitment.

Mathematical experiencing behind self-perceptions of mathematical commitment in primary school

In nursery school and the early years of primary school, students with *Innate ability identity* were fostered mostly by their own *liking* of mathematics and willingness to take part in mathematical activities and interactions. Their strong *willingness* to know mathematics was evident as described by John:

> *For example, when I was in standard one and two, and even in standard three, I felt that maths is good and I liked to do it again and again, even at home. That push was there in me, but I didn't think about. I had a feeling that I really wanted to do it even if the teacher gave no homework. (John)*

As John narrated, strong willingness characterised their mathematical engagement from the earliest grades of primary school. For most of the students, the first grade seemed to mark the beginning of mathematical commitment, which became more evident at the beginning of the fourth or fifth grade. This commitment had resulted from previous success in mathematics (i.e., at home and during the early years of school) and the students' self-perceptions as mathematically competent as well as from their desire to maintain their success in upper grades where mathematics became more complex. Asha offers a typical experience of this:

> *I felt that I was good in math. But something it happened. ...I mean maths was getting tough and I wanted to be still good in it. I had the feeling that I must study it and keep my position…I liked maths, but this feeling to perform well was in me all the time. I knew it was up to me to do well. (Asha)*

Overall, the sense of commitment was founded on the students' positive perceptions of themselves as mathematically competent and also on their liking and enjoyment of mathematical problem solving. Both had been developed and still were shaped by their parents and supportive home environments.

Mathematical experiencing behind self-perceptions of mathematical commitment in secondary school

Students had arrived at secondary school with a strong sense of mathematical commitment. This sense of commitment had been associated with positive self-perceptions of mathematical competence as described by Kilolo:

> *It's like when you know you're very good in maths, you feel like wanting to do it every now and then if there is time. You do it even if the teacher doesn't ask you to do it. It's because you feel maths is yours and you like it. That happened to me and is still happening. Of course, sometimes you do it because of exams. (Kilolo)["you" refers to 'I']*

This sense of mathematical commitment was challenged by similar *Contextual factors* that challenged their perceptions of mathematical competence, namely, the abstractness of mathematical concepts, shortage of learning materials (especially books), and a difficult teacher in the second grade. The students' strong mathematical commitment was demonstrated when they sought ways of surmounting these obstacles (e.g., by studying independently, attending private tutorial classes, and seeking assistance from parents and senior students) in order to maintain their high performances in mathematics (these obstacles and how students surmounted them are detailed earlier in this section).

In general, the students' mathematical commitment developed at home and in primary school was strong enough to enable these students to overcome *Contextual factors* that could impede their learning of mathematics and they continued to maintain their status as high mathematics performers. But this commitment was also supported by their positive self-perceptions of mathematical competence.

6.1.4 *Mathematical experiencing* behind self-perceptions of mathematical ambition

Home-based Mathematical experiencing behind self-perceptions of mathematical ambition

The home-based context was an environment in which students with *Innate ability identity* began to develop their early sense of ambition while taking part in arithmetic activities, reflecting on these experiences or evaluating themselves through comparison. They had developed an idea of academic achievement goals and also had learned to set them. However, their goals were not clear or specific but had often been based on competitiveness. Typically, learning arithmetic was associated with outperforming others on a task. For students like Kilolo, home was an environment where setting of targets to outperform others was developed when parents encouraged competitive behaviour and became 'judges' during competitions as illustrated next.

Sometimes I competed with my sister. If we got an exercise, everybody wanted to do better than other. I mean it wasn't so serious, that's what we did…Maybe we had goals, but we didn't say 'ok now I must get A and I must be number one.' I just simply tried to get higher scores or to draw something quicker than my sister… My father was a kind of a judge because he said or announced who did better, So we competed with each other.. .(Kilolo)

Some parents had set performance goals for their children when teaching them. For example, in an effort to support Asha in learning basic arithmetic skills, her parents had set challenging targets for her, for example, to complete tasks without making a single mistake. Although this created difficult moments for Asha, particularly when she was forced to attempt exercises that were too difficult for her, she had apparently learned to be ambitious in setting her own goals.

Even though achievement targets had not always been specific, these students had appraised themselves based on their performance outcomes. The students had experienced joy after succeeding in mathematical tasks. On the other hand, they reacted with negative emotions to perceived low performance. These responses were consistent with their parents' emotional reactions as Asha and Kilolo recall in their diaries.

If I did well, especially if the test was difficult, they showed happiness and they made me feel like somebody who's important. They also gave me something like a new pencil or eraser. I became happy because I knew they would give me something, but I didn't guess what they would give me. (Asha)

They were not good people to you if you did an exercise badly… Sometimes I was afraid of them, especially of my father. They were angry if I did badly. They shouted at me.(Kilolo)

The students had learned to associate performance with achievement goals in home-based mathematical learning situations and to value the importance of striving for realising achievement goals.

Mathematical experiencing behind self-perceptions of mathematical ambition in primary school

The perception of having innate characteristics for success in mathematics strengthened these students' ambition during primary school. They had individually set goals that increased their involvement in mathematical activities. They often had aimed at outperforming others in terms of mathematics test scores, and this was supported by their parents. Kilolo, for example, had a strong ambition to lead the class in mathematics. His goal, also shared by his father, had been to gain the best mathematics test scores.

> *I was only dreaming of being the best one…wished to be the one who is better than anyone in maths and English in our class. I thought about getting the highest score in maths. I knew I could it. Especially in standard seven I was more than happy when I had beaten the whole class. My father liked this too and he kept telling me to do better than anyone. (Kilolo)*

Also, these students particularly in the seventh (i.e., the highest) grade aimed at excelling in the nationally organised final examinations that would increase their chances to be accepted in the best secondary schools in the country. Katanga presented an example of this ambitious goal.

> *I wanted to pass maths and do other subjects very well because I wanted to go to the best secondary school and do more maths and science. The best secondary school accepted easily students with very high grades in maths and science, and I wanted to get there.(Katanga)*

These students consistently set targets characterised by competitiveness, which their parents supported. Ambitiousness in terms of attaining higher scores and being the best students in class was maintained throughout the primary school period. Furthermore, ambition among these students was still associated with strong emotional reactions to success or failure in mathematics. Gaining a higher or highest grade in class resulted in positive emotions such as joy or strong sense of triumph, whereas getting bad test scores or grade resulted in negative reactions such as sadness or embarrassment. Unsuccessful achievement had also often provoked anger among family members which sometimes made students victims of parental anger as John narrates:

They all [parents] got disappointed. They didn't believe what was stated in the report and they asked me why I failed. Whatever I said they didn't want to hear it. One day my father slapped me because I had got C in maths and B in science. He told me not to fail again. I knew I had failed. (John)

However, strong emotional experiences *fostered* the students to maintain high mathematics performance levels by exercising *agency* for improving their scores when needed. But students' strategies to maintain or improve their performances mainly constituted doing more mathematical exercises as illustrated by Katanga.

You've got to cool down if things went bad. I mean when you overcome anger or shame or something like that, you think about how it all happened. But didn't think as thoroughly as now but just aimed to exercise more and do better next time. (Katanga)

Mathematical experiencing behind self-perceptions of mathematical ambition in secondary school

During the first grade in secondary school, these students experienced difficulties due to having to learn mathematics in a new language (English), facing abstract mathematical expressions they did not clearly understand, and due to a shortage of learning materials. In the second grade, these students experienced difficulties in interacting with their mathematics teacher. But despite these challenges, students with *Innate ability identity* sustained their sense of ambition in mathematics. They continued setting challenging goals and committed themselves to them even if mathematics was becoming more complex as Kilolo recalled:

When I got into problems, like when I wanted to get A in maths, I worked hard and really got it. I knew that I could do well in maths in the future as well.... Maths in form three is very tough and I know also this time that it is tough. So I have to be sure of myself. (Kilolo)

Even during moments of challenges or threats to self-perceptions of mathematical competence, the students' reactions to success or failure were similar to their previous *Mathematical experiencing* (e.g., in primary school). That is, success in achieving the goals (i.e., a high score in a test) resulted in experiences of joy. Failure to achieve the goals instead resulted in feelings of sadness or embarrassment. Katanga, for example, reported such experiences as quoted below:

> *When I did well I felt good. It was like 'I've managed it,' but this did not happen often. I got sometimes very low marks and I didn't like them. I felt shameful and really very bad in my heart.(Katanga)*

These students' ambition was further reflected by an incremental pattern of average performances in mathematics tests (i.e., test scores increased over time). Students with this identity scored in secondary school mathematics an annual average of 70.7% in the first grade, but in the third grade their score increased to 78.7%.

6.1.5 Conclusion on Mathematical experiencing behind Innate ability identity

Overall, through *Mathematical experiencing*, students with *Innate ability identity* did not only gain mathematical knowledge but the process also positively shaped their self-perceptions of mathematical competence, participation, commitment and ambition. The process consisted of their engagement in *Concrete experiencing* (involvement in mathematical activities) and *Conceptual experiencing* (e.g., reflecting and self-evaluations). At home, the process was first *fostered* mostly by parental *coercion*, then also by students' own *liking* of mathematics and *willingness* to learn mathematics. The role of parents was crucial in orienting these students to learning mathematics even before they began school.

Along with the development of their mathematical identity (mostly in secondary school), ambition and agency became important *Fostering factors* for the students' mathematical experiencing. *Agency* was exercised, for example, when students made their own decisions on how to maintain their success in mathematics when experiencing difficulties in the first and second grades in secondary school.

Contextual factors constituted an important factor in affecting these students' *Mathematical experiencing* and identity development. For example, the availability of evaluation criteria (e.g., grading scales) in school was useful for these students' evaluation of their mathematical performances. Peers formed another important *Contextual factor* for comparison and self-evaluation. In their secondary school third grade, the students also justified their positive self-perceptions of mathematical competence with reference to their previous high performances in mathematics test scores, which seemed to uphold these perceptions.

6.2 Mathematical experiencing related to Persistent effort identity

As discussed in Chapter 5, *Persistent effort identity* was characterised by positive self-perceptions, active interaction with others while learning mathematics, and strong ambition and commitment to mathematics learning. In particular, students with this identity perceived themselves as individuals who could succeed in mathematics through persistent effort. In this section, I analyse *Mathematical experiencing* at home, in primary and secondary schools influencing these perceptions and the development of *Persistent effort identity*.

6.2.1 *Mathematical experiencing* behind self-perceptions of mathematical competence

Home-based Mathematical experiencing behind self-perceptions of mathematical competence

For students with *Persistent effort identity*, home-based *Mathematical experiencing* and development of self-perceptions of mathematical competence were weak or nonexistent. Of the seven students with *Persistent effort identity*, only three had gained home-based elementary mathematical skills prior to primary school; the rest began to gain such skills in primary school. Although the elementary mathematical skills learned at home were practical and intended for use in the students' daily lives, they (skills) formed a useful background for primary school. For example, Molero's parents, living in a rural environment, provided Molero with counting skills for counting cattle in a native language (Maasai). These skills later turned out to be useful in learning basic mathematics in primary school as described below.

> *They [parents] have a lot of cows. They can't read or write but they can count. ...My father taught me how to count in Ki-Maasai when I was very little. I knew how to count cows and to count money, but I didn't know how to count in Swahili or English. So when I began primary school I had to learn counting in Swahili and to write numbers in Swahili. I learned quickly because I knew counting. (Molero)*

Similarly, students who lived in urban areas had gained elementary mathematical skills relevant to their family's home-based economic activities. Materu, for example, had grown up in a city and had gained skills intended for her family's economic activities. But these skills enabled Materu to learn mathematics in primary school as she remarked in the quotation below.

> *Our home is in Tabata in Dar es Salaam. My mother had a small shop and we sold things like clothes, soap, fruits, vegetables, drinks and bottled water. This was too much for my mother, so she needed my help… When I was six she taught me to read and write in Swahili how to count money and how to keep information about things we sold and the prices. It was hard at first but I did it. (Materu)*

These cases suggest that although the students' experiences of learning basic mathematical skills varied depending on parental purposes and home location, they formed an important foundation for learning school mathematics. Another common feature was that these three students did not have a chance to evaluate and perceive their mathematical competence prior to primary school because they did not attend nursery schools where they would evaluate their mathematical skills and competence based on peer comparison. Furthermore, parents did not play a strong role in these children's learning of mathematics or in influencing their thinking about themselves.

Mathematical experiencing behind self-perceptions of mathematical competence in primary school

The perceptions of mathematical competence among all seven students with *Persistent effort identity* had arisen in early primary school while students' with different home backgrounds evaluated themselves against their peers' performances. With time, particularly in the beginning of the fifth grade, students had become more concerned about their success in mathematics, and self-appraisal of mathematical competence had become important. Mariam described this change in the following quotation.

> *I wasn't the best student in my class but I knew I was good. Yet, I thought about it especially when I was in standard six. It's because I wanted to do better in all subjects. This is the time when I was really working hard in maths and English, because I knew that these were the hardest subjects. So I worked hard to know them well. My dream was to go to secondary school. (Mariam)*

The most important source of their positive mathematical self-perceptions was their effort and the resulting high achievement outcomes. Students also enhanced their consciousness about their mathematical competence by comparing their mathematics test scores with those of others in their classes. But, as Joseph indicated, this tendency had not been a powerful source of perceived competence in mathematics.

> *I wanted to see how others did in tests, but it didn't matter if I did better than others. Some students used to congratulate to me when my achievements got better. I knew I was rising in their eyes, but it was not so important if I did better than others. I was indeed happy when I began to get better marks and more attention from the teacher. (Joseph)*

In short, students had begun to be aware of their mathematical competence during their early grades, but these thoughts strengthened as they moved on to upper grades of primary schooling.

Mathematical experiencing behind self-perceptions of mathematical competence in secondary school

Students with *Persistent effort identity* faced challenges to their mathematical self-perceptions and views of mathematics in secondary school due to the nature of teacher-student interactions in the classroom and their individual involvement in mathematical activities. One source of these challenges was the use of English as a new teaching language. As with *Innate ability identity* students, students with *Persistent effort identity* had insufficient English language skills and thus were unable to understand first grade secondary school mathematical concepts. Because of this, Joseph had doubted his mathematical capabilities as quoted below:

> *I learned English in primary school but it wasn't like in here. The teacher talked quickly and it wasn't clear at all. I was worried because I was thinking that maybe I can't learn maths any more. Perhaps I was not good even if I had passed primary school exams.(Joseph)*

This problem had arisen at a time when achieving higher than in primary school was of great concern to the students. Moreover, insufficient learning materials (e.g., mathematics books) and lack of parental support impeded students' learning of mathematics in the first secondary school grade. But compared to students with *Innate ability identity*, these students approached these challenges differently. They formed study groups and regularly participated in them as narrated by Ambrose:

> *I was in the group that Luca [a group leader] formed and it is still there. We worked hard together and we helped each other…It was not only about maths but other subjects as well like English, biology and physics. (Ambrose)*

These groups were useful. As a result of working on mathematical tasks that students had assigned to each other and using other forms of peer support such as helping weaker students or sometimes inviting students from upper grades to "teach" them, these students began to see increased improvement in their mathematical performances. Rehema illustrated such progress in the following quotation.

> *It was becoming easier to understand maths in the classroom because English was becoming better and I began to understand the language of maths. When I joined the group it was so difficult for me. Now we had come to know each other well and it's better. My grades were beginning to be good. I began to know that I am good in maths if I work hard and use groups. (Rehema)*

However, another problem emerged in the second grade, consisting of a new mathematics teacher who was uncommitted to teaching, easily irritable, and unclear when teaching. Also students with *Innate ability identity* experienced this problem, as presented in Section 6.1. Instead of seeking individualistic strategies in tackling the problem (as students with *Innate ability identity* did), students with *Persistent effort identity* mostly counted on their study groups to improve their learning as reported by Molero:

> *By then we had discussion groups. So we discussed math and other subjects in groups. That was the best way to refrain from failing. Sometimes we invited students who new better than us and when they came, they taught us the difficult topics. (Molero)*

When these students entered secondary school, they already had positive self-perceptions of mathematical competence gained through self-evaluations of success in mathematics in primary school. They also understood that their mathematical competence resulted from their persistent effort and that with more effort expenditure, they could still increase their competence in secondary school mathematics. These self-perceptions and views were challenged when these students experienced difficulties. They could yet strive to overcome these challenges mainly by participating in self-organised study groups. The resulting success (i.e., higher test scores) consolidated these self-perceptions and the understanding of the link between effort and success.

6.2.2 *Mathematical experiencing* behind self-perceptions of mathematical participation

Home-based Mathematical experiencing behind self-perceptions of mathematical participation

Of the seven students with *Persistent effort identity*, three had gained basic arithmetic skills prior to primary school. As pointed out in the preceding section, although these skills were not meant to enable students to succeed in school, they formed a background that enabled them to learn primary school mathematics easily. One distinguishing feature in the parent-child interactions among these students was the teaching of basic arithmetic using a less strict, coercive approach compared to parent-child interactions among students with *Innate ability identity*. Molero describes this experience:

> *No, they didn't force me but just taught me. I come from Longido and my parents live there. They have a lot of cows. They can't read or write but they can count. Counting is important because you have to know if all the cows have come back from the fields and sometimes we sell cows or meat or milk... My father taught me how to count.(Molero)*

Another feature, also illustrated above by Molero, is that children were able to learn the meaning of arithmetic expressions later because the teaching of arithmetic skills was grounded on the use of such skills in day-to-day life.

In these home contexts, *Mathematical experiencing* among students with *Persistent effort identity* was less intensive (i.e., had limited content with less frequent interactions) compared to *Mathematical experiencing* among students with *Innate ability identity*.

Mathematical experiencing behind self-perceptions of mathematical participation in primary school

In the beginning of primary school, there was a slight difference in the way students with *Persistent effort identity* adapted to school life. For some students, mathematics content had been somewhat familiar due to learning some of the skills at home. Ambrose and Molero had not experienced significant difficulties in their first primary school grade as Ambrose recalled:

> *It was strange how teachers were teaching…things like punishment were completely new to me. Yet everything the teacher taught was familiar to me. So I didn't have much to do. But many didn't know as much as I did and they had to work hard in order to learn. The teacher discovered that we knew so much of what he taught. So he asked us to help others who got problems. (Ambrose)*

However, for other students the primary school stage had been unfamiliar since they had not gained the elementary skills at home. But they learned the skills quickly because the students' had strong *willingness* to learn them, although the strictness of the teacher may also have influenced this as Sifuni reported:

> *The teacher was strict. If you got anything wrong she shouted at us or sometimes she beat us with her small stick. So I worked hard…first the numbers and alphabets, then writing simple sums and sentences. I worked hard because I liked it, but the teacher also forced us to work hard. I also practiced at home the things we did at school. I learned quickly, and in the middle of the year I could do simple arithmetic. (Sifuni)*

Another reason for learning the skills quickly was to catch up with students who had gained similar skills at home or in nursery school. During the first three years of primary schooling, the differences in basic skills had disappeared. However, the curriculum for mathematics and other subjects was becoming more advanced, and the students had to increase their effort. This was the time when some of these students had developed stronger commitment to subjects other than mathematics. Generally, the intensity of *Mathematical experiencing* had increased among the students later during primary schooling. The main reason was to pass the final primary school examinations and gain access to secondary school.

Willingness to succeed and increased effort, guided by the goal to qualify for secondary school enrolment, had been essential for these students' mathematical success. These features also were necessary in circumstances where personal contacts with teachers were uncommon (except for a few very successful students who could even be named in recognition during classes) due to large class sizes as Rehema recalled:

> *There were so many in my class, about 100students and only two maths teachers. So we were divided into two groups and each group had one teacher. But one teacher left the school when we were in standard three and only one teacher remained. The teacher knew very few students like prefects and students who were very smart. It was not possible to seek the teacher for help. (Rehema)*

Second, none of the students had experienced teacher-organised activities in which they could interact through discussions. Also these students had rarely experienced peer support in mathematics learning because of tight school schedules. Rehema illustrates these experiences:

> *We all came to school from far away each day. We came to school in the morning, went back home at noon for lunch, came back to school for afternoon lessons, and went home in the afternoon. Teachers did the same. We didn't stay at school as we do here. So, how can you do anything with another student, and when? It was not possible. If you have friends at home or near your home, that's maybe possible. (Rehema)*

In short, primary school-based mathematical participation as part of *Mathematical experiencing* was more intensive compared to home-based *Mathematical experiencing* for students with *Persistent effort identity*. Although classes were large and had limited close teacher-student interactions, the students were fostered to participate and learn mathematics mostly by their strong willingness to succeed in mathematics. Through peer-based and performance-based self-evaluations of mathematical competence, these students learned about themselves (e.g., their competences) and their participation in relation to mathematics.

Mathematical experiencing behind self-perceptions of mathematical participation in secondary school

Teacher-student interactions in the classroom or students' individual involvement in mathematical activities can involve challenges to students' mathematical self-perceptions and how students view mathematics. When students with *Persistent effort identity* were in the first grade of secondary school, they came to re-evaluate their sense of commitment, self-perceptions of competence, and perceived value of mathematics as they had to learn more abstract mathematical concepts in English as a new language of instruction. For example, the level of English Joseph and Mariam had learned in primary school was inadequate for understanding first grade secondary school mathematics. Because of this, they doubted their mathematical capabilities as illustrated in the following two quotations:

> *I can say it was terrible…I had learned English in primary school but it wasn't like this one here. The teacher talked quickly and it wasn't clear at all. I was worried because I was thinking that maybe I can't learn maths any more. Perhaps I was not good even if I had passed in primary school exams. I didn't know if I would do well in math because I didn't understand the teacher.(Joseph)*

> *The vocabulary was really tough; it was not like in primary school. The English of maths is special; it was not ordinary because it was hard to understand the long words.(Mariam)*

This problem, together with other problems such as insufficiency of text books and a difficult mathematics teacher in the second grade (as mentioned previously in this chapter), made these students intensify their mathematical interactions and participation in order to tackle these problems and increase chances of success in mathematics. They formed study groups in which they regularly met other students to study together. These groups had been useful. As a result of working on mathematical tasks that students had assigned to each other, and using other forms of peer support such as helping weaker students or sometimes inviting students from upper grades to "teach" them, these students had begun to realise improvement in their performances. Rehema, for example, described such an experience as follows:

> *It was becoming easier for me to understand maths in the classroom because my English was becoming better and I began to understand the language of maths. In the early time, before I joined the group, it was so difficult for me. Now we had come to know each other and so it's better. My marks were beginning to be good because of the group and also we began to understand the teacher, although not very much, but we understood him better than before the groups began. I began to know that I am good in maths if I work hard and attend groups. (Rehema)*

Overall, as Rehema illustrates, working hard individually and in study groups resulted in improvements in students' understanding of mathematical concepts and an increase in test scores. This further resulted in the strengthening of these students' positive self-perceptions of their mathematical competence. Students' understanding of the link between effort and success in mathematics and their strong willingness to gain higher scores in mathematics tests made these students increase their effort and surmount obstacles through active participation in study groups and individual engagements in mathematical activities.

6.2.3 *Mathematical experiencing* behind self-perceptions of mathematical commitment

Home-based Mathematical experiencing behind self-perceptions of mathematical commitment

Mathematical commitment in home-based contexts for students with *Persistent effort identity* did not develop. The most important reason was that parent-child interactions related to mathematics were rare (for the three students) or nonexistent (for the four students), which also means that students did not clearly perceive their mathematical competence and the importance of mathematics for them. Ambrose gave an example of these home-based contexts that did not support the development of students' mathematical commitment.

> *In our house no one talked anything about maths. We talked much about religion and Christian faith and about life and work, but nothing about maths, science or English. So, I didn't know if maths is important or not. (Ambrose)*

Mathematical experiencing behind self-perceptions of mathematical commitment in primary school

Mathematical commitment among students with *Persistent effort identity* began to develop in primary school, particularly during higher grades in which their sense of commitment was experienced more consciously. Feeling committed to mathematics was associated with mathematics becoming harder and thus requiring more attention. For example, Joseph felt committed to engaging more in mathematics, particularly when mathematics was becoming more complex.

> *When I was in standard one and two, and even standard three, there was nothing that forced me to learn maths but I learned. Perhaps it was sometime in standard four or five, when I felt I had to do more maths. In the beginning, I wanted to know English and science. So I used more time for those, but then I found maths was becoming harder for me and I felt the need to use more time to it as well. (Joseph)*

The sense of mathematical commitment was also associated with *liking* mathematics and a strong *willingness* to succeed in the final examination. The willingness to qualify for entry into secondary school, as recalled by Mariam, also seemed to contribute to the strong sense of commitment to taking part in mathematical activities:

> *But later, I think in standard five, I became more interested in maths and English. I worked hard in these subjects and I was good in them, but I wasn't the kind of person who got top marks. Yet I liked math and English. I wanted to do well in these subjects. They were not easy subjects but I wanted to pass the final examination and go to secondary school. (Mariam)*

During the upper grades of primary school, students with *Persistent effort identity* were highly committed to learning mathematics and other subjects. This sense of commitment seemed to have fostered their persistence in dealing with obstacles to learning at home. For example, when Molero returned home from school, he quickly completed domestic work assigned to him by his parents in order to spend the remaining time on mathematics learning. The willingness to succeed in mathematics (i.e., to gain high test scores) and qualify for entry into secondary school was the main long-term incentive for their commitment to learning mathematics.

Mathematical experiencing behind self-perceptions of mathematical commitment in secondary school

In secondary school, the students with *Persistent effort identity* were strongly committed to learning mathematics. Their commitment was reflected in their persistence in learning mathematics when facing challenges such as inability to clearly learn mathematics in a new language as described by Mariam in the following quotation:

> *I felt like I don't know much English and this was somehow bad. The vocabulary was really difficult, it was not like in primary school. The English of maths is special, it was not ordinary because it was hard to understand the long words. (Mariam)*

They adopted learning strategies to succeed in mathematics learning, which again reflected high mathematical commitment. These students worked hard in their self-organised study groups that were formed in the first grade in secondary school and continued to be active in their upper grades.

The students' high mathematical commitment was further reflected in their active interactions in the study groups. The students assigned mathematical tasks to each other in these groups. They helped each other in solving challenging problems with more competent students supporting the others. Also, these students invited other students from upper grades to help them learn difficult mathematical problems. These were instances of their mathematical commitment, and it paid off as Rehema narrated:

> *It was becoming easier for me to understand maths in the classroom because English was becoming better and I began to understand the language of maths. Before I joined the group it was so difficult for me. Also we came to know each other well and so it's better. My marks began to be rise because of the group and we began to understand the teacher, although not very much, but we understood him better than before the groups began. I began to know that I am good in maths if I work hard and attend the groups (Rehema)*

On the whole, these students' high commitment to learning mathematics in secondary school was mainly indicated by their persistence in striving to increase their mathematical competence through study groups and working hard in them while also overcoming serious challenges threatening their efforts. Understanding the applicability of mathematics to their specialisation in science, positive self-perceptions of mathematical competence and thoughts about a future career requiring mathematical knowledge all contributed to their high mathematical commitment.

6.2.4 *Mathematical experiencing* behind self-perceptions of mathematical ambition

Home-based Mathematical experiencing behind self-perceptions of mathematical ambition

Deficiency or lack of *Mathematical experiencing* at home amongst students with *Persistent effort identity* meant that these students did not have a chance to develop their sense of mathematical ambition. Four students who had no experience in learning arithmetic at home did not have an idea of setting achievement goals until they started primary school. This also applied to three other students who had been taught arithmetic relevant to day-to-day life. One of the latter students, Molero, having been taught by his parents, illustrates such lack of exposure to achievement goals in the following quotation:

> *They [parents] can't read or write but only count. So they were teaching me to count cattle. It was learning without thinking about getting A or B or maybe a score. They just taught me.(Molero)*

Although the parents of these three students seemed to have the goal of teaching basic arithmetic until their children were able to use the skills in home-related activities, this goal was not clearly communicated to their children during parent-child interactions.

Mathematical experiencing behind self-perceptions of mathematical ambition in primary school

The idea of setting achievement goals appeared more salient at higher rather than lower primary school grades among these students. At higher grades, their need to set mathematical goals accompanied strong willingness to succeed in mathematics by increasing their effort. At this stage, they had become ambitious because they had desired to achieve higher than before with a vision of being in a secondary school "one day". For Materu, for example, an increased "seriousness" had been associated with her ambitious goal of obtaining "the highest score".

Moreover, ambitiousness of achievement goals was associated with competence-related appraisals. Molero had learned of his mathematical competence based on his previous experiences of spending enough effort and gaining successful results as described next.

> *I did a lot of work in standard one and I knew much because of that. It would not be possible without working hard myself. I was the only one who knew maths and other things, more than anybody at home. I was different because of working hard. So when I said that I should get A in next exam, I started preparing myself for that because I felt it was possible. (Molero)*

Students determined ambitious achievement goals without parental influence although some parents allowed them to study at home often after doing domestic chores. Generally, setting goals was characteristic of learning mathematics in upper grades, particularly towards the final year when targets became more ambitious. These students learned from their own experiences rather than through parental influence that effort was necessary to realise their goals. The desire to become accepted by a secondary school was the key incentive.

Furthermore, the students' reactions to performance outcomes varied. As with setting goals, their emotional reactions to higher achievement outcomes were low in their lower grades but became more intense in upper grades. During lower primary school grades, failure in mathematics was not a serious matter and thus resulted only in mild emotional reactions, particularly if performances were high in other school subjects. Moreover, mathematical success did not imply significant emotional reactions if there was dissatisfaction with performance in other subjects. Thus, at this stage of schooling, overall academic success rather than success in mathematics resulted in more intense and positive emotions while overall academic failure was associated with strong negative emotions. However, with the increase in complexity of mathematics in upper primary school grades and the students' need to succeed in mathematics, mathematical success and mastery of the subject had been perceived as more important as Mariam narrated:

> *If I worked hard and got low scores, I felt completely disappointed. But I knew that I had to work harder ...I didn't want maths to prevent me from joining secondary school… If you fail in maths, the total marks become low and you can't go to secondary school. (Mariam)*

The data and analysis emphasise the importance of primary school as a setting where the development of *Persistent effort identity* actually started. The salient experience among these students was evaluation of outcomes (test scores) of their effort in mathematics and practical understanding that their mathematical competence resulted from persistent effort.

Mathematical experiencing behind self-perceptions of mathematical ambition in secondary school

In secondary school, students with *Persistent effort identity* faced several challenges such as insufficient English language skills in the first grade, shortage of mathematics textbooks, and the difficult teacher in the second grade. Yet, these obstacles did not undermine their ambition to succeed in mathematics. For example, through effort and the support of a study group, Joseph improved his English language skills and became more active in doing mathematics both individually and in self-organised study groups. His mathematical ambition was fostered mostly by his vision of studying a specialised set of physical science subjects in upper secondary school grades and becoming an engineer. He narrated his ambition as follows:

> *I was excited when I thought about being a real scientist or mathematician. It seemed possible. You know that if you choose a specific combination in A level, you know exactly what you will be if you work hard…So, now I know that if I choose PGM [Physics, Geography, and Mathematics] I can study more and become an engineer. (Joseph)*

These students also set specific achievement goals and strived to achieve them individually but especially by being active in the study groups. The students' positive evaluations of their mathematical competence, their certainty of gaining more mathematical competence through increased effort, and their understanding of the applicability of mathematical skills to sciences were key factors behind their persistent mathematical ambition as Joseph narrated:

> *When I decided that I would study maths and science, I felt that even if things would be more difficult in form three I would still do well. I would do well by working hard and also by doing everything that was necessary for doing well, like discussing with others in our groups. (Joseph)*

Thus, like students with *Innate ability identity*, these students' ambitiousness was reflected in the achievement goals they set and their strong emotional reactions to success or failure in achieving them. That is, they experienced positive emotions such as joy or surprise upon success and negative emotions such as unhappiness after a failure. Ambrose illustrates below:

> *I was getting B or sometimes C. If I heard that there was a test next week, I knew I would do B or C but not below C. If I got less I became unhappy, because I was thinking about what was wrong with me, all the hard work…But I felt surprised if I achieved higher than what I thought. (Ambrose)*

These students' emotional reactions, particularly the negative ones, were accompanied by finding out reasons for not scoring according to their expectations and also with finding ways to avoid failure in future mathematics tests. These students demonstrated strong ambition through setting high achievement goals and reacting strongly particularly to low performances in mathematics tests.

6.2.5 Conclusion on Mathematical experiencing behind Persistent effort identity

The data on mathematical experiencing for students with *Persistent effort identity* suggests the significance of contextual factors in shaping *Mathematical experiencing*. These students' parents, constituting a key factor in the home context, did not create (or created limited) home-based environments to support their children's mathematics learning before they began school. Significant *Mathematical experiencing* for the students occurred in primary and secondary schools where it was shaped by *Contextual factors* such as teachers, peers and formal evaluation criteria. The consequences of the lack of or deficient *Mathematical experiencing* at home and prevalence of school-based *Mathematical experiencing* can be summarised in four ways. First, the limited or non-existent home-based *Mathematical experiencing* restricted students' development of self-perceptions of mathematical competence at home. But these perceptions began to develop in primary school and developed further in secondary school mostly due to positive mathematical self-evaluations based on peer comparison and mathematics test scores gained through their own effort. Their willingness to succeed in mathematics was reflected by the strategies they employed to surmount obstacles such as mathematical abstractness and language difficulties. Their principal strategy was to study in self-organised groups. These strategies and individual effort resulted in improvement of test scores, which sustained their positive self-perceptions of mathematical competence. The students were then able to justify their positive self-perceptions of mathematical competence based on their previous high mathematical performances due to their high effort.

Second, the limited (or non-existent) home-based *Mathematical experiencing* constrained students' development of self-perceptions as individuals who actively participated in mathematical activities at home. These students' self-perceptions of mathematical participation began to develop mostly in primary and secondary schools due to their active participation in mathematical participation. Although there were restrictive *Contextual factors* such as large classes and limited teacher-student interactions in primary school, these students were actively involved in mathematical activities because they had strong willingness to increase their mathematical competence and to raise their mathematical performances. In secondary school, these students had already developed a clear understanding of the link between increased effort and success in mathematics. This understanding plus positive self-perceptions of their mathematical competence and willingness to increase their mathematical competence through increased effort fostered these students' effort in mathematics learning mostly through studying actively in self-organised groups.

Third, the limited or non-existent home-based *Mathematical experiencing* impeded students' development of self-perception as individuals who were committed to mathematics. These perceptions began to develop in primary school, particularly when the students began to perceive their mathematical competence that developed as a result of their effort in learning mathematics. This sense of commitment became stronger in secondary school where it was enhanced through these students' positive self-perceptions of mathematical competence, awareness of the possibility of increasing their mathematical competence through increased effort, and their understanding of the value of mathematics for their specialisation in physical sciences and for their future careers.

Finally, the limited or non-existent home-based *Mathematical experiencing* restricted students' development of self-perceptions as students who had high mathematical ambition at home. This self-perception reflected by setting high achievement goals began to develop in primary school and was more evident in secondary school. Despite the restricting *Contextual factors* such as lack of mathematics-related teacher-student interactions, these students' ambition was 'fuelled' by their understanding of mathematical competence as the result of their own effort, their knowledge of the usefulness of mathematics in understanding sciences, and their vision of becoming more successful in mathematics in the future grades thus securing a mathematics-related career. Their persistent ambition was reflected in the incremental pattern of average performances in mathematics tests. For example, these students scored an annual average of 44% in the first grade in secondary school, but in the third grade the average score increased to 63.6%.

Thus, some Contextual factors influencing Mathematical experiencing for students with *Persistent effort identity* were restrictive (e.g., deficiency or non-existence of parental support at home and lack of teacher-student interactions) but others were supportive (e.g., peer support in self-organised study groups). The deficiency or non-existence of home-based parental support for these students had implications for mathematics learning such as striving harder in learning mathematics in secondary school compared to students with *Innate ability identity* who had been more intensively supported by their parents in learning mathematics at home before they began school. Moreover, while students in the former category began to develop positive mathematical identity in school, students in the latter category began to develop this identity at home due to parental support. The overall conclusion is that the development of *Persistent effort identity* occurs when students, through self-evaluations based on their *Mathematical experiencing*, learn that their mathematical competence and success results from their own persistent effort.

6.3 Mathematical experiencing related to Image-maintenance identity

As discussed in Chapter 5, *Image-maintenance identity* was characterised by students' positive mathematical self-perceptions. However, although students with this identity perceived themselves as mathematically competent, they considered their commitment to learning mathematics, mathematical ambition, and the degree of personal involvement in mathematical activities to be low. The key reason was their commitment to other subjects perceived as more important to their lives. At the same time, these students desired to be viewed by their fellow students as mathematically competent. In this chapter, I examine the development of this identity through analysing students' *Mathematical experiencing* at home and in school.

6.3.1 *Mathematical experiencing* behind self-perceptions of mathematical competence

Home-based Mathematical experiencing behind self-perceptions of mathematical competence

There were ten students with *Image-maintenance identity* involved in this study. Of these, only four had elementary mathematical experiences gained at home; the rest gained practical life-related experiences unrelated to mathematics and therefore did not develop any mathematical self-perceptions in their home contexts. Two of these four students who experienced mathematics at home did not attend nursery school. During interactions with their parents in learning mathematics, the parents did not think in terms of mathematical competence but emphasised the necessity of effort for success in mathematics. These parents wanted to ensure that their children learned the basic mathematical skills (and other school-related skills) to enable them to succeed later in primary school. Rajab recalled such early experiences as illustrated in the following quotation:

> *They said nothing about whether I can do maths or not. They wanted me to know maths quickly before I went to primary school… They taught me to count from 1 to 10 and then from 1 to 20 and…from 1 to 100.(Rajab)*

Because the parents did not have an impact on their children's thoughts about mathematical competence and the children did not attend nursery school where they could have evaluated their mathematical competence based on peer performances, their sense of mathematical competence was not evident to them.

This applied, for example, to Kibasa who was prevented by his parents from attending a nursery school but was taught by his parents at home:

> *I didn't get such feeling [of being more competent than others]... Of course my parents knew much better than me but I didn't think about that. I didn't go to nursery. I was at home and my father taught me. There weren't other children than me, and my parents. (Kibasa)*

The remaining two students, who had been taught elementary mathematics both at home and in nursery school, developed a way of thinking about their mathematical competence in nursery school. Their self-evaluations derived from their comparisons between their own mathematical skills and those of their counterparts especially those who had not learned such skills at home. Anna, for example, learned about her high mathematical competence through peer comparison in the following way:

> *I began to feel that I knew more than others, because many children whom I played with in nursery didn't know much arithmetic and they were asking me to help them.(Anna)*

Overall, home-based *Mathematical experiencing* for students with *Image-maintenance identity* did not foster the development of their self-perceptions of their mathematical competence despite increases in their mathematical knowledge. Yet, some of them could positively evaluate their competence in mathematics through peer comparison in nursery school.

Mathematical experiencing behind self-perceptions of mathematical competence in primary schools

Positive self-perceptions of mathematical competence among students with academic background, which had begun to develop before they started primary school through comparison with other children in nursery schools, persisted in primary school. Comparison with peers and the activities of their teacher or peers was the main basis for the development of their self-evaluation of competence in primary school. Such experiences are reflected in the next two quotations:

> *Some students in my school didn't know arithmetic at all. I was sorry for them. When I compared them with me, I saw that I was much better than them. (Rajab)*

I was helping because the teacher asked us to help. Sometimes other students asked me to help them and I helped them… I felt like I knew more than others. (Anna)

As students from both home backgrounds reached higher grades, thoughts about mathematical competence became more salient in the students' thinking. This was due to the differences in mathematical skills that were made salient through the use of the formal evaluation scale (0 – 100%). This practice of ranking students according to their performance in mathematics tests encouraged them to think more about their ability in mathematics. However, students in this identity category did not view the scores and rankings as fixed. Based on their experiences at home and experiences in mathematics learning in school, they knew that their mathematical performance and competence could change relative to their effort, as Shukuru illustrates:

Maths was getting tough especially when standard five began. It was then possible to get zero if you don't work hard. I worked hard and things weren't bad. It's like playing football. If you work hard and you're clever, you will get the goal. (Shukuru)

Generally, positive self-perceptions of mathematical competence among students with *Image-maintenance identity* developed through self-evaluations of their success in mathematical activities based on peer comparison and on evaluation criteria (e.g., grading scale) available in their schools. Based on improvement of test scores relative to their effort, they perceived themselves as mathematically competent and as capable of increasing this competence through increased effort.

Mathematical experiencing behind self-perceptions of mathematical competence in secondary schools

Students with *Image-maintenance identity* began their secondary school with positive self-perceptions of mathematical competence and could justify these self-perceptions by citing their mathematical achievement in the past as Sikitu illustrates:

I had really good marks in my primary certificate, so it was clear that I'm good in maths. I didn't know how things in this school were in the beginning but I knew I will do well. (Sikitu)

Like students with *Persistent effort identity*, these students had learned from previous mathematical experiences (at home and primary school) that their mathematical competence developed as a result of their effort rather than representing an innate characteristic. Based on the understanding of the relationship between effort and development of mathematical competence, these students continued to rely on their effort to succeed in mathematics, particularly in their first and second grade of secondary school. Agnes, for example, pointed out such a viewpoint:

> *Secondary school is a different place not like primary. Here you must really do the work…you must struggle and then you will be able to do maths. I had to work hard because maths was complicated. (Agnes)*

During the two secondary school grades, these students, like those with other positive identities, sustained their positive mathematical self-perceptions even when experiencing serious challenges (i.e., language problems, lack of textbooks, and a difficult teacher). But they chose to specialise in arts, which marked the beginning of a negative pattern of *Mathematical experiencing* (i.e., less frequent participation in mathematical activities and weaker mathematical commitment and ambition) while retaining positive mathematical self-perceptions of competence. They supported their positive mathematical self-perceptions by referring to their previous higher mathematical performances and explained their current lower test scores as resulting from their concentration on arts.

6.3.2 *Mathematical experiencing* behind self-perceptions of mathematical participation

Home-based Mathematical experiencing behind self-perceptions of mathematical participation

Of the ten students with *Image-maintenance identity*, only four had experiences of mathematics at home. A common feature among these four students was their parents' direct involvement in their children's learning by creating home-based environments to help their children learn basic school subjects including mathematics. They, for instance, had provided learning materials and interacted with their children in the learning process. Rajab illustrates this experience:

> *They wanted me to know maths before I went to primary school. They taught me to count from 1 to 10 and then from 1 to 20 and…from 1 to 100. I was using small boards that my father brought from school because he was teaching in that school. I used them to write numbers, or they wrote them and they wanted me to say loudly what kind of number it was. (Rajabu)*

Another common characteristic was the perception among these four students' parents that effort was necessary for success. This perception was reflected in the parents' talk about their own past experiences when they 'had worked hard' in order to develop their academic competences. Based on this belief, parents had often set achievement goals for their children. In some families to which these four students belonged, achievement goals had been rather strict and the students had been required to realise them within a planned timeframe. This approach had been associated with unpleasant moments for the students as illustrated by Rajab:

> *If your father says that today you must learn to write 1, 2, 3, 4, and 5, you must work hard and do as he says. It was hard of course. He ordered me to try again and again until I knew. I had to know it the same day. (Rajabu)*

But in other families to which the four students belonged, parent-child interactions in learning were more flexible and relaxed. In addition, although some of these students' parents had allowed their children to attend nursery schools, they had perceived these schools as not effective in providing children with the right academic skills. Because of this perception, the parents continued teaching their children while their children attended nursery schools.

Conclusively, home-based *Mathematical experiencing* among students with *Image-maintenance identity* was limited to only four students. Home contexts for these students were characterised by parental direct, and in some cases, coercive relationships with children when teaching them elementary mathematics and other academic skills.

Mathematical experiencing behind self-perceptions of mathematical participation in primary schools

In the beginning of primary school, there were differences between students with home-based mathematical experiences and students without these experiences in the way they interacted and involved themselves in mathematical activities. Students with home-based mathematical experiences learned mathematics more easily compared to those without such experiences. These differences were more evident when students with home-based mathematical experiences supported their peers voluntarily or after being asked by their teachers. In contrast, students with non-academic background were mostly recipients of peer help as Anna narrated:

> *Some pupils in my class knew much arithmetic, and about writing and reading. They were like me. But others didn't know how to do it. They kept asking me to help them or to teach them so that they would know like I did. It was normal to help each other. If you know, you will let the other know it too. I liked to help. (Anna)*

While students with home-based mathematical experiences continued being supported by their parents in learning mathematics, students without this experience or parental support relied mostly on their own effort at school and home. This resulted in continued higher mathematical competence among students in the former category compared to students in the latter category. But these differences were not as great as they had been in the first grade. Yet, being a "top" performer in mathematics tests had an advantage of being recognised and praised by teachers in the large classes in which the students learned mathematics. While Godfrey, being an 'average' performer, did not receive any recognition during the whole period of primary school, Rajab, with top rankings in mathematics test scores, received regular recognition and praise from teachers. However, the lack of recognition and praise did not discourage students like Godfrey whose name did not appear in top positions in the ranking based on mathematics test scores.

Generally, in primary school, all students with *Image-maintenance identity* liked mathematics and were willing to gain mathematical skills through increasing their effort. They set ambitious achievement goals and strived to achieve them. The four students (i.e., those who had experienced parental support before primary school) got support from their parents, but the rest of them mostly relied on their own effort. Although there was teacher-student interaction in the classroom, its effect on these *Image-maintenance identity* students' learning of mathematics was limited due to large class sizes.

Mathematical experiencing behind self-perceptions of mathematical participation in secondary schools

As was the case for all students who participated in this study, positive self-perceptions of mathematical competence and commitment being developed in previous years among students with *Image-maintenance identity* were challenged by a change in the language of instruction (from Swahili to English) and complexity of mathematical concepts in the first grade in secondary school. As a result, these students had begun to envision possibilities of future mathematical failures, and this had given them feelings of discomfort. This situation resulted in students' exercise of their agency by finding other ways (apart from attending classes) to increase their mathematical competence. The main way was to study in self-organised groups in which these students (together with those with *Persistent effort identity*) supported each other. Anna, for example, narrated this experience in the following quotation.

> *We got into groups because we were getting used to each other. We formed groups and did maths together. It was good because everyone was serious. We wanted to keep on being good in maths. If you know more than others, you'll help them and tomorrow they can help you. That's how it went…Maths was becoming ok for us and we did well in tests because of this.(Anna)["you" refers to 'I']*

Other strategies of learning mathematics in this challenging situation included asking parents to buy learning materials for them because these lacked in the school, consulting the mathematics teacher after official hours, and seeking help from upper grade students. While these students' positive self-perceptions were strengthened in the second grade due to improved mathematical performances, their engagement in mathematical activities began to weaken. Although the new teacher's inability to interact with students had weakened their mathematical engagements, preoccupation (in this second grade) with discussions on whether to specialise in science or arts in the third grade was the most important reason for their reduced participation. The school traditionally required subject specialisation in beginning in third grade. All students with *Image-maintenance identity* chose to specialise in Arts, and thence, these students gradually shifted their attention from mathematics. These students liked mathematics and also liked being good at mathematics and being viewed by other students as good at it. Yet, they perceived it as unnecessary for them to succeed in the Arts. It only was necessary for students who specialised in the Sciences. Kibasa illustrated such an experience in the following way.

> *We discussed in our groups that our aim was to know very well the Arts but not Science. So all agreed and when time to choose came, we all chose Arts. Maths was yet important because we were good at it, but most of the time we thought and talked about Arts. (Kibasa)*

Moreover, the students had envisioned their future Arts-related careers (e.g., journalism, language teaching, or expertise in history) which then weakened their participation in mathematical activities.

Generally, specialising in and increasing commitment to Arts with a subsequent decrease in commitment to mathematics learning were features that distinguished mathematical participation among students with *Image-maintenance identity* from mathematical participation among students with other positive identities. These students, however, maintained a degree of mathematical participation necessary for them to pass mathematics tests in order to be viewed by other students as students who could still do well in mathematics tests.

Conclusion

Self-perceptions of mathematical participation among students with *Image-maintenance identity* mostly began to develop in primary school where their liking of mathematics and willingness to gain mathematical skills was apparent. At that time, they also were aware of their ambitious achievement goals and increased effort to achieve them, partly with the support from their parents and teachers. These students were also intensively engaged in mathematical activities in the first grade of secondary school, but their involvement began to decline in the second grade. This was the time when the students specialised in and increased their commitment to the Arts while maintaining their mathematical involvement high enough to pass (at least minimally) mathematics tests. To pass the tests and be perceived by other students as still mathematically competent was important for these students. Due to such primary and secondary school mathematical experiences, they perceived themselves as individuals who were less frequently involved in mathematical activities in the third grade than in previous grades.

6.3.3 *Mathematical experiencing* behind self-perceptions of mathematical commitment

Home-based Mathematical experiencing behind self-perceptions of mathematical commitment

Of the ten students with *Image-maintenance identity*, only four experienced mathematics at home. As a result of parents' mathematics-related interaction with these students (which sometimes was coercive), these students gained elementary mathematical skills. Moreover, students who were allowed by their parents to attend nursery schools could ascertain their mathematical skills. Awareness of the students' own mathematical skills was associated with these students liking of mathematics and willingness to continue learning mathematics. Rajab, for example, illustrated this experience:

> *First I hated them...[parents]. Then I began to like my parents because I knew I was learning maths when they teach...I really liked maths and I wanted to study it now and then. I saw that I was better than others in nursery. (Rajab)*

For the remaining students (i.e., of the ten with *Image-maintenance identity*), early involvement in mathematical activities was associated with their own willingness to gain mathematical skills rather than with parental coercion. This mainly was due to the less strict and more flexible parental approach to 'teaching'. Willingness to gain more skills had grown to the point of initiating tasks and doing them even if parents had not provided those tasks. Sikitu reports such activity in the following quotation.

> *I even liked more and more because I started knowing arithmetic and I felt very excited to do things that I didn't do before. If they didn't give me something to do, I took my notebook and worked on adding numbers, subtracting them or even wring my parents' names. I asked them to look at what I did. (Sikitu)*

Conclusively, the children's willingness to continually gain mathematical skills without waiting for parental coercion can be regarded as the beginning of their mathematical commitment. The four students' parents in this *Image-maintenance identity* category played an important role in creating home-based conditions that enabled their children to start developing this commitment. The rest of students with this identity did not experience such parental support at home and thus their sense of mathematical commitment did not develop at this stage.

Mathematical experiencing behind self-perceptions of mathematical commitment in primary schools

While students with *Mathematical experiencing* at home developed their mathematical commitment before primary school as result of both the parental influence and their own willingness to know mathematics and other subjects, other students without this background started to feel committed to mathematics learning at school after learning the elementary mathematical skills at school. With time, the sense of commitment in both student categories was accompanied by willingness to succeed in mathematics as Godfrey recalled:

> *I think it was in standard five when I was beginning to feel that school is really part of my life. At that time, I wanted to be good in maths and science but I also worked hard in all other subjects…I did sometimes maths or some other stuff when others were playing (Godfrey)*

Near the end of primary school, the students' mathematical commitment was strengthened by their' enthusiasm to gain high scores in the final primary school examination in order to qualify for admission to secondary school. Accordingly, in primary school, these students' commitment to learning mathematics developed from their desire to know mathematics and other subjects, to their willingness to succeed in mathematics, and finally to their desire to obtain enough credits for admission into secondary school.

Mathematical experiencing behind self-perceptions of mathematical commitment in secondary schools

Mathematical commitment among students with *Image-maintenance identity* was strong in the first grade of secondary school despite the challenges these students faced, as Rajab recalled:

> *I got into problems in learning maths, but I liked maths. Maths was fine and I felt that maths was in me. I felt excited about it. I liked doing it sometimes alone, or other times, I worked with my friends…I liked studying it. When I didn't work on it, I felt uncomfortable just like something is missing in me. (Rajab)*

However, even though these students' self-perceptions of mathematical competence remained positive and strong during the second and particularly the third grade, the strength of their mathematical commitment then began to decline. The most important factor in this weakening commitment was the students' decision to concentrate on studying Arts and devote most of their time to Arts and less time to learning mathematics. Agnes, for example, illustrated this experience:

> *Yes, I liked maths but I knew it was not something for me to do in the future…You can study maths even if you choose arts. Maths is for all, but I didn't do much maths because I needed more time for arts. (Agnes)*

Conclusion

The overall picture of mathematical commitment among students with *Image-maintenance identity* was that of its declining pattern—from strong commitment in primary school and in the first grade of secondary school to weak commitment in the third grade of secondary school. These students were aware of this pattern, and in the third grade, they perceived themselves as less committed to mathematics than they were in their previous grades.

6.3.4 *Mathematical experiencing* behind self-perceptions of mathematical ambition

Home-based Mathematical experiencing behind self-perceptions of mathematical ambition

Those students with *Image-maintenance identity* who had home-based mathematical background had developed a goal-oriented way of thinking while doing tasks assigned by their parents. In particular, this occurred when parents had instructed and expected their children to do arithmetic tasks correctly as Rajab illustrated:

> *You had to do everything well and if you made only one mistake, it was bad. My parents wanted me to do everything correctly. If one sum was not correct, then they got angry and ordered me to practice until I get everything well. (Rajab)*

Parents also influenced their children's development of goal-oriented thinking through their regular practice of marking and giving scores to their children's attempted arithmetic tasks. This parental behaviour influenced the children who then started to evaluate themselves based on the scores and parental remarks related to their attempted tasks. For some of these four students with home-based mathematical background, the self-evaluations were associated with fear of getting a low score or negative parental remark. On the other hand, when they got high scores from their parents, their self-evaluations were associated with joy or sense of relief. Rajab described such evaluations and experiences as quoted below:

> *I feared them in the beginning. I tried hard and I began to do well…Later I was beginning to know well. …I felt good and happy when I did well because I knew that no one would shout at me. My parents became happy too when I did well. (Rajab)*

Thus, their parents set the base to the development of ambition among the students with *Image-maintenance identity* before school years. These students had started to think in terms of achievement goals when attempting the mathematical tasks that had been regularly assigned by their parents, who also encouraged or coerced their children to do well in those tasks and provided feedback on their performances. However, the sense of ambition did not begin to develop among students without this home-based background in mathematics.

Mathematical experiencing behind self-perceptions of mathematical ambition in primary schools

While the four students who had been oriented to school mathematics at home were determined to increase their effort to become "the best" in mathematics in the beginning of primary school, this ambitious goal was not at this stage characteristic of students without this background. For students like Godfrey who did not have such home-based *Mathematical experiencing*, the goal of outperforming others in class developed after learning the basics of mathematics in primary school. Godfrey describes this ambition in the following quotation.

> *Few times I was at the top. It felt good to do better than anybody else in class. I felt good and happy, and I liked my friends to see my scores. Then I also showed my parents how good I was. It made me feel free to continue to do more and put more effort. (Godfrey)*

In higher primary school grades, mathematical ambition among all students with *Image-maintenance identity* was fostered by their enthusiasm to increase mathematical competence and thus improve chances of being admitted to secondary school. Furthermore, the intensity of reactions to achievement outcomes increased with time among the students. In the beginning and also later in primary school, students with home-based background in mathematics became sad or disappointed when they failed in mathematics tests. In contrast, mathematical success had been associated with joy and pride and also with willingness to maintain the high level of performance as Kibasa described:

> *It was so bad if I failed because it meant that I was not good in maths. And if I was not good, what would happen if I failed the exams in standard 7? It's pointless to pass all subjects and fail only in maths…If you fail in maths in primary school, they don't choose you to go to secondary school. I didn't want to fall below B. (Kibasa)*

Such reactions occurred in higher primary school grades for students without a home-based mathematical background. This happened when they began to experience success in mathematics mostly after their perceived effort and awareness of their mathematical competence. At this stage, these students reacted strongly when their overall performance levels were below their expectations. Failure among these students was associated with sadness and uncertainty about their mathematical competence but also with willingness to strive more for future success. On the other hand, success in mathematics was associated with joy and willingness to continue learning mathematics. The enthusiasm to increase mathematical competence in order to gain high scores in the primary school final examination fostered the ambitiousness of achievement goals among all students with *Image-maintenance identity*, regardless of whether they had a home-based background in mathematics or not. Again, a high score in mathematics in that mathematics examination would increase these students' chances of admission to secondary school.

In conclusion, the sense of ambition began to develop after experiencing mathematics in primary school for most students with *Image-maintenance identity*. Only four of the ten students in this category developed their sense of ambition at home through mathematics-based interactions with their parents. However, mathematical ambition became stronger and consistent towards the end of the primary school period among all the students. Setting goals and evaluation of the achievement of these goals were then possible because of the availability of evaluation criteria in primary schools (e.g., grading scales) and the schools' practice of ranking students based on test scores.

Mathematical experiencing behind self-perceptions of mathematical ambition in secondary school

Much like participation and commitment, mathematical ambition among students with *Image-maintenance identity* had a weakening pattern during secondary school years. In the first grade of secondary school, these students' mathematics achievement goals were ambitious. This ambitiousness was sustained up to the second grade despite the challenges the students faced as previously described. But in the third grade the students became more concerned with Arts subjects they had specialised in. Rajab illustrates this change in perspective as follows:

> *I liked maths and everybody knew it, but I worked more for arts because it's my life already. I still do maths, but maybe there was no time for maths. I didn't think like getting A or B in maths but just wanted to pass it. I didn't like to leave it out completely, it's a nice subject and I liked it. (Rajab)*

The students set ambitious goals to succeed in Arts in the third grade instead of setting such goals to succeed in mathematics. Lower mathematical goals were also associated with decreased optimism for future success in mathematics. However, this did not result from the students' perceptions of themselves as mathematically incapable but rather from the fact that they had not given priority to mathematics. The declining pattern in the ambitiousness of these students' achievement goals corresponded to a similar decline in their mathematics test scores between the first and third grades. On annual average, students with this identity scored 74.7% in their first grade, but their average mathematics performance dropped to 41% in their third grade after specialising in the Arts.

Yet, the students reacted strongly to their mathematics test results that were below a pass mark (i.e., total failure). These reactions were highly emotional as the students still wished to be perceived by other students as mathematically competent. On the other hand, a sense of satisfaction was associated with getting scores that indicated a pass in mathematics tests. Rajab illustrates such experiences and emotional reactions as follows:

> *I didn't like to fail completely because if I failed I didn't feel good at all. I wanted to pass all exams…I felt it was a shame when they all look your scores on the wall and say 'ah he has got F'! - I don't like that. It's ok if I get something above F, that's what I like. It doesn't have to be C or anything higher, but D is enough. If I get it, I feel it's done and then I'm happy to do other things… no shame. (Rajab)*

In short, the decline in mathematical ambition (reflected by the setting of less ambitious achievement goals) among students with *Image-maintenance identity* began in the second grade in secondary school. It was further reflected in a corresponding decline in their mathematics test scores. However, these students continued to perceive themselves as mathematically competent and wanted to be considered as such by other students as well. This tendency appeared to be the main reason why these students' emotional reactions were still strong after their failure in mathematics tests.

Conclusion

The strong mathematical ambition that began to develop in primary school started to decline in the second grade of secondary school among students with *Image-maintenance identity*. Yet, these students sustained their sense of mathematical competence. Their concern, reflected in the tendency to avoid failure in mathematics tests, was to maintain their image (i.e., to be viewed by other students) as students who were still mathematically competent. These students were aware of this declining pattern of their mathematical ambition in their third grade of secondary school and perceived themselves as students with weaker mathematical ambition (i.e., as students who set low achievement goals)as compared to the past.

6.3.5 Conclusion on Mathematical experiencing behind Image-maintenance identity

Mathematical experiencing among students with *Image-maintenance identity* was partly similar to that for students with *Persistent effort identity* before and during primary school and even during the first secondary school grade. That is, in some home contexts, parents actively interacted with their children and fostered their learning of mathematics. The parents also influenced their understanding of the link between effort and success while learning mathematics. Moreover, the majority of the students with this identity gained mathematical knowledge in primary school and became aware of their developing mathematical competence mainly as a result of their effort. This had occurred through their self-evaluation based on peer comparison and mathematics test scores. However, this pattern of *Mathematical experiencing* started to change when student's mathematical involvement, commitment and ambition began to weaken in the second grade and mostly in the third grade of secondary school. The key reason was that these students specialised in Arts and diverted their attention from mathematics to Arts which they perceived as more important to their future lives as compared to mathematics. While perceiving their mathematical competence positively, these students then participated in mathematics mostly to avoid failure in mathematics tests and maintain their image as those who could still pass these tests despite their preoccupation with Arts.

The concern for image maintenance and a declining pattern of mathematical involvement, commitment and ambition, and even the decline in their average mathematics test scores, distinguished *Mathematical experiencing* among students with *Image-maintenance identity* from *Mathematical experiencing* among students with other positive mathematical identities. These former students perceived themselves as mathematically competent but also as those who participated in mathematical activities and were committed to mathematics in the third grade to a lesser degree as compared to their previous school years. In consequence, positive self-perceptions of mathematical competence are not always associated with high mathematical participation, strong mathematical commitment, ambition or an incremental pattern of mathematical performances. The key factor mediating this relationship relates to students' evaluation of the low relevance of mathematics to their future lives.

6.4 Mathematical experiencing related to Oppositional identity

In this chapter, I focus on the nature of *Mathematical experiencing* associated with students' negative or *Oppositional identity* that was presented in Chapter 4 (Subsection 4.3.3). The aim is to address this research question: *What kind of Mathematical experiencing characterises students' negative mathematical identity?* The students with this identity perceived themselves as having low mathematical competence, not participating in mathematical activities, and lacking mathematical commitment and ambition. As detailed in the following sections, these students' narratives suggested that *Mathematical experiencing* for them at home, in primary school and secondary school had mostly been unsupportive.

6.4.1 *Mathematical experiencing* behind self-perceptions of mathematical competence

Home-based Mathematical experiencing behind self-perceptions of mathematical competence

Of the 11students with *Oppositional identity* in the study, four were exposed to elementary mathematics at home while the remaining 7 did not experience any mathematics at home. However, home-based exposure to elementary mathematics among the four students was limited. That is, interactions with their parents in learning mathematics occurred less frequently compared to the students with *Innate ability identity*. Zuberi described this kind of *Mathematical experiencing* as follows:

> *There was not much talk at home about maths. They didn't say anything about maths, but they taught me to write, read and do arithmetic. It happened when they had time…Most of the time I just played with other kids. (Zuberi)*

Moreover, the students did not evaluate their mathematical competences in these limited parent-child interactions. This derived from the fact that their parents did not make them to think of themselves in certain ways in relation to mathematics. The four students rarely thought about their competence in mathematics or other academic skills in nursery schools either. The lack of self-evaluations was related to the absence of tests as the nursery schools emphasised play instead of classroom work. Daudi, for example, recalled how he compared himself with students who did not have the mathematical skills that he had. Yet, this peer comparison was not associated with serious self-evaluation of his mathematical competence:

> *I'm not sure if I felt that I was better than anybody, but maybe somehow yes… because I liked to show others in nursery how to add numbers. Many didn't know clearly how to do it. So, yes, somehow I felt I was like someone who was better than them. But I didn't take it so seriously ...In nursery it was not easy to know who is good or isn't good in arithmetic or writing because we didn't do tests or exams.(Daudi)*

In general, home-based *Mathematical experiencing* among the four students was too inadequate to enable them to develop clear self-perceptions relating to their mathematical competence. The lack of close interactions with parents and limited involvement in mathematics learning meant that there was no or only limited opportunities for these students to evaluate their mathematical competence and to develop such self-perceptions. The remaining seven students in this *Oppositional identity* category did not experience mathematics before they started primary school. As a result, their sense of mathematical competence began to develop later in primary school.

Mathematical experiencing behind self-perceptions of mathematical competence in primary school

Even though self-perceptions of mathematical competence were not clearly formed or not formed at all in the home contexts among students with *Oppositional identity*, these perceptions became clearer to all students in this category during the early grades of primary school. In primary school, they had been involved in a higher degree of interaction and engagement in mathematical activities as well as in self-evaluations based on these experiences. Again, their self-evaluations leading to the development of self-perceptions of mathematical competence were supported by the academic assessment criteria that existed in primary schools. Another influential factor was the students' variation in their mathematical competence, which opened up possibilities for comparing each other's competence in mathematics during their interactions. These influences are apparent in Daudi's remarks:

> *In primary school you know it because there are test and exams and you can see the results. You just look at the board and you know it as teachers wrote your name and your mark and marked if you're first or 20th or last. So you compare yourself...I was very good in standard one but not the best one. (Daudi) ['you' refers to 'I']*

However, in higher grades of primary school when mathematical content became more complex, students began to doubt their mathematical competence particularly in the beginning of their fifth grade. These doubts and self-evaluations of weak progress seem to have evolved into perceptions of low mathematical competence as a result of low mathematics test scores. Moreover, some of the parents fostered the development of their perceptions of low mathematical competence in different ways. For instance, the parents of students with home-based *Mathematical experiencing* interpreted their children's failure in mathematics as resulting from lack of giftedness. This was reflected in Mapunda's narrative:

> *Schools give reports to their parents to show them how students do in exams. Parents got reports two times in each year in our school. So my parents knew clearly how I was doing in maths. They also knew when I was getting poor results in maths, but they said it was ok because we are not good at maths in our family. They said that I should work harder in other subjects. I now think they were right. (Mapunda)*

This parental attribution of children's failure to lack of mathematical gift (an innate characteristic) was expressed to the children only after they consistently had gained low mathematics test scores in primary school. It was not expressed during their home-based interactions with parents before starting school. Even though parents expressed this attribution in the middle of primary school, this attribution as well as students' self-evaluations based on low mathematical performances, had made students consider low mathematical competence as their innate quality.

However, not all parents expressed this attribution to their low performing children. Other parents were indifferent about their children's poor records in mathematics, that is, they gave no comment on their children's low mathematics test scores. This indifference together with the parents' tendency to appreciate their children's higher academic performance in other subjects somewhat supported these children's view of themselves as mathematically incompetent. Mary, for example, reported such an experience:

> *When my father saw my reports he used to praise me because I did well in many other subjects. And he was happy if I was the sixth or seventh even though I had low mark in maths. He said nothing about my math knowledge, but I knew I was poor in maths. (Mary)*

For other students, particularly those who had begun their *Mathematical experiencing* in primary school, self-evaluation of low mathematical competence in primary school was based on their consistently low scores despite their effort and being encouraged by their parents to 'work harder' and improve their performances. Ema's parents, for example, had only basic education, and they wanted their children to gain more advanced skills in mathematics and other subjects. Yet, they were unable (due to their low mathematical skills and limited academic scope) to support their children's learning of mathematics at home. Furthermore, when students like Ema had increased effort in learning mathematics but had experienced little or no success, mere parental support did not help them succeed in mathematics or the development of positive mathematical self-perceptions.

Finally, these students' self-perceptions of low mathematical competence were, to some extent, consolidated through the way mathematics teachers interacted with them. For example, teachers often praised or rewarded high achieving students but rarely encouraged students who did not perform well. Teachers' lack of support for low performing students discouraged them from increasing their effort in learning mathematics. This experience is illustrated as follows:

> *The teacher liked students who were good in maths. They said nice words to them and sometimes they gave something like notebooks or pens or even books. But I feel they didn't care about people like me…I felt that no one supported me or even recognised me in maths classes. But I shouldn't complain. I got gifts for doing well in English and science. So it wasn't too bad. (Mapunda)*

Although parents and teachers played an important role in the development of the students' self-perceptions of low mathematical competence, these self-perceptions were mostly based on students' own evaluations of consistently low mathematics test scores in comparison with other students' mathematical performances. Some parents, through attributing their children's low test scores to lack of mathematical gift and being indifferent to their children's low scores in mathematics tests, supported students' own observations of their low performances despite their increased effort. But among some students, lack of parental support intensified their negative self-evaluations of mathematical competence and strongly enhanced their negative view of themselves in relation to mathematics.

Mathematical experiencing behind self-perceptions of mathematical competence in secondary school

Early secondary school *Mathematical experiencing* was associated with a weakening sense of mathematical competence among students with *Oppositional* *identity*. In the first secondary school grade, they perceived themselves as individuals with deficient mathematical skills. This perception developed due to low or lack of success in mathematics in their upper primary school grades, a deficiency they carried over to secondary school. Mary illustrates such an experience:

> *I didn't do much maths in primary school because I didn't like it. English and history were my favourite subjects and I used more time for them. I went back to maths just before the final exams because I wanted to pass maths. This is why I told you that I had poor basis and I can't learn maths any better here. (Mary)*

These students did not succeed in mathematics in the first grade (in secondary school) despite their increased effort. Even students like Mary who did not like mathematics in primary school had interest in secondary school mathematics in the beginning of the first grade. This pattern of failure consolidated negative perceptions of mathematical competence. The students experienced lack of success because of their poor background in mathematics and their inability to surmount obstacles that students with positive mathematical identity were able to surmount (i.e., complexity of mathematical concepts, shortage of learning materials, and a difficult teacher in the second grade). These factors were responsible for the lack of correspondence between these students' increased effort and performance.

Mathematical experiencing involving a lack of correspondence between effort and results (scores) offered some of the students concrete proof of what their parents had repeatedly told them—that they had no gift for success in mathematics. Thus, justification of their negative self-perceptions of mathematical competence was based on this experiencing. This was the case for Zuberi, for example.

> *When you try hard and you see nothing changing, you ask yourself why? This was the same for me. Then I remembered what my parents had told me when they saw F in maths in my school reports: Our family has no talent in maths. That's all. (Zuberi)*

Perceived low mathematical competence had serious consequences for these students' choice of school subjects to specialise in secondary school. All students with *Oppositional identity* ignored mathematics and chose to study Arts, even though mathematics was compulsory during the lower secondary school grades. Mapunda describes such a decision:

> *For me maths and science are things that I can't do well. If maths is difficult in secondary school, it is so with science too, because science has a lot to do with maths. It's not here like in primary school. Like if you think about physics, it's a lot of maths in it (Mapunda)*

Generally, the limited or negative *Mathematical experiencing* in secondary school among students with *Oppositional identity* diminished the chance for the development of positive self-perceptions of their mathematical competence. Their earlier self-perceptions of low mathematical competence were consolidated in secondary school not only by consistent failure in mathematics tests despite their increased effort, but also by parental perceptions of lack of mathematical giftedness that they communicated to their children, the difficulty of mathematical concepts, unsupportive teachers, and lack of books.

Conclusion

There were two important factors influencing students with *Oppositional identity* to perceive their mathematical competence negatively. The first was their *Mathematical experiencing* at home and in primary school that prevented them from sufficiently gaining mathematical skills. This consistently resulted in low mathematics test scores and negative self-evaluations of their mathematical competence. The second factor was these students' continued failure in mathematics tests in secondary school despite their increased effort. Their self-perceptions of low mathematical competence and consistent failure in mathematics tests also were caused by students' inability to surmount obstacles in the first and second grades of secondary school. Such *Mathematical experiencing* made these students justify their negative self-perceptions of mathematical competence as based on previous failures in mathematics tests and ignore mathematics and concentrate on the Arts.

6.4.2 *Mathematical experiencing* behind self-perceptions of mathematical participation

Home-based Mathematical experiencing behind self-perceptions of mathematical participation

There were no home-based interactions or individual involvement in mathematical activities among seven of the total students with *Oppositional identity*. Even though the four other students with this identity had parent-child interactions and had been engaged in home-based mathematical activities, this had little impact on their mathematics learning or on how they perceived their participation in relation to mathematics. First, interactions between parents and their children occurred irregularly in learning mathematics (and other basic skills) and only when parents had spare time. Second, parents were not strict in these interactions and it did not matter how successful their children were in learning mathematics. The reason for this lack of strictness was, as Mapunda narrated, that these parents only wished to introduce mathematics to their children as a way of orienting them to school life.

Third, before starting primary school, parents did not try to make their children think in certain ways about mathematics or about themselves in relation to mathematics when 'teaching' their children elementary mathematics. The parental interest was to enable their children to develop basic mathematical ideas as a way of orienting them to primary school mathematics. Zuberi reported such experience:

> *There was no talk about maths at home. They [parents] didn't say anything about maths, but they taught me to write, read and do arithmetic. (Zuberi)*

Even though these four students gained some basic knowledge of elementary mathematics, their participation in mathematical activities at home was rare, and they did not learn much. However, even with this little knowledge, the students could observe the difference in terms of mathematical knowledge between them and the children who did not have this knowledge in nursery school:

> *I didn't know much maths at that time, just a few things about maths. But this was somewhat important in nursery, especially when I saw others who did not know maths at all..They did not even know about counting. (Daudi)*

Generally, the mathematics-related home-based interactions for the four students with *Oppositional identity* lacked intensity and seriousness. They were irregular and parents did not coerce their children to be engaged in mathematics learning. As a result, the four students gained little mathematical knowledge and did not develop clear perceptions of their mathematical participation. On the other hand, the other seven students with this identity did not experience mathematical participation at home at all.

Mathematical experiencing behind self-perceptions of mathematical participation in primary school

Among students with *Oppositional identity*, there were more interactions and engagement in mathematical activities in primary school compared to the time before they began primary school. However, in the beginning of primary school, students varied in terms of the interactions and engagement, resulting in acquisition of mathematical knowledge. Unlike students with home-based *Mathematical experiencing* who learned basic mathematical skills relatively quickly, students without this background needed a longer time and more effort before they began to understand the basics and to acquire the skills. They also reported having sought peer support—an indication of their willingness to learn mathematics. This is illustrated in the following quotation.

> *It depended more on the teacher… Its true, but my friends also helped me. It wasn't easy for the teacher to teach and make us really understand in a short time. There were so many students but I asked friends to help me because they knew more and they were from better homes. So they helped me learn how to do arithmetic and to write. If the teacher didn't come to class, it was the time to ask friends to help me, or sometimes when we played outside. (Ema)*

As students continued with primary school, the parental role in their learning of mathematics became insignificant even for students with home-based *Mathematical experiencing*. At the same time, the students could experience more parental emphasis on other subjects, such as reading. However, even such parental role was lacking among the students who had no home-based *Mathematical experiencing*. They tried to study mathematics on their own at home as in the case of Mary.

> *No one helped me. They had no idea of what I was doing at school. It was up to me to find time and do my homework or practice anything that I did in school. I used to go to sleep late at night. (Mary)*

After attending primary school for a long time, they developed foundations for subjects such as English, general science, history and geography but began to concentrate less on mathematics. One reason was that some parents believed that their children would not be able to do well in mathematics because they had not been successful in mathematics after spending a long time at school. This negative view was reflected in those parents' reactions to their children's academic performance reports as reflected by Zuberi:

> *They became somehow uncomfortable when they found that I got low marks in other subjects not in maths. My mother said that we are not maths people, we have no special ability to do maths well. (Zuberi)*

Another reason for low mathematical participation was the students' perception that subjects other than mathematics were easier to learn, particularly in higher grades, which resulted in spending more time learning these other subjects. However, the students began to pay more attention to mathematics when approaching the final primary school year. The reason for this increased attention and engagement was the students' need to pass the final mathematics examination. Although their final primary school examination results qualified students with *Oppositional identity* to join secondary school, their results were mostly moderate and based on hard work.

To sum up, there was only a minimal degree of interactions and engagement in mathematical activities among students in lower grades of primary school. But their mathematical interactions and engagement increased during the final year of primary school when they were concerned with passing the final examination and hoped to join secondary school. Moreover, the role of parents in fostering their mathematical participation and learning was weak. Likewise, teachers were overwhelmed by large class sizes, which resulted in inadequate teacher-student interactions. On the other hand, peer support, being initially minimal, increased towards the end of primary school.

Mathematical experiencing behind self-perceptions of mathematical participation in secondary school

The students with *Oppositional identity* had a poor mathematical background and they also were aware of this. They perceived themselves as individuals with low mathematical competence. Despite this deficiency and self-perception, these students were willing to learn secondary school mathematics with the hope that in this boarding school (where students would be more settled) it would be possible for them to develop their mathematical competence through an increased effort as Zuberi recalled:

> *I knew I wasn't good at maths...because I wasn't good in primary school. It was like that, but I was thinking that maybe things could be different here because we stay here and study. We don't have to go and come back every day, as it was when I was in primary. So, maybe I become good at maths like others. (Zuberi)*

However, interactions and involvement in mathematical activities that would result in an increase in these students' mathematical competence were obstructed by difficulties related to the new language used for teaching (English). In particular, they experienced difficulties in understanding the mathematical terms, as commented on by Edwin:

I was very good in English before I came over here. I think I'm still the best one. But the English in maths was terrible. It wasn't normal English. I got problems when I tried to understand it. (Edwin)

In addition, these students (like the students with positive identities) lacked support from their mathematics teacher in the second grade of secondary school. This experience was particularly detrimental to these students because they had poorly developed mathematical skills and self-perceptions of low mathematical competence. Zuberi and Ema, for example, reported these experiences as follows:

Yes I was bad at maths, but then I felt I can't do maths anymore because the teacher didn't help me. So, who could help me? (Zuberi)

She was difficult…Sometimes she could teach well but at many times not. She wasn't a good teacher. She gave us very difficult tests and just a few students passed her test…One day she said to me that even if I worked hard I couldn't do maths well. She told me that's how I was. (Ema)

Consequently, these students began to give up on learning mathematics. Finally, their choice of Arts as their specialised subjects marked the end of their willingness to participate in mathematical activities after the beginning of third grade. Instead, much of their energy was directed to the Arts. As Edwin remarked, this mathematical unwillingness was associated with students' withdrawal from mathematics (giving up) and a dislike for mathematics:

I gave up and I didn't like maths anymore. I didn't like going to maths class but I went because I was afraid of punishment. You know. I still do now. (Edwin)

In short, the students' initial willingness to participate in mathematical activities during the first grade in secondary school was obstructed by their deficient mathematical background and a sense of incompetence in mathematics resulting from evaluations of their low mathematical performances and abilities in primary schools. Incomprehensibility of mathematical concepts in English and an unsupportive teacher in the second grade further frustrated these students. These difficulties together with their specialisation in Arts (which in their view was unrelated to mathematics) were followed by the students' poor involvement in mathematical activities and their concentration on Arts instead.

Conclusion

Home-based involvement in mathematical activities among students with *Oppositional identity* was limited for four students and not experienced at all among the rest of the students. All the students were involved in mathematical activities in their early primary school grades. However, this involvement became weak in the upper primary school grades due to the increase in mathematical complexity, decrease in mathematics tests, and a developing sense of mathematical incompetence. Yet, the students' need to pass the primary school final examinations compelled them to increase their mathematical participation during the last primary school grade. In the first grade of secondary school, these students had been willing to learn mathematics but were undermined by the deficiency in their mathematical skills and perceptions of mathematical incompetence resulting from evaluations of their low mathematical performances in primary school. Incomprehensibility of mathematical concepts and an unsupportive teacher in the second grade further frustrated these students. Due to these difficulties and their specialisation in Arts, the students discontinued their involvement in mathematical activities and concentrated on Arts instead. At the time of this study, these students perceived themselves as not actively involved in mathematical activities.

6.4.3 *Mathematical experiencing* behind self-perceptions of mathematical commitment

Home-based Mathematical experiencing behind self-perceptions of mathematical commitment

Only four of the students with *Oppositional identity* had experiences of elementary mathematics at home. But the mathematics learning conditions at home, such as lack of parental emphasis on mathematics learning and parental interest mostly in literacy skills, resulted in limited participation in mathematical activities among these students. Consequently, the home-based development of their commitment to learning mathematics was limited. Instead, they seemed to have developed commitment to reading and writing that was encouraged and supported by their parents as Mapunda reflected:

> *No I didn't feel that this is something [mathematics] I wish to do every now and then. But reading, yes, I was feeling good to learn to read, also to write something...They [parents] didn't teach me a lot of maths. Maybe it wasn't their interest. They [parents] taught me a lot of reading and writing but I didn't learn maths much. (Mapunda)*

Limited participation in mathematical activities continued among the students even in nursery schools where more emphasis was put on playing than on academic activities. Consequently, *Mathematical experiencing* among students with *Oppositional identity* was not intensive enough for them to commit themselves to mathematics learning and to develop a sense of who they were in terms of mathematical commitment.

Mathematical experiencing behind self-perceptions of mathematical commitment in primary school

All students with *Oppositional identity* had begun to develop a strong commitment to learning arithmetic during their first primary school years. However, after self-evaluation based on decreasing mathematics test scores in higher grades, their mathematical commitment began to weaken. This pattern had developed along with the students' increasing doubts about their mathematical competence and their perceptions of mathematics as a difficult, uninteresting and confusing subject. Edwin describes such changes in perceptions:

> *I didn't feel any pressure put on me to do maths. I didn't even like it because everything in maths was getting harder, and maybe it also was confusing. Maths in the beginning of standard 5 wasn't nice like arithmetic in standard one or two. It was different. So I said to myself why should I waste time in maths? Why shouldn't I use my time for science, English and geography?' These were fine subjects and I liked them. They were difficult but I did well. (Edwin)*

Yet, another change occurred in their final primary school year. Like other students who participated in the study, students with *Opposition identity* were concerned with passing the final mathematics examination, which was necessary (along with passing other subjects) to increase chances for admission to secondary school. Despite low mathematics performance records and perceptions of low mathematical competence, *Oppositional identity* students increased their effort in mathematics in order to pass the final (national) examination. But the difficulty in learning mathematics in upper primary school grades lead to the loss of their mathematical commitment, and they began to view themselves as not committed to mathematics as Ema illustrated:

> *I worked hard just when an exam ahead. I didn't feel like, yes, this [mathematics] is what I like or this [mathematics] is something I feel like continuing to do. It was just something to pass for me. (Ema)*

On the whole, while the students' commitment to learning mathematics in their first primary school grades was genuine (i.e., they really wished to know mathematics) and directed towards mastery of arithmetic skills, increase in the difficulty of mathematics and these students' doubts about their mathematical competence in higher primary school grades weakened their sense of commitment. Although the students increased their involvement in learning mathematics during the final year, this involvement was accompanied by their view of themselves as uncommitted to learning mathematics. At this stage, their aim was only to pass the final mathematics examination and thus to increase their chances for admission to secondary school.

Mathematical experiencing behind self-perceptions of mathematical commitment in secondary school

In the beginning of the first grade in secondary school, students with *Oppositional identity* were willing to learn mathematics and began to "work hard" in mathematics despite their limited mathematical background. They believed that in a new environment (a boarding school) where there were no home-related interferences (e.g., domestic work), they would gain mathematical skills through increasing their effort. But this willingness and commitment did not last long. With the previously developed perceptions of low mathematical competence and problems in learning mathematics due to difficult concepts and an unfriendly teacher, *Oppositional identity* students detached themselves from mathematical activities mostly during the second grade of secondary school. The choice to specialise in Arts became their only best alternative. Ema, for example, reported her decision on mathematics in the following way.

> *When the time to choose Arts came I became happy because it was time for me to quit maths for ever…Maths is impossible, so what do you do? You just push it out of your way. This is what I did. It gives me time to do other things well and freely. (Ema)*

While giving up on learning mathematics, these students had justifications to support their decision to give up (besides the justification that they had low mathematical competence). First, they understood the application of mathematics to physical sciences, but they regarded mathematics as useless to them as they could not master it. Another justification was that the Arts these students chose to study did not require the knowledge of mathematics as Edwin narrated:

> *You can't continue doing something if you know it can't help you because you're not good at it. You can't use it anywhere. This is why I said to myself that enough is enough and I go with Arts and so I won't need maths anymore. Maths can't bother me anymore. (Edwin) ["you" refers to 'I']*

Conclusion

Even though mathematical commitment among students with *Oppositional identity* began to develop in their early primary school years, it weakened during upper primary school grades. This weakening was due to the students' inability to do well in the more complex mathematics, which resulted in a decrease in their mathematical performances despite their increased effort and development of self-perceptions of low mathematical competence. These students withdrew their commitment to mathematics particularly in the second secondary school grade, due to similar reasons plus difficulties such as lack of textbooks. Instead, they increased their commitment to the Arts because they excelled in such subjects and could envision their future careers as related to them. As a result of this *Mathematical experiencing*, these students developed a self-perception of not being committed to mathematics.

6.4.4 *Mathematical experiencing* behind self-perceptions of mathematical ambition

Home-based Mathematical experiencing behind self-perceptions of mathematical ambition

In home contexts, parents of the four students with *Oppositional identity* whose children experienced mathematics at home did not influence the development of their children's sense of mathematical ambition such as by setting clear achievement goals for them. Accordingly, these children did not clearly think in terms of goals when learning mathematics. This was the case even when these students attended nursery school. Mapunda and Zuberi recalled these experiences:

> *I didn't think about any goal or what I should really do. It's like that now but it was not at that time. (Mapunda)*

Even [in nursery school] we didn't think at all that I must get A, or I must be the best in maths or reading. (Zuberi)

Due to the limited home-based *Mathematical experiencing* that did not contribute to the development of their mathematical ambition, these students could not have any clear self-perceptions of their ambition with respect to learning mathematics before they started school.

Mathematical experiencing behind self-perceptions of mathematical ambition in primary schools

Mathematical ambition in the earlier grades of primary school did not constitute any specific achievement goals among all students with *Oppositional identity*. But even with this lack of specific mathematical goals these students desired to master the basic arithmetic skills as in Zuberi's case.

I know that what I learned at home and in nursery wasn't enough. It was too little. So I needed more. I wanted to know arithmetic well. (Zuberi)

However, all these students were affected by factors that hindered mathematical experiences and identity development during their upper primary school grades. These consisted of factors such as lack of mathematical interactions and weak engagement with mathematics, developing self-perceptions of low mathematical competence due to continued low performance despite increased effort, and the weakened mathematical commitment as a result of these hindrances. Students had turned more of their attention to subjects other than mathematics during these grades and their mathematical ambition had become very low. After these experiences and lack of mathematical ambition, students' low performance outcomes were mostly associated with a sense of indifference as in Edwin's case:

I didn't care about it. Nobody said anything about it. My parents just checked how I did in all school subjects. I think maths wasn't important for them. So I did well in other subjects. It was fine if I got 20% or 40% or even 10%. It was just ok. (Edwin)

But again during the final primary school year, the students began to perceive the importance of mathematics in increasing their chances for admission to secondary school. As students strived to prepare themselves to pass the final examination, they set specific mathematics achievement goals. These were based on grades (e.g., D or C) that were not highly ambitious (compared to those set by students with positive mathematical identity), but the students worked hard to achieve them. At this stage, a high mathematics test score was a good predictor of their success in the final examination and thus resulted in feelings of relief, hope and optimism. In contrast, their failure in mathematics tests was followed by experiences of disappointment as was the case with Mapunda:

> *If you got anything higher than F it was a success at that time. I felt that now I'm really prepared to pass the final exam and it felt really good. But if I got F, that was bad. I regretted that I had spent my time practicing maths. But in any case I kept on and on. It was really a struggle. (Mapunda)*

In sum, although ambition in terms of setting clear achievement goals was not apparent in their earlier primary school grades, students with *Oppositional identity* were strongly willing to learn mathematics at that time. However, this willingness diminished later when mathematics became more complex, leading to the development of their negative self-perceptions of mathematical competence with consistently low mathematics test scores. But in the final year, these students' mathematical ambition increased as reflected by their more specific achievement goals. These goals were related to passing the final examination by increasing their ability and to qualify for admission to secondary school. However, despite these experiences and increased effort during their final primary school year, these students did not perceive themselves as mathematically ambitious.

Mathematical experiencing behind self-perceptions of mathematical ambition in secondary school

Despite the challenges caused by the complexity of mathematical concepts, mathematics achievement goals were common among students with *Oppositional identity* in their first secondary school grade. Students were still optimistic about their possibilities for success in mathematics. This ambition was associated with particular emotional reactions when the goals were not achieved as expected. Ema, for example, illustrated such reactions she experienced when she did not realise her achievement goal.

> *I didn't do much maths in primary school and I always got low marks. But here I did a lot of work in form one because this is a new kind of school. I wanted to do well in maths but not to get A or B because that was too much for me, maybe C, but I didn't get even that. I felt bad because I just wasted time. I got disappointed. (Ema)*

Later, in the beginning of the second grade, the students lost their hope for success in mathematics. This was mostly due to failure in achieving their goals despite their increased effort and also because of their previously developed sense of low mathematical competence. The unsupportive mathematics teacher in this grade was also an important factor for their loss of hope for succeeding in mathematics. Consequently, these students experienced a loss of ambition in the sense that they no longer had set any achievement goals for mathematics. Instead, they reacted indifferently to their low mathematics scores. Zuberi, for example, reported these experiences:

> *I worked really hard but didn't get good mark. I knew the reason. I wasn't good at maths since primary school years, and the teacher couldn't really help me. She didn't help anybody. So, I stopped thinking about maths or how high I should aim at maths. (Zuberi)*

On the whole, these students' beginning sense of ambition in the first secondary school grade was weakened especially during the second grade. Students' perceptions of low mathematical competence, which they also had experienced in primary school, then resumed mainly due to their consistently low mathematics test scores despite increased effort and also due to the unsupportive teacher. As a result, these students gave up on learning mathematics and concentrated on the Arts instead. With this *Mathematical experiencing*, these students maintained their self-perceptions as individuals with no mathematical ambition.

Conclusion

Self-perceptions of mathematical ambition among students with *Oppositional identity* did not develop in home contexts because parents did not promote the habit of setting specific achievement goals and striving to achieve them during home-based interactions. In primary school, these students had strong willingness to gain mathematical skills in their early grades, and they strived to gain these skills without setting clear achievement goals. But this willingness and effort were weakened in their higher primary school grades mainly due to the increased complexity of mathematics but also because of limited interactions with teachers in the overcrowded classes. The more specific achievement goals in the final primary school grade did not indicate students' high ambition but rather were aimed at gaining minimal mathematical skills to increase the possibility of passing the final examination and qualifying for admission to secondary school. In secondary school, these students renewed their willingness to increase their effort in learning mathematics but despite their specific mathematical goals, their performance levels declined over time. The students' official records indicated that while these students' average annual mathematics test score was 16% in the first grade (the lowest in their class), this score decreased to 9% in the second grade and further to 8.5 in the third grade (the number of students in this calculation were eleven i.e., all students with *Oppositional identity* who participated in this study). These scores appeared to confirm the students' previously formed self-perceptions of low mathematical competence. Moreover, because of parental insistence that their children's lacked a mathematical gift (as shown in other sections of this chapter) and other factors such as an unsupportive mathematics teacher, these students became unwilling to learn mathematics. In the third secondary school grade, they did not set mathematical achievement goals anymore and they perceived themselves as students who did not have mathematical ambition.

6.4.5 Conclusion on *Mathematical experiencing* behind Oppositional identity

The limited home-based mathematical interactions and learning of mathematics characterised experiences of four of the eleven students with *Oppositional identity* while the lack of early mathematical experiences characterised the rest of the students. Consequently, *Mathematical experiencing* had little or no impact on the development of these students' positive mathematical identity. This unsupportive *Mathematical experiencing* accompanied these students into primary school due to two main factors. First, over-crowded mathematics classes prevented teachers from interacting with individual students while teaching mathematics. Lack of teacher-student interactions in turn impeded students' efforts to gain mathematical knowledge while in class. Second, parents' perceptions of their children as lacking a gift for mathematics and their transmission of these views to their children significantly contributed to the children's consistent failure in school mathematics tests. The perception of low mathematical competence resulting from the students' self-evaluation of these experiences continued in secondary school where the difficulty of mathematical concepts, unsupportive teacher, and a weak mathematical background strengthened these negative perceptions. This resulted in the students' low willingness to participate in mathematical activities. Moreover, the students withdrew themselves from learning mathematics and concentrated on the Arts in the third grade of secondary school. They perceived themselves as mathematically incompetent and as not participating in learning mathematics, and as uncommitted to learning mathematics with lack of mathematical ambition. The negative self-perceptions were supported by these students' tendency to justify their negative mathematical identity based on their previous low mathematics test scores. The students opposed learning mathematics and were strongly unwilling to learn mathematics in the third secondary school grade in particular. Their continued unsupportive *Mathematical experiencing* resulted in *Oppositional identity*.

6.5 Summary on *Mathematical experiencing* behind positive and negative identities

The preceding sections of this chapter present findings on *Mathematical experiencing* as an essential process for students' positive and negative mathematical identities to develop. In the following sections of this chapter, I summarise the findings.

6.5.1 Home-based Mathematical experiencing

Mathematical experiencing began at home for students with positive mathematical identity, but the nature and degree of home-based *Mathematical experiencing* varied with the type of mathematical identity. This experiencing was positive and more intensive among students with *Innate ability identity* compared to those with other discerned mathematical identities. Students with this identity were regularly taught mathematics by their parents, often under strict and coercive conditions. In these interactions, parents also contributed to their children's views of themselves as mathematically gifted. As a result, these children tended to evaluate themselves as mathematically competent even before beginning their primary school. In addition to parental perceptions of giftedness, their positive self-evaluations were further strengthened by their interactions with other children who had less or no mathematical skills. These features constituted the basis for the development of their positive self-perceptions of mathematical competence.

However, home-based *Mathematical experiencing* among students with other positive mathematical identities (*Persistent effort* and *Image-maintenance*) was not as intensive as it was among students with *Innate ability identity,* and some students with *Persistent effort* and *Image-maintenance* identities did not gain mathematics-related experience in their home contexts. The students with *Persistent effort* and *Image-maintenance* identities who had undergone home-based *Mathematical experiencing* gained mathematical knowledge and began to develop mathematical identity through interactions with their parents at home. However, these interactions were limited and thus their knowledge was less developed compared to that gained at home by students with *Innate ability identity*. Instead, home-based interactions especially among the students with *Persistent effort identity* stressed the importance of increasing effort for success in mathematics.

According to the framework of *Mathematical experiencing* presented in Chapter 2, the initial form of the cycle of *Mathematical experiencing* for children with *Innate ability identity* was formed through mathematical participation (i.e., individual involvement in mathematical activities and interactions in learning mathematics), characterised by parental coercion and parent-child interactions before primary school. When children gained mathematical skills and evaluated themselves positively, the most important *Fostering factor* was students' own liking of mathematics and willingness to gain mathematical skills. Parents and home-based learning activities represented *Contextual factors* that supported these children's acquisition of mathematical skills and the development of their positive self-perceptions of mathematical competence. Similarly, among children with *Persistent effort* and *Image-maintenance* identities who had experienced mathematics at home, the initial form of the cycle of *Mathematical experiencing* was formed at home through less intensive parent-child interactions before primary school. Despite the deficient *Contextual factor* (parent-child interactions) and the resultant limited mathematics knowledge, the children could evaluate themselves positively and enhanced their liking of mathematics. The parent-child interactions and the children's liking of mathematics (a *Fostering factor*) supported the children's learning of mathematical skills and development of mathematical identity. However, the initial form of the cycle of *Mathematical experiencing* among children with *Persistent effort* and *Image-maintenance* identities who had not experienced mathematics at home was formed in primary school.

Negative parental influences on children's thoughts about their mathematical competence constituted another important feature of *Mathematical experiencing*. This applied largely to the parents of the students with *Oppositional identity*, most of whom did not expose their children to mathematics. The few parents who were involved in their children's learning of mathematics did so rarely, concentrating more on developing their children's reading and writing skills. Moreover, these parents perceived their children as lacking a gift for mathematics and communicated this perception to their children. Consequently, the *Mathematical experiencing* cycle for students with *Oppositional identity* did not clearly begin to develop in home contexts where parents represented a *Contextual factor* that limited children's learning of mathematics.

To sum up, these findings demonstrate that different mathematical identities existed in a single mathematics classroom because students had come with different mathematics-related experiences. The primary factor for the differences was the extent to which parents were involved in their children's *Mathematical experiencing* and development of mathematical identities. Intensive parental involvement during early stages of mathematics learning was more likely to ensure positive development of children's view of themselves in relation to mathematics.

6.5.2 School-based Mathematical experiencing

Mathematical experiencing in primary school

Identity-based differences in *Mathematical experiencing* were also found in primary school among the students who participated in the study. *Mathematical experiencing* for students with positive identities favoured the development of their mathematical identity. Their mathematical participation in primary school resulted in high performance and positive mathematical self-perceptions, especially perceptions of their high mathematical competence. However, students with more intensive home-based *Mathematical experiencing*, particularly those with *Innate ability identity*, participated in primary school mathematical activities more easily and successfully than students with other positive identities. Despite these students' stronger mathematical background, their parents still supported them (e.g., by buying them mathematics books) though not as intensively as was the case before primary school. For example, the parents bought their children mathematics books. These *Contextual factors* and positive self-perceptions of mathematical competence contributed to students' success in mathematics and resulted in the maintenance of their self-perception as mathematically gifted. Thus, the strengthening of these positive self-perceptions of mathematical competence among students with *Innate ability identity* in primary school seemed to mark the beginning of the complex form of the cycle of *Mathematical experiencing* in which liking of mathematics was no longer a key *Fostering factor*.

Emphasis of effort as an essential attribute for success in mathematics most notably characterised *Mathematical experiencing* among students with *Persistent effort* and *Image-maintenance* identities. Increase in these students' mathematical knowledge and test scores resulting from an increase in their effort strengthened their perception that they were mathematically competent because of their effort. Whereas the key *Contextual factors* among these students were mathematics teachers and peers, the most important *Fostering factors* emanated from their positive self-perceptions of mathematical competence. The development of these positive self-perceptions of mathematical competence among students with *Persistent effort* and *Image-maintenance* identities in primary school suggest the beginning of the complex form of the cycle of *Mathematical experiencing* in which these self-perceptions of mathematical competence became central in enhancing and sustaining mathematical commitment and ambition (the identity-related *Fostering factors*).

Mathematical experiencing in primary school among students with *Oppositional identity* further supported the development of negative mathematical identity. Despite the effort to increase their problem solving skills and improve their mathematics test scores, these students mostly experienced failure in problem solving and tests. The failure occurred because of their weak mathematical backgrounds and *Contextual factors* (e.g., overcrowded classes limiting students' interactions with teachers and insufficient or lack of positive parental support) that impeded their mathematics learning efforts. In addition, some of the students' parents were indifferent while other parents attributed their children's low mathematics test scores to their lack of mathematical giftedness. Negative self-evaluations based on these experiences gave way to the development of these students' self-perceptions of low mathematical competence. In short, the initial form of the cycle of *Mathematical experiencing* for these students, fostered by their liking of mathematics in the early primary school grades, ultimately developed negative self-perceptions of mathematical competence due to the students' failure to overcome the limiting contextual factors and their weak mathematical background. Thus, the complex form of the cycle of *Mathematical experiencing*, which for these students was negative, can be considered as beginning to develop during the final primary school grades.

Mathematical experiencing in secondary school

In secondary school, there were challenges (e.g., difficulty in understanding mathematical concepts and lack of mathematics text books) to which students responded differently depending on the strength of their mathematical background and their mathematical self-perceptions, particularly self-perceptions of mathematical competence. Due to self-perceptions of mathematical incompetence and weak mathematical background, students with *Oppositional identity* were overwhelmed by the challenges. This ultimately led to their withdrawal from learning mathematics in secondary school. The teacher's unsupportive behaviour in class in the second grade and these students' decision to specialise in Arts constituted important *Contextual factors* for the students' withdrawal from learning mathematics.

Students with positive mathematical identity responded to the impeding *Contextual factors* (e.g., the difficult teacher in the second grade and shortage of books) in secondary school by employing various strategies to overcome them. Specifically, students with *Innate ability identity* studied mathematics mostly by themselves and then sought support from more knowledgeable persons like upper grade students, private tutors, and parents. On the other hand, students with *Persistent effort* and *Image-maintenance* identities increased their effort in mathematical activities and surmounted impeding *Contextual factors* through participation in self-study groups in which the students also supported each other in learning mathematics. As a result, these students gained mathematical skills and improved their mathematical performances. Furthermore, they continued to perceive themselves as mathematically competent and capable of enhancing their competence through increased effort. Students with positive mathematical identities continued their participation, and their mathematics test scores improved despite the lack of support from their teacher. Moreover, positive self-perceptions of mathematical competence, higher mathematics test scores, and perception of mathematics as useful to their personal lives (i.e., applicable to their specialised academic subjects) constituted important reasons for continuing to participate and succeed in mathematics.

There were differences in students' emotional reactions to their failure in problem solving or mathematics tests as well. Basically, emotional reactions were stronger among students with positive mathematical identity than among students with *Oppositional identity*. Unlike students with positive identity who felt sad or embarrassed after failure in a mathematics test, students with *Oppositional identity*, especially in the third grade, reacted indifferently (i.e., with an I-don't-care attitude) especially in their third secondary school grade. Finally, endorsement through justification was expressed by all students regardless of the type of their mathematical identity. While students with positive mathematical identity referred to their previous mathematics achievement and test scores as reasons for perceiving themselves as mathematically competent, students with *Oppositional identity* pointed to their previous and consistent mathematical failure as the reason for their negative self-perceptions in relation to mathematics (especially in relation to their mathematical competence).

The exercise of agency (e.g., employing strategies to overcome challenging *Contextual factors* or deciding to withdraw from mathematics), students' mathematics-related commitment or lack of it, thinking about the future, and strong positive or negative mathematical self-perceptions are theoretically understood as features of mathematical identity. Appearance of these features suggests mathematical identity had become more cohesive (compared to its early development in primary school) and more strongly influenced students' learning of mathematics in secondary school. We can thus conclude that the second *Mathematical experiencing* cycle was more clearly taking place during the students' secondary school grades. On the other hand, the lack of mathematical commitment and ambition among students with *Oppositional identity* marked the breaking of the second *Mathematical experiencing* cycle in the beginning of the third grade. The most important factor in this breaking was the students' self-perceptions of low mathematical competence accompanied by their specialisation in Arts, which did not require knowledge of mathematics. Finally, the weakened mathematical commitment and ambition among students with *Image-maintenance identity* in secondary school suggest that positive self-perceptions of mathematical competence are not always associated with strong mathematical commitment and ambition. Instead, how students perceive the usefulness of mathematics to their personal lives is an important mediating factor between mathematical identity and commitment to learning mathematics.

Generally, despite the impeding *Contextual factors* in secondary school, *Mathematical experiencing* continued to favour the development of positive mathematical identities among students with *Innate ability*, *Persistent effort*, and

Image-maintenance identities. In contrast, this experiencing continued to enhance the negative mathematical identity among students with *Oppositional identity*, leading to their withdrawal from learning mathematics.

6.5.3 Overall conclusion

Four students' mathematical identities, namely, *Innate ability identity, Persistent effort identity, Image-maintenance identity,* and *Oppositional identity*, were identified in Chapter 5. Characteristics of *Mathematical experiencing* for each identity, analysed in this chapter, provide more background detail for each identity. The degree of parental involvement in the students' mathematics learning varied across identities, and this variation had implications for children's success in mathematics at school. Important lessons on effective parental involvement in children's mathematics learning can be drawn from parents for students with *Innate ability identity.* It can be learned from these parents that pre-school intensive and persistent parental involvement in children's mathematics learning is an effective way of laying mathematical foundations and developing positive mathematical identity for their children's mathematical success in school. It can also be learned that continued support for these children at school is an effective way of helping them succeed in learning mathematics. The importance of this parental role was evident in their children's consistent success in school mathematics despite the enormous school-related challenges such as overcrowded classes and a shortage of mathematics teachers.

In contrast, the limited amount or lack of such preschool parental involvement and lack of parental support at school was accompanied by lesser mathematical success in school among most of the students with other positive and negative identities compared to students with *Innate ability identity*. The extreme case was the students with *Oppositional identity* who, despite their increased effort in primary school, experienced frequent failure. Their weakening mathematical identity and lack of mathematical basic skills in primary and secondary school was the reason for giving up learning mathematics and becoming resistant to such learning in their secondary school third grade. A discussion of key findings on mathematical identities and *Mathematical experiencing* for each identity is presented in Chapter 7.

7 DISCUSSION

The aims of this study were to identify characteristics of students' mathematical identity and examine the development of this identity in a Tanzanian mathematics classroom. Analysis of data revealed four types of identity—*Innate ability, Persistent effort, Image-maintenance*, and *Oppositional*—and that these identities differed depending on how the students had experienced mathematics during the years prior to the fieldwork. In this chapter, I discuss these results presented in Chapters 5 and 6 to contextualise them within the literature on mathematical identity and indicate the extent to which this study contributes to the research on mathematical identity. This was the primary goal of this thesis. However, the findings also have practical implications for particular aspects and research of mathematics learning in Tanzania. These are briefly discussed as part of "reflections and recommendations" in section 7.5.This chapter begins with a general discussion of the research findings on the students' mathematical identities and then focuses in more detail on specific identities.

To begin with, I introduced in Chapter 5 two broad categories of students' mathematical identity that existed in the same classroom characterised by an instructional approach that gave most of the authority to the teacher and prevented students from exercising their agency and shaping their own learning (Boaler, 1997; Cobb et al., 2009). Previous studies suggest that variations in students' mathematical identities depend on the instructional approach and the consistency of applying the approach in the classroom (e.g., Cobb et al., 2009). Approaches that provide opportunities for students to exercise their agency (e.g., to plan, make choices and decisions, and manage their learning) as they take part in mathematics learning, have been found to be associated with students' positive view of themselves. In contrast, instructions and classes in which such opportunities are limited are linked with students' conflicting view of themselves in relation to mathematics; that is, their sense of agency is challenged (Boaler, 1997; Boaler & Greeno, 2000).

The present study focused on students in a secondary school class in which students' chances to exercise their agency were consistently (and over time) limited by teacher dominance. Students' narratives in this study suggested that a possibility existed for not only negative but also positive mathematical identities to develop in such classes. Accordingly, an instructional approach in a secondary school classroom seems to represent only one of several factors influencing the development and impact of students' mathematical identity. Furthermore, the findings of this study revealed that students' previous mathematical experiences represented a key factor in their identity development (cf. McGee, 2015; Sfard & Prusak, 2005). If students have previous positive experiences of mathematics and have consequently been able to form a positive and coherent sense of themselves in relation to mathematics, they are likely to sustain this positive sense of self even when opportunities to exercise their agency are limited or not provided in the current class (cf. Anderson, 2007; McGee, 2015). On the other hand, how students imagine their future in relation to mathematics is also an important factor in their mathematics learning (Anderson, 2007). Students' narratives suggested that picturing a positive future relationship with mathematics (from students' points of view) can sustain students' mathematical activities and a positive mathematical identity even in circumstances where a teacher-dominant instructional approach is employed.

Previous studies link mathematical identities further to students' specific behavioural tendencies. Accordingly, positive identity is not only associated with demonstration of high commitment to mathematics (evidenced in students' active involvement in mathematical activities), but also with a tendency to be opposed to the denial of opportunities to exercise their agency, for example, by abandoning the class and joining other classes where such opportunities are offered (Boaler, 2002a; Boaler & Greeno, 2000; Cobb et al., 2009). This behaviour was also observed in the mathematics classroom studied here. Students with positive mathematical identity tended to sit in front of the classroom (i.e., closer to the teacher) whereas those with negative mathematical identity tended to avoid front seats and preferred to sit at the back of the classroom. Moreover, while students in the former category were strongly committed to mathematics, those in the latter category demonstrated unwillingness to take part in mathematical activities. This oppositional behaviour was not, however, demonstrated in class by students with positive identity. This was presumably because they were aware of being liked by the teacher due to their commitment to learning mathematics. The teacher more frequently initiated interactions with committed students than with those who seemed to lack commitment by asking questions or praising them in class, for instance. These findings suggest that mathematical identity, whether positive or negative, is reflected in behavioural tendencies (actions) accordingly in favour or disfavour of mathematics.

I discuss the findings of the study more specifically in the next sections. The first focus is on specific types of students' mathematical identity: the positive categories of *Innate ability identity, Persistent effort identity*, and *Image-maintenance identity*, and the negative category of *Oppositional identity*. Second, I discuss the nature of students' previous *Mathematical experiencing* associated with these identities as illustrated in the conceptual framework in Chapter 2. The role of the home- and school-related *Contextual factors* is emphasized in this *Mathematical experiencing*. The discussion on different mathematical identities and the nature of *Mathematical experiencing* behind these identities is aligned within the social cultural and social psychological viewpoints that emphasise the centrality of contextual or environmental factors in mathematical identity development (e.g., Sfard & Prusak, 2005; Wenger, 1998). This chapter ends with the researcher's reflections and discussion of the implications of the study with suggestions for further research in the area.

7.1 Positive mathematical identities

Positive mathematical identity develops in classes where students are offered opportunities to exercise their agency (Boaler, 2002c; Cobb et al., 2009). Such opportunities lacked in the mathematics classroom on which this thesis focused but three kinds of positive mathematical identities (see Chapter 4) were identified. Although the perception of having the capacity to succeed in mathematics was a common feature of these identities, each type of mathematical identity entailed distinct characteristics. I discuss both the common and specific features of these three positive mathematical identities in the following sections.

7.1.1 Innate ability identity

The most distinguishing feature characterising *Innate ability identity* was the students' perception of having innate capacity for success in mathematics and their negative perception of prolonged effort. These students considered working hard in solving a single mathematical problem as indicating low mathematical competence. Although this view is often considered as misleading (e.g., because of its potential to impede students' persistence in solving challenging problems), it prevails in schools (Anderson, 2007). It derives from how students have experienced mathematics and evaluated their experiences. For example, continued success in mathematics, quickness in getting correct answers, and positive parental influences seem to generate students' perceptions of competence as nature-given (Anderson, 2007; Gee, 2001). Similarly, students with *Innate ability identity* had frequently succeeded in previous mathematics tests, and their test scores were higher in primary and secondary school compared to the students with other mathematical identities. These students experienced mathematical success even after they had spent minimal effort. Evaluation of their own mathematical performances against other students' lower performances despite their great effort seemed to positively shape these students' self-perceptions of their mathematical competence.

As reported above, the role of parents is critically important in the development of children's perceptions. In the process of socialization, parents influence their children's perceptions of themselves as having or lacking an innate competence in mathematics (Anderson, 2007; Gee, 2001). In the present study, this kind of parental socialisation was stronger among students with *Innate ability identity* than among other students. Other specific features of *Innate ability identity* included the students' perceptions of additional characteristics needed for mathematical success. Preference to study mathematics mostly individually (except in the classroom in which interactions were necessary, mostly with the teacher) and to rarely seek support from peers in the same class represented such additional attributes. These students also considered themselves as highly ambitious (i.e., as individuals who set challenging achievement goals) and highly committed to mathematics. Moreover, students' mathematical identity is often associated with thoughts about their future in relation to mathematics (Anderson, 2007; McGee, 2015). This applied to the students with *Innate ability identity*. The perception of having an innate mathematical capacity was associated with their positive future thoughts related to mathematics — particularly thoughts about continuing to study mathematics in upper grades and colleges and then seeking a career related to mathematics. This future-oriented thinking adds meaning to students' mathematics learning (Anderson, 2007; Cobb et al., 2009; McGee, 2015). For students with *Innate ability identity*, as for those with other positive identities, mathematics learning was perceived as meaningful due to the applicability of their mathematical skills to physical sciences and the prospect of engaging in a career requiring knowledge of mathematics, such as work in mechanical engineering.

Furthermore, self-evaluation based on achievement of performance goals is inevitably associated with positive or negative emotions (Lazarus, 1991; Malmivuori, 2001). This relationship varies depending on how students perceive themselves with regard to mathematics, particularly how they perceive their mathematical competence (Bandura, 1997; Malmivuori, 2001, 2008). For students with *Innate ability identity*, self-evaluation based on achievement of ambitious targets (e.g., scoring the highest grade in a test) resulted in positive emotions, such as joy, while self-evaluation based on not achieving the ambitious targets was followed by strong negative emotional reactions, such as shame or embarrassment. These emotional experiences are often succeeded by a desire to strive more to improve achievement outcomes (e.g., test scores) (Hannula, 2006a), which again applied to students with *Innate ability identity*. For them, shame or embarrassment had to be overcome through various strategies (including attending private tutorial classes) to improve achievement outcomes. Although joy resulting from success was associated with their desire to succeed in future mathematics tests, it was seemingly less forceful than shame or embarrassment in making these students strive for mathematical success. This suggested that, as compared to positive emotions, negative emotions had stronger fostering influence among students with *Innate ability identity*.

According to Sfard & Prusak (2005), one of the ways of ascertaining identity is to assess the extent to which the narrator endorses (i.e., confirms) his or her identity. The students with *Innate ability identity* endorsed their mathematical identity by justifying their mathematical self-perceptions. They typically stated, for example that: "I am gifted in mathematics because this is what my parents have been telling me (the first justification) and my test scores have always been the highest in class (the second justification). This form of endorsement may have an important role in maintaining a positive mathematical identity. Students thus sustain their positive view of themselves with regard to mathematics by maintaining supportive justifications for their self-perceptions.

In short, *Innate ability identity* consisted of the perception of having innate capacity for mathematics that further sustained students' high commitment to learning mathematics when other factors such as high mathematics test scores supported their self-perceptions. These students' involvement in current mathematical activities was further supported by their optimistic thinking about the value of mathematics for their future activities. Moreover, positive and particularly negative emotional experiences based on self-evaluation of mathematical performances also characteristically had fostering impact on their mathematics learning for students with *Innate ability identity*. Lastly, students' endorsement of mathematical identity through justification of self-perceptions appeared to further sustain *Innate ability identity.*

7.1.2 Persistent effort identity

The main feature that distinguished *Persistent effort identity* from other positive mathematical identities was the perception of persistent effort as the key to success in mathematics and the disregard for the idea of inborn mathematical capacity as necessary for success. For these students, mathematical competence was not a fixed characteristic but depended on how much effort they spent (cf. Bandura, 1997). In particular, they perceived themselves as persistent persons who promoted their mathematical competence through persistent effort. Perceiving oneself as mathematically competent based on effort expenditure derives from one's previous encounters with mathematics and one's perception of the benefits of effort behind achievement outcomes (Bandura, 1997; Malmivuori, 2001). These students' test scores had improved relative to the increase in their effort. Their self-evaluation was mostly based on comparison between current and past test scores. In their view, improved mathematical skills and an incremental pattern of scoring were related to their mathematical competence that increased over time.

The preference to study mathematics in informal self-organised groups (organised after formal classes) was also most notable among students with *Persistent effort identity*, as compared to the students with other mathematical identities. The important role of peers in learning has been noted elsewhere though not specifically in regard to persistence in learning mathematics (e.g., Bandura, 1997; Damon, 1984; Owens, 2008). The reasons for this preference among the students can be found in the context of their mathematics learning. Clearly, informal self-organised study groups represented important student learning strategies. Learning from peers in a more relaxed manner out of classrooms seemed to enhance students' mathematical knowledge unlike learning from the teacher in formal class settings that were often characterised by strict discipline. The teacher in the studied mathematics class did not provide students with the opportunity to organise groups by themselves. He often organised students into pairs and allowed them to engage in brief discussions. However, the students apparently needed informal groups consisting of a more relaxed environment with like-minded members to learn mathematics in interaction with each other.

Persistent effort identity was also characterised by self-perceptions of high mathematical commitment and ambition developed through students experiences of mathematics (Anderson, 2007; Bandura, 1997; Weiner, 1986). The students had experiences of prior high involvement in mathematical activities and also the view of commitment and ambition as prerequisites for success in mathematics (Cobb et al., 2009). Moreover, *Persistent effort identity* was associated with future-oriented thinking in regard to mathematics—referred to as *imagination* or forethought by researchers (Anderson, 2007; Bandura, 2001; Wenger, 1998). While taking part in mathematical activities, students often imagine how useful mathematics will be to them in the future, and this imagination varies depending on how students perceive themselves in relation to mathematics (Anderson, 2007; Boaler, 2002b; McGee, 2015). Thoughts about continuing to study mathematics and then seeking a career related to mathematics also characterised students with *Persistent effort identity*. Because of the imagination of a mathematical future, they considered their current involvement in mathematical activities as important (Anderson, 2007; Cobb et al., 2009). In particular, these students were inspired by the prospect of applying their mathematical skills to science in upper grades and the possibility of getting a mathematics-related career.

As was the case with *Innate ability identity,* strong emotions were another important feature of *Persistent effort identity*. Students with this identity had experienced positive emotions such as happiness or joy after realising their mathematics achievement goals. In contrast, negative emotions such as disappointment were experienced after a failure to meet the targets. These emotional experiences are common in mathematics learning situations and are also closely associated with self-evaluations of performance relative to achievement goals (Bandura, 1997; Lazarus, 1991; Malmivuori, 2001). In addition, the relationship between emotions and self-evaluation is suggested to vary with the type of a mathematical identity and to be linked to a desire to improve achievement outcomes (McGee, 2015; Sfard & Prusak, 2005). Similarly, for students with *Persistent effort identity*, like those with *Innate ability identity,* emotional reactions were associated with a desire or urge to strive to learn mathematics in order to improve their performance (Bandura, 1997). This applied particularly to their negative emotional experiences as a way of recovering from such experiences. Positive emotions like joy after self-evaluations of success and negative emotions such as disappointment after self-evaluation of failure were associated with these students' willingness, or an urge to increase effort and improve future performances in mathematics tests.

Like *Innate ability identity*, *Persistent effort identity* was closely associated with students' tendency to endorse their mathematical identity by justifying their mathematical self-perceptions based on their previous mathematics success. Even when the students were asked questions that specifically sought data on how they perceived themselves in relation to mathematics, they tended to both express their positive mathematical self-perceptions and provide evidence of their previous mathematical experiences to justify why they perceived themselves as they did. This close relationship between expression of mathematical identity and justification appears important for understanding mathematical identity as linked to students' previous mathematical experiences of which the students are conscious.

In short, the students' self-perceptions of mathematical capacity emanating from an increase in effort characterised *Persistent effort identity*. These perceptions upheld the tendency among students with this identity to set ambitious achievement goals and commit themselves to these goals. The resultant high mathematics test scores and the perceived usefulness of mathematics for possible future careers fostered these students' continuation of learning mathematics. This continuation of learning mathematics was also fostered particularly by the students' negative emotional experiences and endorsement through justifications deriving from their self-evaluations based on previous mathematical performances.

7.1.3 Image-maintenance identity

The most distinguishing feature for *Image-maintenance identity* was the students' positive mathematical self-perception linked with a strong desire to also be perceived in this way by other students. However, students' strong commitment to study Arts rather than mathematics resulted in a declining pattern of mathematical performance (i.e., test scores decreased over time) despite their impressive performances prior to their third secondary school grade. Thus, to maintain their image as mathematically competent, these students strived to avoid failure in mathematics tests. Achieving at least a pass grade in mathematics would distinguish them from other Arts students who had extremely low mathematical competence and test scores. This strong desire for recognition has a theoretical explanation. Students with positive self-perceptions are often concerned with whether there is a difference between how they view themselves and how others (e.g., fellow students or teachers) view them in relation to mathematics (cf. Bohl& Van Zoest, 2002; Burke &Reitzes, 1991). A discrepancy may appear between how individual students perceive themselves and how they think others perceive them, which often has a basis in doubting one's competence(Stets & Burke, 2003; Turner & Stets, 2005). Decreasing mathematics test scores were the concern among students' with *Image-maintenance identity,* who also were aware that other students could judge their mathematical competence based on their scores. As a result, these students strived to avoid failure in mathematics tests.

However, due to decreasing mathematical commitment and ambition (associated with setting less ambitious goals), these students sometimes experienced failure. Test scores that indicated failure prompted the students to suspect that other students thought negatively about their mathematical competence (cf. Stets & Burke, 2003; Turner & Stets, 2005). This suspicion is usually accompanied by negative emotions (Stets & Burke, 2003; Turner & Stets, 2005) and an urge to reduce the experienced discrepancy, for example, by engaging in a behaviour that may improve one's image (Turner & Stets, 2005). Similarly, for students with *Image-maintenance identity*, self-evaluation and reflections resulting from failure and concerns about how they were to be perceived by other students resulted in strong negative emotions such as embarrassment or shame. These emotional experiences were further followed by increased effort to improve future mathematics test scores. In contrast, when the discrepancy disappears, positive emotional reactions will result (Op'tEynde, 2004; Turner & Stets, 2005). Accordingly, students with *Image-maintenance identity* experienced satisfaction when they got higher mathematics test scores and their perception of how others perceived them became more positive.

Like other positive identities, *Image-maintenance identity* was associated with future-oriented thinking (or future imagination) relating to mathematics. However, unlike students with *Innate ability identity* and *Persistent effort identity*, these students' future-oriented thinking was not in favour of mathematics. Instead, they envisioned studying Arts in future grades and colleges and also seeking arts-related careers. While students with other positive identities often described how important mathematics would be to their future lives (Anderson, 2007; Wenger, 1998), perceptions of the importance of mathematics was limited to the present situation among students with *Image-maintenance identity*; it did not apply to their future activities or lives. Succeeding in mathematics largely served as a means to preserve their image as students who were mathematically competent (cf. McGee, 2015).

Finally, like other positive identities, *Image-maintenance identity* was closely associated with students' endorsement of their positive mathematical self-perceptions. On the one hand, these students justified their self-perceptions of having capacity to succeed in mathematics. They used their previous high scores in mathematics tests (especially in the first and second secondary school grades) as reasons for perceiving themselves as mathematically competent. On the other hand, they presented justifications for their declining performance patterns (from the high scores in previous years to the current low scores) by pointing to the shift in their commitment from mathematics to the arts. The shift-in-commitment justification, which was not evident in other positive identities, was expressed seemingly to iron out the perceived contradiction between these students' self-perceptions of mathematical competence and their declining mathematics test scores. This endorsement thus had an important role in supporting these students' positive perceptions of their mathematical competence.

Generally, this discussion of *Image-maintenance identity* emphasises the idea that positive mathematical identity is not necessarily associated with high ambition, strong commitment to learning mathematics, positively imagined future relationship with mathematics, or high mathematics performances. *Image-maintenance identity* thus stands out as an exceptional positive mathematical identity. Self-perceptions of mathematical competence and concern for maintaining a positive image in relation to mathematics were the key features in this identity category.

7.2 Negative Oppositional identity

This section deals with students' negative mathematical identity, which in this study was characterised as *Oppositional identity*. The key feature of this identity type was the students' negative mathematical self-perceptions linked with their unwillingness (or oppositional tendencies) to take part in mathematical activities. Specifically, negative self-perceptions of mathematical competence that characterised all students in this identity category was associated with unwillingness (even resistance) to take part in assigned mathematical tasks (e.g., home work) and to interact with others in pairs organised by the teacher. They displayed low or non-existent ambition and commitment to learning mathematics. This finding suggests that while the role of the current teacher is important in the development of students' *Oppositional identity*, this identity is also linked to the students' previous encounters and self-evaluations related to mathematics (Allen & Schnell, 2016; Bishop, 2012). Based on consistently weak mathematical performances despite effort expenditure, students in the present study judged themselves as having low capacity for succeeding in mathematical activities. As a result of these judgments, they gave up learning mathematics mostly in the third grade of their secondary school. Before giving up, these students had set achievement goals and strived to realise them in specific mathematical tasks. But when their strivings were associated with frequent failure despite increased effort expenditure, students began to doubt their capabilities in executing the tasks and ultimately gave up. For these students, failure to succeed in mathematical activities and doubting their mathematical competence had begun several years prior to the third grade.

Students' negative mathematical self-perceptions and associated unwillingness to engage in mathematical activities were further related to the way they perceived mathematics. Students had come to view mathematics as a subject that was irrelevant to their imagined future studies and careers. Mathematics had thus been 'mentally' excluded from the list of subjects that were perceived as relevant to their lives. Consistent with this, Anderson (2007) argues:

> Students who do not see themselves as needing or using mathematics outside of the immediate context of the mathematics classroom may develop an identity as one who is not a mathematics learner. (p. 9)

However, despite the students' negating previous experiences and the perceived irrelevance of mathematics to their present and future lives, they were coerced into attending mathematics classes where their pattern of inactivity was strengthened with no actual learning (cf. Lerman, 2001). The link between negative mathematical self-perceptions and a tendency to be oppositional to such classes was evident in the classroom (cf. McGee, 2015; Martin, 2000). Students, while perceiving themselves as belonging to the Arts group, tended to sit in the back of the classroom and were often preoccupied with non-mathematical activities as opposed to students with positive identities who preferred front seats and being near the teacher.

Furthermore, for students with *Oppositional identity*, the link between mathematical self-perceptions and emotion was unique compared to students with positive identities. While students did not set achievement goals and did not strive to succeed in mathematics tests, they reacted to their extremely low scores with indifference. That is, they did not show interest or concern for their scores. Positive emotions associated with high scores or negative emotions associated with failure in a test were only experienced in the Arts to which students were committed. In rare cases in which the students had scored unexpectedly high in mathematics (though still low compared to students with positive identities), the emotional reaction was surprise.

Even though this emotional aspect of *Oppositional identity* is seemingly not evident in existing literature on students' mathematical identities, it can speculatively be explained in three ways. First, the emotional reaction suggests a significant disconnection between students and mathematics; students did not feel belonging to the community of mathematics learners (Anderson, 2007; Cobb et al., 2009; Wenger, 1998). Second, the reaction suggests that, due to previous negative experiences with mathematics, they had no hope in the subject even after an increased effort. Finally, it also suggests that since mathematics could not be mastered even with increased effort (as perceived by the students), it was useless for the students' present and future lives.

Lastly, *Oppositional identity*, like positive identities, was characterised by students' tendency to endorse their negative mathematical self-perceptions by justifying these self-perceptions based on previous mathematical experiences. However, the endorsement associated with *Oppositional identity* was different from one characteristic of positive identities. While students with positive identities cited their previous positive experiences to explain their positive self-perceptions, students with *Oppositional identity* cited previous negating experiences. Essentially, *Oppositional identity* was characterised by citations of frequent failure in previous mathematics tests in primary and secondary schools and of the associated fruitless effort they had spent on mathematics. The role of endorsement through justification seemed to be impeding. That is, justifying an oppositional (and negative) mathematical identity served to sustain it, thus holding students back from striving for success in mathematics.

In short, the features of *Oppositional identity*—students' negative mathematical self-perceptions, perceptions of mathematics as useless, indifference to failure in mathematics tests, and endorsement (through justification) of the negative mathematical self-perceptions—all characterised *Oppositional identity* as constituting an impediment to mathematics learning.

7.3 Summary on mathematical identities

Besides characterising students' mathematical identities as positive and negative, this discussion points to the importance of mathematical identity in learning mathematics. Positive mathematical identities, particularly their core component of positive self-perceptions of mathematical competence, can foster students to set ambitious achievement goals and commit themselves to learning mathematics. In contrast, negative identity impedes mathematical ambition and commitment. Second, the discussion suggests the occurrence of different students' mathematical identities in the same classroom regardless of a teaching approach employed. The main factor for this occurrence is the students' varying mathematical backgrounds (as discussed in detail in the next section). This, however, does not mean that the role of the teacher is unimportant in the further development of students' mathematical identity. Teachers have a crucial role in creating classroom environments that promote students' ability to understand mathematical concepts, solve mathematical problems, and improve performances on mathematics tests (Bishop, 2012; Boaler, 2002a; Cobb et al., 2009; Lerman, 2001). In such environments, students' negative mathematical identity can become positive and positive mathematical identities can be maintained.

Third, besides creating environments that promote students' mathematical identity, it is important to take into consideration how students view the relevance of mathematics to other subjects and to their imagined future careers (Anderson, 2007). This is because these factors can essentially limit (as was the case with *Image-maintenance identity*) or again foster the positive development of mathematical identities. Fourth, endorsement of self-perceptions through justification was found to characterise positive and negative mathematical identities and seemed to play an important role in sustaining an identity. Creation of environments that support students in gaining positive mathematical experiences can transform students' negative mathematical identity into positive mathematical identity and positive endorsement.

Finally, the observed classroom was part of a wider social and economic context (e.g., the school and government) and was affected by this context, for example, through education policies (e.g., performance evaluation criteria) or traditions and norms of schooling (e.g., the teacher as the main source of knowledge). For instance, the teacher's view of himself as the main source of mathematical knowledge in the observed classroom reflected the widely held view of a teacher as an authority in the class and school. Thus, his teacher-centred approach to teaching was the right one to him. Therefore, when analysing students' mathematical identities, it is also important to examine the broader socio-cultural school contexts in which these identities develop. Efforts to promote students' mathematical identity thus need to include reviews, for example, of school policies and norms related to the teaching and learning of mathematics.

7.4 Discussion on the nature of *Mathematical experiencing* behind mathematical identity

In broad terms, as shown in Chapter 5, students' current mathematical identities can be characterised as positive or negative. Chapter 6 suggests that positive identities are associated with previous supportive *Mathematical experiencing* while negative identity has previous negating or impeding *Mathematical experiencing*. This section discusses the nature of students' *Mathematical experiencing* associated with these identities in the home and school contexts. The conceptual framework of *Mathematical experiencing* proposed in Chapter 2 is used to frame this discussion.

7.4.1 Home-based Mathematical experiencing

Home-based *Mathematical experiencing* is important for the development of mathematical identity. The initial form of the cycle in the framework (in Chapter 2) explains such experiencing. Children are involved in *Concrete* and *Conceptual experiencing* during the first stages of mathematics learning at home. At this stage when mathematical identities are still at initial stages of development, children's mathematical involvement is fostered by their liking of and willingness to learn mathematics or parental coercion. At this stage of identity development, the role of parents is critical (Bleeker & Jacobs, 2004). Home-based socialisation is generally found to influence the development of children's self-perceptions (Cote & Levine, 2002; Erikson, 1968). Children are likely to perceive themselves consistent with how their parents view them (Aunola, et al., 2003; Bleeker & Jacobs, 2004). In the present study, some parents played an important role in helping their children to learn the basics of mathematics and literacy before and during school time. Apart from teaching, the parents had directed their children's thinking about themselves, for example, as mathematically gifted children. Such early *Mathematical experiencing* had made important contributions to the development of a particular kind of mathematical identity among the students in this study.

Specifically, prior to primary school, students with *Innate ability identity* were taught the basics of arithmetic and were socialised to perceive themselves as mathematically gifted. The concrete and conceptual experiencing for these students was more intensive compared to students with other identities. Parents, who often exercised the authoritative parenting style (Darling & Steinberg, 1993; Kordi & Baharudin, 2010), had created situations that encouraged competitiveness reflected in thinking in terms of achieving a given task and striving to perform it well and also in reacting emotionally to perceived success or failure. Students also had experienced strong parental reactions, such as praise or anger, to their (students') success or failure. Consistent with the discussion in literature on the influence of parents on their children's perceptions of themselves of having special qualities (particularly competence) for success in mathematics (Kordi & Baharudin, 2010; LeFevre, 2009), the impact of such *Mathematical experiencing* at home became apparent to students when they were in nursery school. For example, when they compared themselves with other students in terms of their mathematical knowledge and performance, they found themselves more successful than peers even when they spent minimal effort. Such concrete experiencing and associated self-evaluation further confirmed the views of their parents that their children were mathematically gifted.

Home-based *Mathematical experiencing* among students with other positive mathematical identities (i.e., *Persistent effort* and *Image-maintenance* identities) was not as intensive as it was for students with *Innate ability identity*. Additionally, although some parents created home-based environments to help their children gain basic arithmetic and numeracy skills, they mostly exercised a permissive parenting style (Baumrind, 1971; Darling & Steiberg, 1993) with respect to learning mathematics, that is, they were not as strict as were the parents for children with *Innate ability identity*. Other parents did not create such mathematical environments at all. Instead, an important feature of such identities associated with home-based *Mathematical experiencing* was the later development of the students' thoughts about themselves in relation to mathematics. With limited background in mathematics (among many of the students), these students learned that effort was essential for success in mathematics (Bandura, 1997;

Malmivuori, 2001; Weiner, 1986). Accordingly, the students had perceived themselves as mathematically competent or incompetent depending on the degree to which their effort had resulted in desired achievement outcomes. It is the consistent correspondence between effort and success that, over time, had led to positive mathematical self-perceptions and identity denoted here as *Persistent effort* and *Image-maintenance* identities (Boylan, 2004; Cobb et al., 2009).

Parents can also play a negative role with regard to their children's view of themselves as mathematics learners. This can be done, for example, through denying children opportunities to experience parental support at home before they begin school or through socialising children in ways that do not motivate them to have positive experiences of mathematics. As the data for this thesis suggest, these factors encourage students to ignore mathematics and concentrate more on other subjects. In this study, students with *Oppositional identity* were not taught the basics of mathematics as intensively (and strictly) as students with *Innate ability identity* were prior to primary school. Moreover, some parents had later communicated to their children that weak performances in school mathematics resulted from lack of mathematical giftedness. Thus, less intensive or lack of *Mathematical experiencing* at home was associated with students' failure in mathematics later at school and also with parental attribution of failure to the uncontrollable factor of lack of innate ability.

In sum, home-based *Mathematical experiencing* played an important role in students' development of basic mathematical knowledge and mathematical identities. In particular, the role of parents was crucial in this process. Through creating home-based environments for concrete experiencing, parents could enhance their children's basic mathematical knowledge and the development of positive sense of self in relation to mathematics. However, lack of such experiences and parental support could contribute to negative identity development leading to desertion of mathematics.

7.4.2 School-based Mathematical experiencing

Schools are the most important social contexts that provide opportunities for children to take part in mathematical activities and evaluate themselves based on socio-culturally established norms and standards (e.g., grades). They reflect on events in the classroom, assess their experiences, and develop their mathematical self-perceptions as well as perceptions of mathematics as a subject of study (Malmivuori, 2001; McGee, 2015). Since mathematics is not experienced the same way among students in a given classroom, students interpret the meaning of their mathematical experiences differently and come to learn about themselves (e.g., their competences) differently (Eccles, 2009; Risnes, Hannula, & Malmivuori, 1999). As a result, and consistent with the *Mathematical experienc-*

ing conceptual framework (Subsection 2.4.2 of this study), students develop self-perceptions with respect to mathematics depending on how they experience mathematics and evaluate themselves in relation to their *Mathematical experi encing*. Similarly, in the present study, students in primary and secondary school experienced mathematics differently and came to learn about themselves (and the nature of mathematics from their viewpoints) differently. This contributed to the development of particular kinds of mathematical identity.

Furthermore, schools and classrooms are not only places for learning mathematical knowledge, but also for students to experience personal challenges related to learning mathematics (Grootenboer & Jorgensen, 2009; Simon, 1993). Students can experience these challenges or deal with them differently depending on the extent to which they have previously experienced mathematics and the kind of perceptions they have developed about themselves and mathematics (Cobb et al., 2009). In primary school, students who participated in the present study had limited opportunities to engage in mathematics or interact with others in the classroom due to overcrowded classes. In secondary school these students were introduced to a new language of instruction and more advanced and abstract mathematical content. These challenges were further intensified by ineffective or difficult teaching practices in the second grade. However, these *Contextual factors* affected students' mathematical self-perceptions differently. Students with *Innate ability identity* experienced more frequent success than failure mostly due to their stronger basis in mathematical knowledge founded at home, parental support, and their willingness to learn mathematics. Students with *Persistent effort identity* and *Image-maintenance identity* also experienced more frequent successes than failures but these were mostly attributed to increased personal effort. With such experiences and contextual factors, these students sustained their positive images as successful mathematics learners (cf. Boaler, 2002c). They also were able to deal with the challenges in mathematics classroom and maintain or continue improving their mathematics test scores. In contrast, students with *Oppositional identity* were overwhelmed by the challenges and obstacles they faced in mathematics classrooms and at home. Their failures and negative experiences appeared to confirm their perceptions of low mathematical ability. This became more evident during the second grade of secondary school.

The important role of the teacher in shaping students positive mathematical identities has received great attention in research literature (Boaler & Greeno, 2000; Bohl & Van Zoest, 2002; Cob et al., 2009; Grootenboer & Jogersen, 2009; Sfard & Prusak, 2005). This role is mostly attached to the teacher's capacity to structure and organise learning situations that can influence students to perceive themselves in various ways with respect to mathematics. As discussed in Chapter 2, studies and the *Mathematical experiencing* framework suggest that teaching approaches that promote students' sense of autonomy and encourage active participation in mathematical activities foster students' perceptions of themselves as active learners and constructors of knowledge and even owners of the learning process (Boaler, 1997; Cobb et al, 2009; Hassi, 2015). In contrast, learning situations that position the student as a passive receiver of knowledge and the teacher as a dominant authority contribute to students' tendency to perceive themselves as receivers rather than constructors of mathematical knowledge (Boaler & Greeno, 2000; Cobb et al., 2009).

In this study, students with *Oppositional identity* became more overwhelmed by the teacher's hostile behaviour compared to students with positive mathematical identities. In the second secondary school grade, the teacher behaviour, alongside other *Contextual factors* (e.g., abstractness or complexity of mathematics and language-related difficulties) enhanced these students' tendency to give up. However, the present study suggests further that even when the teacher is unsupportive and the teaching approach denies students' opportunities to exercise their agency, not all students in the classroom are negatively affected in terms of their mathematical identity. Some students view such situations as challenges or obstacles and strive to overcome them to increase chances for success in mathematics. Instead of giving up, students involved in the present study who had positive mathematical identities strived to surmount the challenges by increasing effort, working in self-organised groups, and attending private tuition classes.

Beginning school with adequate basic mathematics knowledge has important implications for students' self-perceptions and identity development, particularly in classrooms where the level of mathematical knowledge strongly varies between students. When such differences exist in a classroom, students are more likely to evaluate themselves and their skills based on peer comparison (Sfard & Prusak, 2005). Accordingly, the evaluations lead to positive self-perceptions among students with an adequate academic background and negative self-perceptions among students who lack such background. Similarly, in the present study most of the students who had gained basic mathematical skills before beginning primary school evaluated their competences by comparing their own mathematics test scores with the scores gained by other students. In particular, this applied more to students with *Innate ability identity* who, through this kind of evaluation, came to confirm their parents' views that they (students) were mathematically gifted.

In addition, the findings of this study suggest that two distinct behavioural tendencies may exist in mathematics classrooms where students differ significantly in terms of their mathematical competence and how they view themselves in relation to mathematics, that is, an individualistic and a community-based learning behaviour. The tendency of students with *Innate ability identity* can be characterised as mainly individualistic. They preferred to study independently when they were free from formal classes. They also tended to dominate pair discussions instead of negotiating with other students. In contrast, students with other positive mathematical identities, particularly students with *Persistent effort identity*, preferred to study in self-organised groups that were characterised by negotiations rather than individual dominance in discussions. It seemed that students with *Innate ability identity* strongly believed in their capacity to succeed in mathematics but not in gains by studying together with other equally or less competent students. On the other hand, students with *Persistent effort identity* and *Image-maintenance identity* were aware of their deficient mathematical knowledge and strived to increase it by studying together with other students in small groups. There was also an economic factor that contributed to the need to form small learning groups outside classrooms. Since only a few students could afford books and other learning materials, group work made it possible for the students (including those who could not afford to buy learning materials) to share them.

As illustrated in the conceptual framework in Chapter 2 (Subsection 2.4.2), *Mathematical experiencing* has an emotional aspect as well. Students evaluate themselves and their performances while experiencing mathematics and this self-evaluation is associated with some degree of positive or negative emotions (Hannula, 2006a; Malmivuori, 2004, 2008; Turner & Stets, 2005), which in the conceptual framework is referred to as emotional experiencing. The most important basis for such self-evaluation is mathematics test scores because of the key role they have in denoting students' success or failure and degree of mathematical skill. This clearly applied to the mathematical experiences of the students in this study. More importantly, the pattern of emotional experiencing varies depending on the kind of student mathematical identity (Turner & Stets, 2005). One of these patterns is associated with self-evaluations based on ambitious achievement goals (Bandura, 1997), which typically characterised the emotional experiencing of students with *Innate ability identity* and *Persistent effort identity.* Accordingly, success was associated with positive self-evaluations and positive emotional experiences such as joy while perceived failure was associated with self-evaluations that sought the likely cause of failure and negative emotions such as shame.

In another pattern of emotional experiencing associated with students with *Image-maintenance identity*, emotional reactions prior to the third secondary school grade had been similar to the pattern among students with *Innate ability* and *Persistent effort* identities. However, this pattern changed in the third secondary school grade. Even though in this grade mathematics became less important for these students' future lives, they wished to maintain their image as individuals with the capacity to succeed in mathematics. To ensure this image-maintenance, these students strived to avoid mathematics test scores that suggested a failure. When they had failure despite their strivings, they experienced negative emotions of embarrassment whereas a minimal pass in mathematics test resulted in feelings of satisfaction. Thus, the value of this discrepancy is that it has motivational characteristics; it fosters students' mathematical engagement (cf. Bohl & Van Zoest, 2002; Turner & Stets, 2005).

The pattern of emotional experiencing for students with *Oppositional identity* was initially associated with achieving or failing to achieve ambitious achievement goals in mathematics. This pattern was similar to that among students with *Innate ability* and *Persistent effort* identities, particularly before their enrolment in secondary school. However, this pattern changed in their second grade in secondary school. Their self-evaluations and emotions were then based on low test scores and mathematical failures with experiences of indifference while their self-evaluations and emotions after mathematics test scores indicating a pass (such scores were rare though) were associated with surprise. This change of emotional pattern can be explained using the concept of agency or the students' capacity to make decisions or choices in the process of *Mathematical experiencing* (cf. Boaler, 1997, 2002c). If given opportunity, students can exercise their agency and increase chances for developing a positive mathematical identity (Boaler, 2002c; Cobb et al*.,* 2009). But in the case of the present study, students with *Oppositional identity* exercised their agency in a negative direction, that is, with a diminished ambition for and commitment to studying mathematics, based on their negative mathematical self-perceptions. By choosing to give up learning mathematics and deciding to concentrate on other non-mathematical subjects, these students can be conceived as exercising their agency in disfavour of mathematics.

Finally, the findings of this study strengthen the idea of a close association between endorsement (confirmation of identity) and identity (Sfard&Prusak, 2005). As shown in the preceding sections, the endorsement was expressed through justification, and this association between mathematical identity and endorsement through justification characterised all the four mathematical identities identified in this study. Students in this study endorsed their mathematical identities through justifications based on their previous mathematical experiences. This endorsement through justification seemed to uphold students' mathematical identity during the *Mathematical experiencing* process. Accordingly, students justified their mathematical self-perceptions by making references to their previous *Mathematical experiencing*. However, confirming the linkages between mathematical identity and endorsement requires further research, particularly on students' forms of endorsement other than justification (if they exist).

7.4.3 Summary on the nature of *Mathematical experiencing*

Overall, the development of different types of mathematical identity was in this study found to derive from the variation in students' *Mathematical experiencing.*

For positive mathematical identities to develop, *Mathematical experiencing* should favour students' development of their ability to understand mathematical concepts, to solve mathematical problems, and to succeed in mathematics tests. As data from students with *Innate ability identity* suggest, both parents and teachers can create learning environments to support the kind of *Mathematical experiencing* that sufficiently supports the development of such mathematical ability. To succeed in this, *Mathematical experiencing* should start at home before children begin their primary school and parents should play a key role in this. The school should thus be a place for continuation (not a starting point) of *Mathematical experiencing*. Intensive parental involvement in children's *Mathematical experiencing* may greatly reduce the number of students with *Oppositional identity* and increase the number of students with positive mathematical identities in schools. In addition, analysis of students' mathematical identity should include various *Contextual factors* that shape *Mathematical experiencing* (e.g., school policies and norms) as these factors have a strong impact on the quality of *Mathematical experiencing* and thus the development of students' mathematical identity. For example, the development of positive mathematical identity requires positive *Mathematical experiencing* fostered by *Contextual factors* such as school norms that allow student autonomy when learning mathematics.

7.5 Reflections and recommendations

During the fieldwork, I gained useful insights but also encountered challenges that varied in their degree of seriousness. These challenges and the ways I dealt with them may have implications for judging the trustworthiness of the research, results, and interpretations. In this section I discuss the challenges and lessons drawn from the study, after which I recommend possible areas for further research and propose solutions to some fundamental problems associated with mathematics learning in Tanzania.

7.5.1 Challenges in the study process

To enter the field for research purposes, particularly if the field is a formal institution, permission has to be sought from persons who hold positions of authority. Because these persons control access to sources of information, they are often labelled "gate-keepers" (Garfinkel, 1967). When seeking permission from gate-keepers to enter the field, a sense of uncertainty about whether the permission will be given or not is inevitable. I experienced this uncertainty while waiting for permission from the Commission for Science and Technology (COSTECH) in Tanzania to do fieldwork in Northern Tanzania. The delay of the permission for few months increased uncertainty, but a sense of relief followed after the permission was granted. The second gate-keeper, the deputy head of school, did not cause such uncertainty as the permission was granted immediately.

The disruption of my fieldwork plans throughout the fieldwork period was particularly challenging. This disruption occurred after classes were unexpectedly suspended. Decisions to suspend classes were made due to students' misbehaviour. While the students were outside their classrooms, they were given manual work such as cleaning or gardening. They were sometimes ordered to assemble outside their classrooms to hear an announcement from a teacher-on-duty or listen to a short speech given by an important visitor. There were a few cases in which students who had not paid school fees were ordered to go home and collect the fees. Although disruptions were not regular, they were frustrating when they occurred and resulted in rescheduling my plans from time to time.

Challenges appeared also in relation to the data collection and analysis. One challenge consisted of complications related to the sources and nature of data to be collected. The data were collected in a school with authoritarian characteristics; as a result, students' concern about their personal security initially seemed to inhibit them from giving honest views about the school and themselves in relation to mathematics. While considering this inhibition and its implications, I was not certain about the trustworthiness of the responses they would later narrate to me. But two events occurred that increased the possibility of obtaining valid data from students. First, the deputy head of school, also a mathematics teacher, announced the permission she had given me to all the teachers and students in the school. Second, the third grade mathematics teacher showed interest in my fieldwork by encouraging his students to provide me with the needed information.

However, this was not enough to gain students' trust. I was at the school as a stranger seeming to be accepted by the school authority and the mathematics teachers. I thought there was likelihood that students would not trust me but would think that I might provide their data to the mathematics teachers and school authority. I dealt with this challenge by familiarising myself with the students and interacting with them during the preliminary observations of the school and classroom. While interacting, I behaved in a friendly manner and showed willingness to learn from them. Trust was gradually built in the first few weeks of the fieldwork. But even after the trust was ultimately gained and students were willing to openly respond to my questions by writing their responses in notebooks, they still wanted their names to be hidden using numbers as secret codes and to be accessed only by me. This gave the students a sense of personal security and they could write 'sensitive' information without fear of punishment.

Another challenge with the data collection was related to language translation. Some third grade students wrote their diaries in Swahili and thus required translation of the data into English before analysis. Despite my fluency in Swahili, I needed a longer than expected time to translate the data and verify the translation while retaining the meaning of the original data. The first drafts of my translation were verified through repeatedly asking the students to clarify the data. Apart from this translation challenge, there were additional problems with the data. For example, some of the data given by students were not relevant to the diary questions. Also, a few students did not respond to some of the questions, particularly questions on their pre-school *Mathematical experiencing*. During interactions with the students, I learned that this problem occurred because the diary questions were not clear to students or were not specific enough to limit the students to the specific kinds of information that I needed. Three of the students seemed unable to recall well their childhood mathematical experiences. In response to these observations, I asked these questions again in a different and simpler manner and excluded the data from three students who failed to clearly recall their childhood mathematical experiences.

Even after students understood my diary questions and responded to the questions in detail, some of their texts had parts that were not legible. I asked the few students with illegible handwriting to spare time for diary writing in order to write their texts slowly and more carefully. The data that were illegible or generated through unclear diary questions were not analysed. A further difficulty with the data related to its size, being too large to handle easily. I faced this challenge despite my attempt to conform to the *saturation* principle (Corbin & Strauss, 1998) during data collection and analysis (i.e., ending data collection when new data leads to no new insights on a phenomenon being investigated). In the process of data collection and analysis, judging whether saturation was reached or not was sometimes difficult because the number of students in each of the four identity types was too large and resulted in the large amount of data. As a result, a large amount of repeating (and thus redundant) data characterised my initial drafts. I reduced the data and its sources (i.e., the students) for each identity category so that the remaining data and its sources clearly addressed the main research questions and were representative of students in each of the four identity categories.

Moreover, the emergence of *Image-maintenance identity* was unexpected during the fieldwork because it had not been documented or theorised in the literature on mathematical identity that I had reviewed. To gain a theoretical understanding of it, I reviewed the literature on identity outside mathematics education, mostly in sociology. After beginning to understand it, there was still a puzzle not addressed in the theory: the association of *Image-maintenance identity* with a decline in mathematics test scores as evidenced in this study. The data suggest that the reason was the students' specialisation in Arts and increased study time in these subjects. But the question is whether this identity type would always accompany a decline in mathematics test scores when students specialise in Arts. Further research involving new samples of students with *Image-*

maintenance identity who specialise in Arts may provide a satisfactory explanation.

Furthermore, interpretation of data was based on the meanings the data suggested as well as my understanding of theories and concepts of identity that I had reviewed in literature. It is possible that the influence of theories and concepts may have led to inconsistency between data and my interpretation because of the theoretical bias (Brewer, 2000). In an attempt to minimise this possible inconsistency, a critical approach was applied by raising awareness of my preconceptions through reflexivity and being self-critical of them, by asking questions relevant to the broader aims of the study when these aims had fully evolved, by constantly comparing questions with the data and the data with the theory to ensure consistency between them, and by maintaining trust between myself and research participants. Similarly, the labelling of the four mathematical identity types was based on my interpretation of the data and my understanding of theoretical ideas on identity. This labelling was not done at once. Labels changed as the study progressed and final decisions on the labels were made when the study was nearing its completion. The aim was to ensure that these labels clearly reflected features of each mathematical identity type. The ultimate labels and categories are still subjective. Another researcher might have labelled the identity types differently.

Finally, the findings may not be completely representative of students beyond the school and classroom where the study was conducted. From the post-positivist perspective, this is a major weakness (Brewer, 2000). However, generalisation was not the purpose of this study. Being exploratory, its mission was to identify important features of students' mathematical identity and its development in a Tanzanian mathematics classroom. The overall value of the findings of this study is its revelation of the complexity of *Mathematical experiencing* and its role in mathematical identity development among students in that classroom. Moreover, the development of different mathematical identities as a result of variations in the way students had experienced mathematics may characterise other mathematics classrooms in Tanzanian secondary schools. This likelihood derives from the understanding that mass failure in secondary school mathematics examinations in Tanzania has a long history (Appendix C) and that mathematics classrooms are typically overcrowded with students and have insufficient mathematics teachers and teaching materials (Kisakali & Kuznetsov, 2015). It also derives from the fact that students from wealthier homes and those whose parents have formal education have a better chance to succeed in mathematics learning compared to children whose parents are materially poor or have no formal education (Uwezo, 2010, 2011).

7.5.2 Lessons learned from the study

The preceding discussion on the results of this study draws attention to the possibility of multiple mathematical identities existing in the classroom even when opportunities for students to exercise their agency are limited or nonexistent. This observation has important pedagogical implications that should be incorporated in a teacher's understanding of mathematical identities in explaining students' performance in mathematics. Awareness of the nature and development of such identities, particularly the identity characteristics that impede students' acquisition of mathematical knowledge (e.g., low ambition and commitment) is useful in promoting students' mathematical experiences and helping students improve their mathematical performances. Such awareness can serve as a basis for developing and using teaching approaches that foster students' mathematics learning process and enhance their positive mathematical identity (cf. Cobb et al., 2009; Walker, 2012).

Second, a teaching approach that provides students with opportunities for developing positive mathematical identity and positive perceptions of the value of mathematics can improve students' future imagined relationship with mathematics and can thereby enhance their involvement in current mathematical activities (cf. Hassi, 2015; Walker, 2012). The study also suggests that efforts to change mathematical identities from negative to positive in a bid to enhance mathematics learning may not be accomplished quickly. Students may well be aware of their previous negative mathematical experiences and can thus justify their mathematical self-perceptions based on these experiences (cf. Bandura, 1997). Long-term teaching programs that provide students with opportunities to exercise their agency in learning mathematics aimed at reversing their identities are thus necessary.

Third, *Mathematical experiencing* is essential for the development of students' mathematical identities. The link between these two processes is close and strong (Larnell, 2016). That is, mathematical identity cannot be formed without *Mathematical experiencing*. It is thus important to more explicitly incorporate the role of *Mathematical experiencing* in the theoretical discussion on mathematical identity. This will broaden perspectives on the existing views of mathematical identity and can also help in developing pedagogical implications for learning mathematics. For example, to overcome obstacles caused by negative identities, teachers could analyse students' previous *Mathematical experiencing*. This would enhance their understanding of mathematical identities and on this basis, help students adjust to their teaching approach to enhance the current processes and experiences of students' mathematics learning (cf. Sfard & Prusak, 2005).

Fourth, for *Mathematical experiencing* to have a positive influence on the development of mathematical identities, the role of *Contextual factors* is vital. For example, children's involvement in mathematical activities characterised by parental interactions provides students with a promoting background for further development of their mathematical identity. Similarly, the teacher plays a significant role in mathematics classrooms, thereby influencing this development. In particular, by organising lessons and learning activities in such a way that all students have opportunities to acquire mathematical skills and exercise their agency in classrooms, teachers form a basis for students' future mathematical successes and the development of a positive mathematical identity. Additionally, emotions constitute an important part of *Mathematical experiencing*. They are closely associated with students' self-evaluations and can foster students' further involvement in mathematics learning activities. For example, students may increase effort or look for alternative learning strategies in response to negative emotions (e.g., shame or embarrassment) in order to succeed in future performances and subsequently free themselves from the influence of their emotions (Turner & Stets, 2005). Thus, incorporation of the role of emotions in the current discussion on mathematical identity can increase the understanding of mathematical development.

7.5.3 Recommendations

Further studies

This study demonstrates the existence of four different mathematical identities in a single mathematics classroom in Tanzania and points to the variation in students' previous *Mathematical experiencing* and previously constructed identities as the reason for the variation. The multiplicity of mathematical identities in a classroom *may* be a phenomenon in classrooms where students vary greatly in their mathematical backgrounds as well as economic and educational status of their parents. Thus, a research approach that allows an investigation of a larger number of classrooms and schools whose students have mathematical backgrounds similar to those in this study is suggested. Second, this study underlines the roles of parents and teachers in the development of children's positive mathematical identity, but it focused on students who were already in secondary school. A future study could take an alternative research approach (e.g., a longitudinal design) to analysing these important roles in children's *Mathematical experiencing*. Interview and observation data on parent-child interactions related to learning mathematics at home could produce additional insights into the nature of childhood *Mathematical experiencing* and its impact on the development of students' mathematical self-perceptions. Such data could answer, for example, the question of whether active parental involvement in children's *Mathematical experiencing* necessarily leads to the development of children's positive mathematical identity. Furthermore, this study suggests a decrease in mathematics test scores for students with *Image-maintenance identity* in secondary school. Specialising in Arts and spending more time in these subjects seem to be the reason. I doubt whether *Image-maintenance identity* always accompanies a decrease in test scores at the time of subject specialisation. Investigations of several mathematics classes that are similar to the one studied for this thesis and have students with *Image-maintenance identity* could shed more light on this relationship. Finally, justification as a form of identity endorsement strongly characterised students' expressions of their mathematical identity. It also seemed to play a role in upholding their identities. Further research seeking to establish the role of identity endorsement in mathematical identity development may further broaden the conceptualisation of mathematical identity.

Improving mathematics learning in Tanzania

This study has demonstrated that *Mathematical experiencing* is essential for the development of students' mathematical identities and that in turn, mathematical identities have motivational features that can foster the continuation of *Mathematical experiencing*. For schools in Tanzania to improve mathematics learning, students' positive mathematical identities need to be developed through appropriate *Mathematical experiencing*. For example, application of teaching methods that enable students to develop basic mathematical skills and their encouragement in developing agency and exercising it with support from their teachers could foster such experiencing. But for *Mathematical experiencing* to be effective enough to result in positive mathematical identities in Tanzanian schools, a number of problems need to be addressed. The much talked about problems in Tanzania are those that impede general learning in schools. They relate, for example, to insufficiently developed school infrastructures, lack of trained teachers, shortage of teaching and learning materials, and the unpopularity of mathematics among students and teachers (Kisakali & Kuznetsov, 2015). These also impede *Mathematical experiencing* and the development of students' mathematical identity. Moreover, this thesis adds several fundamental problems to this list and discusses how they could be addressed.

First, mathematics learning in Tanzanian schools is impeded by a language policy that requires students to learn mathematics (and other subjects) in Swahili in primary school and in English in secondary school. Many students do not gain sufficient English language skills in primary school (Telli, 2014; Uwezo, 2010, 2011).Consequently, they experience difficulties in understanding mathematical concepts written or expressed in English in secondary school. This problem was evident also among the students in this study. It can be solved by allowing students to learn mathematics in the same language in primary and secondary school.

Second, parental involvement in children's mathematics learning in Tanzania is low, meaning that most children do not have opportunities to learn basic arithmetic and language skills before they begin school (Center for Economic Prosperity, 2012). Pre-school parental involvement in children's mathematics learning is vital in Tanzania. As shown in this study, for students with *Innate ability identity*, this early parental involvement enables children to develop basic mathematical skills and positive mathematical identity, making it thus possible for children to learn primary school mathematics more easily. Primary schools are overwhelmed by *Contextual factors* such as overcrowded classes and an inadequate number of teachers and thus lack the capacity to develop basic mathematical skills and positive mathematical identities for all pupils in the schools. Publicity campaigns constitute the most practical way of sustainably engaging parents in the development of their children's basic mathematical skills and positive mathematical identities before school. The government of Tanzania has applied a publicity campaigns strategy involving the use of mass media to deal successfully with the spread of HIV-AIDS and malaria. The same strategy can be used for engaging parents to develop their children's basic mathematical skills before they begin school. These campaigns should go hand in hand with improving the available nursery schools and building more such schools to give a chance for all children to attend them. In these schools, basic arithmetic and language skills need to be given more emphasis along with play that mostly involves basic mathematics (LeFevre et al., 2010).

Finally, the students who participated in this study perceived the value of mathematics in terms of its application to science, not its use for their personal day-to-day lives. As a result, the students perceived mathematics as important to those who studied science and needed it to help them learn science easily. This perception impeded mathematical participation among students who did not study science. The perception could be pervasive in other secondary schools in Tanzania. The solution to this problem is to link mathematics content with the cultural environment familiar to the students. This can be done at the curriculum and pedagogical levels. The teaching of mathematics should help students solve problems that are familiar to them thereby enabling them to notice the relevance of mathematical skills to their lives. The resulting positive perceptions of the value of mathematics to the students can motivate them to increase their participation in mathematics learning and develop a positive mathematical identity.

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Appendices

Appendix A: Location of Tanzania

Figure 4. A map of Tanzania showing the regions and neighboring countries of Tanzania. (**Source**: http*://www.infoplease.com/atlas/country/tanzania.html)*

Comment: Students who attended the boarding secondary school that became a fieldwork school for this study had come from different places of Tanzania and were of different ethnic backgrounds.

APPENDIX B: An Overview of Educational Aspects in Tanzania

Management and administration of education in Tanzania

The school in which the research participants studied was part of a broader system of education managed by the Ministry of Education and Vocational Training. The ministry is one of the providers of education. Even if private organisations are allowed to own schools and other institutions of education, the ministry is the sole regulator of education in the entire education system (Ministry of Education and Culture, 1995). It regulates education with the guidance of the Education and Training Policy of 1995 (Ministry of Education and Culture, 1995). The Policy presents aims and objectives of education and training, elaborates the system and structure of education, clarifies matters pertaining to access to education and equity in education, and manages education (Ministry of Education and Culture, 1995).

In practice, the ministry provides and regulates education mainly through a semi-autonomous organisation known as the Tanzania Institute of Education (TIE), which designs, develops, disseminates, monitors and evaluates curriculums for pre-primary, primary, secondary and teacher education. It issues syllabuses to all schools. TIE is also responsible for preparation of teaching materials. Moreover, the ministry regulates education through another semi-autonomous organisation: the National Examinations Council of Tanzania (NECTA), responsible for centrally "designing, regulating, conducting and administering national Standard VII, Form 4, Form 6, and Teacher Education Certificate and Diploma Examinations" (Ministry of Education and Culture, 1995, p. 108). Examinations are centralised and done at the end of standard 7 (in primary schools), grade 4 and 6 (in secondary schools), and teacher education certificate and diploma courses conducted at "specific regular cycles" (Ministry of Education and Training, 1995, p. 109). It also organises diagnostic examinations for primary school children at the end of the fourth grade, and for secondary school children at the end of the second grade. The purpose for these examinations and diagnostic tests is to evaluate the academic progress of students at these levels and to assess the implementation of the curriculum. It also provides certificates based on continuous assessment done in the schools and colleges and results of the final assessment (Ministry of Education and Culture, 1995). However, TIE and NECTA are not responsible for universities (Ministry of Education and Culture, 1995). The ministry regulates education in universities through another semi-autonomous establishment, namely, the Tanzania Commission for Universities (TCU)[1].

The general structure of education in Tanzania

The Tanzanian educational system had a 2-7-4-2-3+ structure of formal education (Ministry of Education and Culture, 1995), meaning that students were supposed to spend two years in pre-primary schools, seven years in primary school, four years in lower secondary school, and two years in upper secondary school. Students could then join higher institutions of education. Students who completed primary or secondary school but did not qualify to proceed to the next level of education could seek admission to vocational or professional training institutions. Thus some students who participated in the present study had participated in mathematics for nine years (i.e., seven years in primary school and two years in secondary school) and others had participated in mathematics for eleven years (including two years in pre-school). Enrolment in lower secondary school required successful performance in the final primary school examinations. In these schools students were supposed to spend four years. In the third grade, students were required to specialise in Arts or Science.

The national education policy required each student at the end of the fourth grade in lower secondary school to state in writing a subject combination, consisting of three principal subjects which he or she would like to study at the upper level of secondary education. Subject combinations were already planned by the government. In the Arts, for example, HGL consisted of history, geography, and literature, while HKL consisted of History, Kiswahili and Literature. In the natural sciences, PGM consisted of Physics, Geography, and Mathematics, and PCM comprised Physics, Chemistry, and Mathematics. Passing the final NECTA examination at the end of the fourth grade offered a range of academic or profession-related possibilities to students. Students with high and acceptable grades could join upper secondary school and spend two years at this level. Students with good grades but not good enough to join upper secondary school could apply for a training college where they could spend a minimum of two years and receive a certificate in a specific skill. This college could, for example, be a training institution for primary school teachers, a nursing college or a Folk Development College (which may also admit candidates with good primary education). These colleges provided hands on skills for professional work (Tanzania Education Directory, 2004).

The curriculum for upper secondary schools was designed to enable students to study subject combinations that they chose at the end of their lower secondary education. Students at this level were mostly taught by teachers with basic aca-

[1] http://www.tcu.go.tz/

demic degrees and rarely by teachers with post-graduate degrees. Each student was required to study one subject combination consisting of three core subjects of his or her choice and a few subsidiary subjects such as religion and civics. At the end of the sixth grade students again sat for National Examinations set by the National Examinations Council of Tanzania. After completing this level of school and being certified, they had several options depending on their performance in their respective subject combinations. Students with high grades (C to A on a national scale) could apply for university studies in one of the universities in the country or overseas. Students with grades that were good but not good enough for direct admission into a university could apply for training in polytechnic colleges or other non-degree professional colleges. This route could later lead to acceptance for admission to a university. Figure 1 presents a summary of the Tanzanian education structure.

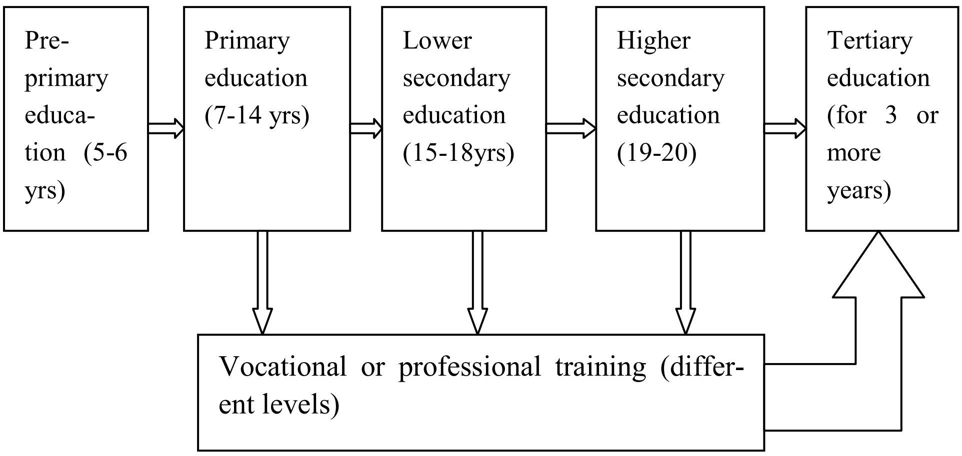

Figure 5. The Tanzanian basic educational structure and the ideal age of students in each education cycle.

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APPENDIX C: MATHEMATICS PERFORMANCE IN TANZANIA

Table 11. Fail percentage rates in mathematics Primary School Leaving Certificate Examinations 1993-2014

Year	Number of candidates	Failed (in %)
1993	362,099	83
1994	360,220	84.3
1995	383,803	81.3
1996	371,962	83.5
1997	413,639	83
1998	636,983	82.3
2007	773,550	82.6
2008	1,017,967	82
2009	999,070	79.4
2013	844,938	71.3
2014	792,118	69.3

Data source: The United Republic of Tanzania, Ministry of Education and Vocational Training, The National Examinations Council of Tanzania, Basic Statistics (1993-2014), Dar es Salaam (The table was originally created for the purpose of this study).

Table 12. Fail percentage rates in mathematics in Certificate of Secondary Education Examinations, 1993-2014.

Year	Number of candidates	Failed (in %)
1993	34,735	78.7
1994	37,985	79.1
1995	37,261	70.1
1996	39,841	77.2
2003	62,105	73.1
2005	82,551	76.5
2007	125,074	68.7
2008	233,848	75.7
2009	351,152	73.4
2013	426,113	82.6
2014	415,270	80.4

***Source**: The United Republic of Tanzania, Ministry of Education and Vocational Training, The National Examinations Council of Tanzania, Basic Statistics (1993-2014), Dar es Salaam (The table was originally created for the purpose of this study).*

APPENDIX D: STUDENTS' MATHEMATICAL CONTEXT AND BACKGROUNDS IN THE FIELDWORK SCHOOL

The significance of mathematics is stressed in the Tanzanian national development vision 2025. According to the vision, "basic sciences and mathematics must be accorded signal importance in keeping with the demands of the modern technological world" (United Republic of Tanzania, 2000, p.20). But in practice, mathematics performance levels in primary and secondary school have been too low for this vision to be realised. Before and after the publication of the vision statement in 2000, about three quarters of students who attempted final mathematics examinations failed each year. A similar scenario was also observed in the school in which fieldwork for this study was done. Both contextual and individual student factors may be responsible for this failure. Even though this study characterises students mathematical identity and analyses its development, some knowledge of *Contextual factors* in which students learned mathematics can suggest reasons for the existence and development of these identities. Thus the sections below provide a brief overview of the context in which students learned mathematics. In addition, the interpretation of data on students' mathematical identity and its development can be more accurately interpreted when data on the mathematical backgrounds of the students is available. This data is presented in the final section of this appendix.

Basic characteristics of the fieldwork school

The school was established in 1973. It was owned by a church organisation but regulated by the government. It was a boarding school located 25 kilometres east from the nearest city Arusha. It was surrounded by a small natural forest consisting of trees, bushes and tall grass, the continuation of which from the school's central area was interrupted by staff apartments and school maize fields that lay a few meters from the school's central area. These features, plus the school itself, occupied a physical space within a radius of about a quarter of a kilometre from its central area, which consisted of the administration block, a student parade ground and a car park. Beyond this limit was a landscape with scattered bushes and isolated natural trees, fields of maize and beans, isolated houses of local inhabitants, a primary school, a church, and to the farther west was the Makumira University College campus located nearly 2 kilometres away. The school was also joined to the 'outer world' by a road that was dusty during dry season but muddy and slippery during rainy season. The road joined the school to the highway that connected the towns of Moshi and Arusha. One could reach the highway, for example, by car, by bicycle or on foot to catch a local commuter bus to Moshi or Arusha.

Students with various ethnic backgrounds had come to this school from different places in Tanzania. Their age ranged between 14 and 18 in lower secondary education classes and between 18 and 21 in upper secondary education classes. The total number of students was 840, 720 being in lower and 120 in upper secondary education levels. The predominant language used in daily conversations outside classrooms was Swahili. English was used for instruction. Of the subjects taught in this school, mathematics was the most unpopular subject. An average of three quarters of lower secondary education students who had attempted government-prepared final mathematics examinations between 2000 and 2015 had failed as Table 2 indicates.

Table 13. Lower secondary school final examination scores: 2000-2009

Year	A	B	C	D	F	Total
2000	-	-	4	21	106	131
2001	-	1	3	22	75	101
2002	1	4	11	11	80	105
2003	1	4	2	16	97	120
2004	-	1	6	16	117	140
2005	-	-	10	14	115	139
2006	1	1	9	19	91	121
2007	1	2	10	20	101	134
2008	2	2	5	23	99	131

Source: *School records availed by the school administration, September 2010 and August 2015.*

In the school's mathematics teachers' view, these scores represented "the real situation" in the whole country. In this particular school, the reason was not necessarily shortage of teachers. According to the teachers, the curriculum consisted of topics some of which were too complex and irrelevant.

The mathematics classroom under investigation

The mathematics classroom was an integral part of the school, which in turn was part of a nationwide system of education. The classroom and mathematics activities carried out in it were subject to the influence of factors of the school context and those of the broader educational system and culture. The classroom mathematical context was indirectly regulated by the school's academic office. He ensured that mathematics lessons (and lessons in other subjects) were taught as planned. The plans were based on government directives. However, the main challenge was the scarcity of textbooks and other teaching and learning materials. These constituted a major drawback to effective teaching of mathematics and the school was responsible for it. The other factor that appeared to impede the teaching of mathematics in the fieldwork classroom was language-related. As was the case in all secondary school classrooms, the teaching of mathematics and other subjects (except Swahili language) in the fieldwork classroom was supposed to be done in English as a quotation from the language policy declares:

> *The medium of instruction for secondary education shall continue to be English except for the teaching of other approved languages and Kiswahili shall be a compulsory subject up to Ordinary Level (Ministry of Education and Culture, 1995, p. 45).*

However, English language proficiency among many students was low, resulting in difficulties among these students in comprehending mathematical concepts and following instructions in the classroom. Using two languages (English and Swahili) for teaching mathematics in a bid to increase chances for students to understand lessons was a regular practice in the fieldwork classroom. Although this practice was not stipulated in the language policy, it was useful in clarifying complex mathematical concepts, suggesting that students would understand mathematics better if they were taught in Swahili, a language in which they were more proficient compared to English.

These were among factors that challenged the teaching and learning of mathematics in the fieldwork classroom. In turn, they challenged the government's determination to promote mathematics and science because similar factors existed in other classrooms and schools in Tanzania (Mungure, 2009).

Background data on students who participated in the study

Students who participated varied in their mathematical backgrounds according to their mathematical identity. There was a degree of variation within identity categories as well. The data showing these variations are presented below.

Students with Innate ability identity

Name	Background information
Katanga	A male student who came from Dodoma's industrial area (Central Tanzania) and attended primary school in the same area. His father was highly educated in mathematics. Mathematics was a popular subject of regular discussion at home. His parents taught him basic mathematics skills before primary school. They supported him materially during school. Katanga attended nursery school and private tuition classes during primary and secondary school holidays. His parents were strict and punitive.
Edward	A male student who came from Dar es Salaam (commercial capital of Tanzania) where he completed primary school. His parents had formal education. They had taught him practical arithmetic (e.g., through counting chickens) and basic English language skills before he started primary school. His parents were strict monitors of his learning progress. They materially support Edward while at school.
John	A male student who came from a suburb in Arusha (a city in Northern Tanzania). He attended primary school in this area, and had highly educated parents who taught him arithmetic and English. John attended private tuition during school holidays and his parents supported him while he was at school.
Asha	A female student who came from Mwenge (a suburb of Dar es Salaam) where she attended primary school. Her parents had high formal education and were strict and punitive. They taught her basic skills in mathematics and English language before she began primary school.
Kilolo	A male student who came from Mwanza (in Northern Tanzania) and had attended primary school in the same area. His parents were generally authoritarian in their parenting style. They were highly educated and taught Kilolo arithmetic before he began primary school. His parents monitored Kilolo's progress at primary and secondary school.
Bisaki	A female student who came from Mwanza and attended primary school in the same area. Her parents taught her basic mathematics and English language skills before she began primary school. Punishments were rare at home but Bisaki experienced parental emotional reactions when she did badly in home-based mathematics exercises. Her parents had high confidence in Bisaki's mathematical competence. Bisaki's brother's impressive mathematical performance at school increased her interest in mathematics before she had begun primary school.

Students with Persistent effort identity

Name	Background information
Molero	A female student who came from Longido village (in Arusha rural area). She attended primary school in the same area. Her parents were Maasai pastoralists and had no formal education. Molero learned how to count cattle and money (after sales of milk) in Maasai language. She had not learned any basics of formal education before primary school.
Ambrose	A male student who came from a rural area of Ruvuma in southern Tanzania and attended primary school in the same area. His parents did not teach him basic mathematics before school, but they taught him reading and writing skills in Swahili to enable him to read the Bible.
Sifuni	A female student who came from a rural area in Kagera (Northern Tanzania). Her parents were farmers who did not have formal education. Sifuni participated in agricultural activities before she began primary school.
Joseph	A male student who came from a suburb in Iringa (a town in southern highlands of Tanzania) and attended primary school in the same area. His parents had basic formal education but did not create home-based environment for Joseph to learn arithmetic before starting school. Instead, Joseph participated in running a chicken project owned by his parents.
Rehema	A female student who came from a suburb in Arusha (a city in Northern Tanzania) where she attended primary school. Her parents had basic formal education, but did not teach her arithmetic. Rehema felt unfortunate when her playmates in a neighbouring house were taught arithmetic and basic English language skills before they started primary school. She needed these skills before beginning school but did not get them.

Data given by Mariam and Materu were not quoted in the study. Their data had meaning that was similar to the data given by other students in the table. Students who dropped out during early stages of the study were: Rafikieli, Musa, and Kalonzo.

Students with Image-maintenance identity

Name	Background information
Rajab	A male student who came from a suburb in Morogoro (Central Tanzania) and attended primary school in the same area. His parents were highly educated. They taught him basic mathematics before primary school and occasionally beat him when he showed lack of commitment to learning these skills. The parents did not always monitor Rajab's learning activities at home.
Kibasa	A male student who came from Mwanza (city area) and attended primary school in the same area. His parents had formal education; they taught him basic arithmetic and English language skills before he began primary school. The parents were neither strict nor punitive but did not allow Kibasa to attend nursery school; they perceived it as unhelpful.
Anna	A female student who came from Sinza (a suburb in Dar es Salaam) and attended primary school in the same area. Her parents were secondary school teachers. Before she began school, they taught Anna basic skills of mathematics and language (English and Swahili) in a relaxed manner.
Godfrey	A male student who came from a rural area in Iringa (in the southern highlands of Tanzania). He attended primary school in the same area. His parents had no formal education; they engaged in agriculture. Godfrey did not receive basic arithmetic skills before beginning primary school.
Agness	A female student who came from Singida town (in Central Tanzania). She attended primary school in the same area. Her parents had formal education and taught Agnes some basic skills in mathematics and language (English and Swahili). Her parents were not strict or punitive while teaching her.
Sikitu	A female student who came from the Arusha city area and attended primary school in the same area. Her parents had basic formal education but did not offer Sikitu a chance to acquire basic mathematical skills before she began school. She only participated in domestic activities.
Shukuru	A female student who came from Moshi (a town in north Eastern Tanzania) and attended primary school in the same area. Her parents had basic education. Shukuru did not have an opportunity to learn basic mathematics at home before beginning school; instead, she participated in domestic work.

Data given by Kabinda and Mollel in the table above were not quoted in the study. Their data had meaning that was similar to the data given by other students in the table. One student, Asante, dropped out during the initial stages of the study.

Stuents with Oppositional identity

Name	Background information
Zuberi	A male student who came from Mtwara (in Southern Tanzania) and attended primary school in the same area. His parents had basic formal education. They occasionally taught him basic mathematical skills before he began primary school.
Daudi	A male student who came from Mara (Northern Tanzania) and attended primary school in the same area. His parents had basic formal education. They occasionally taught Daudi counting skills before he began primary school. Daudi attended a nursery school as well.
Mapunda	A female student who came from Moshi (a town in North Eastern Tanzania). She attended primary school in the same area. Her parents had basic formal education and occasionally taught her arithmetic before she began primary school. Mapunda did not attend a nursery school.
Edwin	A male student who came from a rural area in Dodoma (in Central Tanzania). He attended primary school in Dodoma. His parents had basic formal education. They did not teach Edwin basic mathematical skills prior to primary school. Edwin did not attend a nursery school.
Ema	A female student who came from a rural area in Arusha (in Northern Tanzania). She attended primary school in the same area. Her parents did not have formal education. Ema did not acquire basic mathematical skills before she began primary school.
Mary	A female student who came from a rural area in Singida (in Central Tanzania). She attended primary school in the same area. Her parents were illiterate. Mary did not acquire basic mathematical skills prior to primary school.

Data from Masetu, Tulinave, Mashaka, and Happiness were not quoted in the study. Their data had meaning that was similar to the data given by other students in the table. Peter and Eliud dropped out during the initial stateges of the study.

Conclusion

The tables above provide an overview of how the students who participated in the study (aged between 16 and 17 years) varied widely in their mathematical backgrounds according to their mathematical identities. Yet, they learned secondary school mathematics in the same classroom. As the analyses in the thesis show, these students also varied in their mathematical identities and reacted differently to the challenging *Contextual factors* overviewed above in this appendix.

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United Republic of Tanzania (2000). *The Tanzania Development Vision 2025*. Planning Commission, Dar es Salaam

APPENDIX E: PARADIGMS OF SOCIAL INQUIRY

aspect	Positivism	Post-positivism	Critical theory	Social constructivism
Ontology	Reality is independen t of our existence	Reality exists but can be apprehended through a critical approach. Apprehension of reality canot be perfect	Reality consists of historiacally developed socio-economic, political and cultural structures taken to be real	Reality is appre-hensible. It is in the form of mental constructions that are multiple and intangible. They are socially & experientially based, local and specific, can be shared.
Epistemo logy	Inquirer & object of inquiry are independ-ent entities, inquirer detaches from object of inquiry, avoids influences	Objectivity is a "regulatory ideal", emphasis on exter-nal guardians (e.g., peer reviewers), should fit with pre existing knowledge	Interactive link between inquirer and object of inquiry, inquiry is influenced by values, "find-ings" are value-laden	Interactive link between inquirer and object of in-quiry, "findings" are constructed as investigation pro-ceeds, boundary between ontology and epistemology disappears
Methodol ogy	Hypothesis are tested and veri-fied to establish universal principles, control of influencing variables	Modified experi-mental or manipu-lative, hypotheses are falsified (not verified), inquiries are based on real situations	Emphasis of dialogue be-tween inquirer and respondents. Dialectical inter-changes create awareness of unpleasant social structures and change of these structures	Individual con-structions can be elicited and refined only through inter-action between the researcher and the respondents. Vary-ing constructions can be interpreted using conventional hermeneutical techniques and are compared and

				contrasted through a dialectical inter-change.

This table was created for the purpose of this study. It is a summary of Guba and Lincoln's discussion on paradigms in social research (Guba & Lincoln, 1994, 2005).

APPENDIX F: A Sample of Forms Used to Compile Students' Scores in Previous Tests and Examinations

Student	**FORM 1**			**FORM 2**			**FORM 3**			**FORM 4**	
	MT	TT	FT	MT	TT	FT	MT	TT	FT	MT	TT
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

MT = Mid-term Test; TT = Terminal Test; FT = Final Test

APPENDIX G: Questionnaire for the Head of School/Academic Officer

QP/May/2010

Dear Head of School/academic officer,

I have prepared questions on mathematics learning in your school and would be grateful if you have time to provide answers to them. The information you provide will only be used for academic purposes.

----

1. Please complete the table below by filling in the numbers of students in your school for each grade and year of performance in 'O' Level mathematics national Examinations from 2000 to 2010:

YEAR	A	B	C	D	F
2000					
2001					
2002					
2003					
2004					
2005					
2006					
2007					
2008					
2009					
2010					

Grading Scale: A = 81-100%; B = 61-80%; C = 41-60%; D = 21-40%; F = 0-20% (total marks in percentage = 100).

2. There is a belief among students in Tanzania that solving complex mathematical problems requires special ability in mathematics. Does this belief prevail in your school in any significant way? If it does, how serious is its impact on performance in mathematics among students?

3. O-Level performance in mathematics examinations in Tanzania has been very low over the years. One factor related to this trend is the way national examinations are set. In your experience, does this factor significantly contribute to the low levels of performance? If yes, how does it do so?

4. English language is used as the medium of instruction in Tanzanian secondary schools. There is a sudden switch from Kiswahili (which is used in primary schools), to English, the language of instruction at secondary level. How much do you think (or in your experience) this switch is an obstacle to achievement in mathematics among students in your school?

5. The government of Tanzania and organisations like the Mathematical Association of Tanzania (MAT) strongly believe that in-service training of the existing teachers and improving pre-service teacher training programmes can enhance learning and improve performance in mathematics in secondary schools. How would you comment on this with respect to your school?

6. In your view, is there any practical and immediate way of reducing the number of O-Level candidates who fail in national examinations?

7. Shortage of the right type of mathematics text books appears to be a common problem in most of the schools in Tanzania. How much does this shortage (if it exists) affect mathematics teaching, learning and performance in your school?

8. It is important for any school to recruit the most competent teachers who have both knowledge of mathematics, pedagogical skills and commitment. Does the process of recruiting good quality mathematics teachers pose problems in your school? If yes, how? And if no, how do you manage the process of recruiting them?

9. Normally, students tend to question the importance of subjects, particularly those that are perceived to be complicated. Do students in your school generally feel that mathematics is important to them? Is this feeling widespread in the school to the extent that it has notable impact on their motivation in learning mathematics?

10. In your view, what could be the most effective way of raising performance levels among O-Level students in your school?

Thank you for your time.

Sincerely,
Doward Kilasi.

APPENDIX H: Questionnaire for Mathematics Teachers

QMTs/March/2010

Dear mathematics teacher,

I would like to kindly ask you to complete this questionnaire at the time of your convenience. The information you provide will be used for academic purposes only.

A. Please fill these blanks with your background information

Gender category (Male or Female) …………………………..........
Age ……………………………………………………….............
Teaching experience (number of teaching years or months) ………..
Grades (forms) that you have taught…………………………………

B. Please respond to the following questions

1. Generally, how do students in the classes that you currently teach or those you have taught think about their ability in mathematics? How does this thinking affect the way they participate in mathematics classes?
2. Can you briefly describe how you feel or what things you think about in relation to teaching mathematics?
3. What makes you happy about the students you teach?
4. What makes you feel uncomfortable with your students?
5. How do you think students perceive mathematics as a subject?
6. How do you feel when students ask you questions in class?
7. How do you react to students who fail in mathematics tests or those who fail to do well the assignments you give them?
8. How much do you help those who come to your office for extra tutorials? How do you feel about them?
9. In your view, what could be the best way of raising mathematics performance levels among students in your class?

Thank you for your time.

APPENDIX I: Examples of Guiding Questions During Fieldwork

I: Guiding questions used for observing the school campus

1. What kind of physical features characterises the school campus?
2. What do teachers and students typically do at school?
3. How is the school administered?
4. How do members of the school community share information?
5. What key issues are associated with mathematics education in the school?
6. What external factors influence education in the school?

II. Examples of questions to guide collection of data relating to mathematics learning context

1. What kind of physical features characterise the observed mathematical context?
2. What key features define the mathematical content and context of third graders?
3. What kind of social norms mediate mathematics-related interactions in the classroom?
4. What does it mean to be a mathematics teacher in grade three?
5. What does being a third grader mean with respect to learning mathematics?
6. What kind of external factors influence the mathematics context?

III. Examples of start-up questions on students' characteristics of mathematical identities (These diary questions were asked one at a time)

1. What kind of person do you think you are when it comes to mathematics?
2. What do you think about your ability in mathematics? Why do you think so?
3. How important is mathematics to you?
4. In your view, do you think anybody can succeed in solving grade three mathematical problems? Why do you think so?
5. What kind of score have you wanted to get as a result of doing mathematics tests or examinations?
6. Have you felt any urge (msukumo) in you to do mathematics even if no one tells you to do it? Do you still have the urge? Why do you think you have it or don't have it?
7. How often do you do mathematics when you are not in class? How do you do it (alone or in groups?)
8. How much do you participate in mathematics classes? Why?
9. What future plans do you have concerning mathematics? Why do you have the plans?

10. How much have you scored in previous tests in grade three?

IV. Examples of start-up questions on the role of Mathematical experiencing in mathematical identity development. (These diary questions were asked one at a time)[2]

Experiencing mathematics prior to primary school

1. Did you learn any mathematics before you began primary school? If yes, how did you learn?
2. Did you have any idea about the importance of mathematics before you began primary school? If you had it, how was it like?
3. What did you think or feel about your ability in mathematics before you started primary school?
4. How much did you succeed? How did you feel about it?
5. Did you have the urge (msukumo) to do maths on your own?
6. How did you feel when you succeed or did not succeed in maths?

Mathematical experiencing during primary school

1. How often did you participate in maths classes in primary school? How much did you learn maths?
2. Did you have an idea about the importance of mathematics while in primary school? If you had it, how did you get it? How was it like?
3. What did you think or feel about your ability in mathematics when you were in primary school?
4. How much did you succeed in maths in primary school? How did you feel about it?
5. Did you have the urge to do maths on your own in primary school?
6. How did you feel when you succeeded or did not succeed in maths in primary school?
7. What else did you think about your progress in mathematics?

[2] Some of these questions were also used to start up focus group discussions. Responses for each question were further elaborated or clarified through asking more specific questions.

***Mathematical experiencing* in secondary school (up to grade two)**

1. How much have you participated in maths in grades one and two in secondary school? How much have you learned maths as a result?
2. What thoughts do you have about what mathematics means to you now and in the future?
3. Have you had an idea about the importance of mathematics while in secondary school? If yes, how has it been like and how did you get it?
4. What have you been thinking about your ability in mathematics while you are in secondary school?
5. How much have you succeeded in grades one and two? How have you felt about it?
6. Have you had the urge to do maths on your own in grade one and two?
7. How have you felt as a result of being successful or unsuccessful in maths in grade one and two?

APPENDIX J: Themes, Sub-themes, and the main Codes that 'Evolved' During Fieldwork

I. Sub-themes and codes for 'the field' theme

THEME	SUB-THEMES	MAIN CODES
THE FIELD SCHOOL	Gate-keepers and access to the filed	F1 The Commission for Science and Technology F2 Accessing the school F3 Location of the school F4 Security issues of school campus
	Teacher' and student's activities	F6 Teacher qualifications and role F7 Teachers' activities F8 Student population characteristics F9 Students' academic and non academic activities
	School as an organised formal and social structure	F10 "Terms" of the academic year F11 School regulation F12 Tests and examinations F13 Student's government
	Modes of correspondence in the school	F14 The notice board F15 The notebook F16 Academic reports to parents F17 Direct talk F18 Formal meetings
	Mathematics education in the school	F19 Teachers' views F20 Official records F21 Administrator's views F22 External factors

F = Field

II. Sub-themes and codes for the theme of 'characterisation of mathematical context'

THEME	SUB-THEMES	MAIN CODES
MATHEMATICAL LEARNING CONTEXT	The physical space	MC1 The class room MC2 The classroom's physical objects
	The subject matter	MC3 Mathematical subject matter as the core MC4 Nature of mathematical subject matter MC5 Objectives for teaching mathematics
	Social norms	MC6 Norms for entering the classroom MC7 Norms for interaction in the classroom MC8 Norms for appearance MC9 Norms for exiting the classroom
	Being a mathematics teacher	MC10 Teacher's professional background MC11 Teacher as guardian of class discipline MC12 Teacher as a planner MC13 Teacher as the primary assessor
	Being a student in James' class	MC14 Learning in an ethnically diverse class MC15 "Science" and "Arts" students MC16 Interactional difficulties
	External influences	MC17 The policy of subject specialisation MC18 The language of instruction policy MC19 Mathematical content is externally determined MC20 Methods of assessment are externally determined

MC = Mathematics Context

III. Sub-themes and codes for 'characteristics of positive mathematical identities' theme

THEME	SUB-THEMES	MAIN CODES
POSITIVE MATHE-MATICAL IDENTITY	*Innate ability identity*	PC1 Highly influenced by institutional factors in favour of mathematics PC2 Positive self-perceptions of mathematical competence PC3 Mathematical competence viewed as inborn PC4 Some interaction, mostly individualised involvement in tasks PC5 Strong ambition for success PC6 Highly committed to mathematical activities PC7 Future imaginations strongly associated with mathematics PC8 Highest performance outcomes in mathematics
	Persistent effort identity	PC9 Highly influenced by institutional factors in favour of mathematics PC10 Positive self-perceptions of mathematical competence PC11 Mathematical competence viewed as effort-based PC12 Highly interactive and personally involved in tasks PC13 Strong ambition for success PC14 Highly committed to mathematical activities PC15 Future imaginations strongly associated with mathematics PC16 High performance outcomes in mathematics
	Image-maintenance identity	PC17 Weakly influenced by institutional factors in favour of mathematics PC18 Positive self-perceptions of mathematical competence PC19 Mathematical competence viewed as effort-based PC20 Weakly interactive and less involved in tasks PC21 Ambition mostly to avoid failure

		PC22 Future imaginations faintly associated with mathematics PC23 Weakly aligned with mathematics PC24 Modest performance outcomes

PC = Positive Characteristics

IV. Sub-theme and codes for characteristics of mathematical identities' theme

THEME	SUB-THEMES	MAIN CODES
NEGATIVE MATHEMATICAL IDENTITY	*Oppositional identity*	**NC1** Influenced by institutional factors in disfavour of mathematics **NC2** Negative perceptions of mathematical competence **NC3** Mathematical competence viewed as essentially inborn **NC4** Limited interactions, rare or no personal involvement in mathematical activities **NC5** Lack of ambition to succeed in mathematics **NC6** Lack of commitment to mathematics **NC7** Future imaginations not associated with mathematics **NC8** Lowest performance outcomes in mathematics

NC = Negative Characteristics

V. Sub-themes and codes for the theme of role of Mathematical experiencing

THEME	**SUB-THEMES**	**MAIN CODES**
RECALLED MATHEMATICAL EXPERIENCING	*Mathematical experiencing* in *Innate ability identity*	ME1 Innate ability identity pattern prior to primary school ME1.1 parents as key socialising agents ME1.2 the sense of competence in arithmetic is experienced ME1.3 feeling ambitious and committed to arithmetic is experienced ME1.4 future children-mathematics relationship imagined by parents

		ME2 Innate ability identity pattern in primary school ME2.1 school as context for further socialisation ME2.2 less effort and higher success experienced at school ME2.3 high mathematical competence 'proved' as inborn ME2.4 continued parental involvement ME2.5 active involvement despite unsupportive school environment ME2.6 relevance of mathematics to future lives not clearly imagined ME3 Innate ability identity pattern in secondary school ME3.1 positive self-perceptions of competence sustained ME3.2 viewing higher competence as inborn challenged ME3.3 imagined relevance of mathematics in future enforced by school ME3.4 sustained ambition and commitment to mathematics ME3.5 highest test scores in mathematics
	Mathematical experiencing in *Persistent effort identity*	ME4 Persistent effort identity prior to primary school ME4.1 parents as moderate socialising agents for some students ME4.2 the sense of competence in arithmetic is moderately experienced ME4.3 feeling ambitious and committed to arithmetic occasionally experienced by some students ME4.4 future children-mathematics relationship rarely imagined by parents ME5 Persistent effort identity in primary school ME5.1 for some students, school was context for

		further socialisation ME5.2 for other students, mathematics was first experienced at school ME5.3 more effort and incremental success experienced at school ME5.4 high mathematical competence viewed as resulting from effort ME5.5 parental involvement not significant ME5.6 active involvement despite unsupportive school environment ME5.7 relevance of mathematics to future lives not clearly imagined ME6 Persistent effort identity pattern in secondary school ME6.1 positive self-perceptions of competence are challenged but sustained ME6.2 viewing higher competence as effort-related is further confirmed ME6.3 imagined relevance of mathematics in future enforced by school ME6.4 active involvement mainly in study groups ME6.5 sustained ambition and commitment to mathematics ME6.6 incremental pattern of test scores in mathematics
	Mathematical experiencing in *Image-maintenance identity*	ME7 Image-maintenance identity pattern prior to primary school ME7.1 parents as moderate socialising agents for some students ME7.2 the sense of competence in arithmetic only experienced by some students ME7.3 feeling ambitious and committed to arithmetic occasionally experienced by some students ME7.4 future children-mathematics relationship rarely imagined by parents ME8 Image-maintenance identity pattern in

		primary school ME8.1 for some students, school as context for further socialisation ME8.2 for other students, mathematics first experienced at school ME8.3 more effort and incremental success experienced at school ME8.4 high mathematical competence viewed as resulting from effort ME8.5 parental involvement not significant ME8.6 active involvement despite unsupportive school environment ME8.7 relevance of mathematics to future not clearly imagined ME9 Image-maintenance identity pattern in secondary school ME9.1 positive self-perceptions of competence challenged but sustained ME9.2 viewing higher competence as effort-related sustained ME9.3 imagined irrelevance of mathematics in future ME9.4 less active involvement in mathematical activities ME9.5 decreasing ambition and commitment to mathematics ME9.6 declining performance levels in mathematics
	Mathematical experiencing for students with *Oppositional identity*	ME10 Oppositional identity pattern prior to primary school ME10.1 parents as rare socialising agents ME10.2 the sense of competence in arithmetic rarely experienced ME10.3 feeling ambitious and committed to arithmetic rare to none ME10.4 future children-mathematics relationship not imagined by parents

		ME11 Oppositional identity pattern in primary school ME11.1 school was first context for mathematics-related socialisation ME11.2 incongruence between effort and success experienced at school ME11.3 high mathematical competence viewed as inborn ME11.4 lack of parental involvement students' learning ME11.5 unsupportive school environment undermined students' efforts ME11.6 relevance of mathematics to future not imagined ME12 Oppositional identity pattern in secondary school ME12.1 self-perceptions of low competence enhanced by challenges ME12.2 viewing lower competence as nature-determined was sustained ME12.3 imagined irrelevance of mathematics in future ME12.4 rare or no involvement in mathematical activities ME12.5 lack of ambition and commitment to mathematics ME11.6 maintaining the lowest level of performance in mathematics

ME = Mathematical Experiencing

Appendix K. Selected memos showing the development of the *Mathematical experiencing* conceptual framework

The memos—researcher's field notes and reflections tracking the development of a theoretical model through coding of data (Corbin & Strauss, 2008)—were the basis for developing the Mathematical experiencing conceptual framework. Codes guiding the writing of the memos were based on data used for developing the themes and subthemes that addressed the research purpose. The coding leading to the construction of the framework began after the emergence of the four mathematical identity categories and continued while the recalled Mathematical experiencing theme was developing.

Memo 1

The main track of open and axial coding of data (Corbin & Strauss, 2008) is aimed to result in themes and sub-themes of the mathematics learning context, mathematical identity characteristics, and mathematical identity development as shown in Appendix J. A separate peripheral track of open and axial coding, leading to the construction of a data-based conceptual framework (to be contextualised within the general theory on mathematical identity), is necessary for interpretation of research findings, given the lack of a suitable conceptual framework in the literature on identity.

To begin with, classroom observation data on students' participatory behaviour in mathematics learning contexts indicate that students use their sense organs when they engage in mathematical activities and mathematics-related interactions. That is, they use their eyes to look, for instance, at mathematical assignments, peers and mathematics teachers; they use their ears to hear, for example, what the teacher or peers say; and they use parts of their body such as hands, for example, when copying mathematical notes into their notebooks. This facet of mathematical participation is in this fieldwork considered to be *concrete* because it more closely and directly links the students to mathematical activities, peers, teachers, and written material. It thus gives students a concrete mathematical experience, and for this reason, I label it *Concrete experiencing*.

However, the diary data and records of discussions with students on their mathematical self-perceptions indicate that *Concrete experiencing* is not an isolated process; it accompanies mental activities such as mathematical reasoning (e.g., thinking about the right procedure for solving a mathematical problem), reflecting (e.g., on teacher's comments, peer remarks, or mathematical concepts), interpreting (e.g., mathematics test scores), and self-evaluating. Seemingly, *Concrete experiencing* stimulates these mental activities. As a result, these activities can persist even after *Concrete experiencing* has ended. An instance of this ongoing mental activity after *Concrete experiencing* ceases is when these students continue thinking about mathematics tests even though they attempted such tests hours, days, months, or even years ago:

> *"when I try to solve a math problem and fail to get the right solution, I think about it even when I'm in bed at night"..." I remember my father telling me that if I can't learn how to do simple maths and to read the story books which he had bought for me and if I can't write simple sentences in English and Swahili he would not let me go to primary school".*

Although this more conceptual activity is linked to *Concrete experiencing*, it is a distinct form of experiencing. Because of this distinctness, I term it *Conceptual experiencing*. Further coding of the diary data reveals a link between *Conceptual experiencing ("when I get a low maths test score, I wonder why"*) and emotional reactions ("*I feel embarrassed when I get low test scores*" or "*I feel good when I get a high test score"*). There is ample data-based evidence that these students experience various positive or negative emotional reactions while conceptually experiencing mathematics. This emotional part of experiencing can be referred to as *Emotional experiencing*. Although, in practice, *Emotional experiencing* appears to be intimately intertwined with *Conceptual experiencing*, isolating it theoretically leads to the possibility of studying it more for in-depth understanding of its link with *Conceptual experiencing*.

In short, the processes of *Concrete experiencing*, *Conceptual experiencing* and *Emotional experiencing* are, undoubtedly, essential to mathematics learning. They can be collectively referred to as *Mathematical experiencing*. Moreover, narratives of how students perceive themselves in relation to mathematics elucidate a link between *Conceptual experiencing* and mathematical identity [e.g., "*I'm good at maths*" (suggesting positive mathematical identity)..."*because I always get high test scores*"..."*my classmates also know it*"(reasoning and self-evaluation)] OR ["*I'm poor in maths*" (suggesting negative mathematical identity)..."*I have always scored low in maths tests"* (justification, self-evaluation)]. This link is frequent across the data, suggesting its essence to mathematics learning as well. The *Conceptual* and *Emotional experiencing* appear to foster students to engage in (or disengage from) *Concrete experiencing,* for example:

> *I think about why I've failed in a maths test...I feel embarrassed...I do more exercises and prepare myself for the next test.*

This fostering is certainly facilitated by complex motivators embedded in students' mathematical identity such as mathematical commitment, ambition, and agency. Other motivators, such as willingness to engage in mathematical activities and liking mathematics, are noticeable from the data but seem to be less important than these identity-related complex motivators. Interestingly, this link between identity and these complex motivators is evident across all the four identity categories—*Innate ability*, *Persistent effort*, *Image-maintenance*, and *Oppositional identity*, as the data demonstrates. The term *Fostering factors* can thus be used to more directly denote these motivational factors because they foster students to engage in (or disengage from) *Concrete experiencing*. Thus, there is a cycle running from *Concrete experiencing* to *Conceptual experiencing,* then to mathematical identity, and through the *Fostering factors* in mathematical identity, back to *Concrete experiencing*.

To clarify this cyclic pattern, I focus on data specifically related to simultaneous equations. In the data, students solve a simultaneous equation while inevitably involving their sense organs in this activity (*Concrete experiencing*), in the process of solving the equation, the students think about the procedure, evaluate themselves with respect to how they progress in this activity, and often express emotions during the activity (*Concrete*, *Conceptual and Emotional experiencing*). Self-evaluations frequently appear to challenge the established positive mathematical identity when the students fail (this applies mostly to those seated in front of the classroom). The students are then fostered by their agency (e.g., making personal decisions), ambition (reflected in their achievement goals) and commitment (i.e., a sense of obligation to succeed in solving mathematical problems) to attempt the equation problem again (*Concrete experiencing*). This cycle is needed for an equation problem to be solved. If the cycle ends with an incorrect solution, repetition of the cycle is inevitable. Sometimes the cycle repeats several times until a solution to the problem is reached. This means that these students experience many repetitions of the cycle in each mathematics lesson. I term the cycle *Mathematical experiencing* cycle, necessary for the development of mathematical identity and acquisition of mathematical skills.

Furthermore, the diary data on students' earlier engagements in mathematics (at home or primary school) suggest a lack of mathematical identity during those initial engagements among these students. Instead, the data indicates willingness to learn mathematical skills, liking mathematics or even coercion as essential *Fostering factors*. Thus, the *Mathematical experiencing* cycle was simpler during the initial stages of mathematics learning compared to the time when mathematical identity was formed and developed. It was simpler due to a lack of this identity and its fostering factors. As students narratives indicate, the *Mathematical experiencing* cycle in the initial stages of mathematics learning ran from *Concrete experiencing* to *Conceptual experiencing, then* to *Fostering factors* of willingness to learn mathematics, liking mathematics or parental coercion. The cycle then ran back to *Concrete experiencing*. But there is an important observation here. Repetition of this cycle in its basic (simple) form appears, over time, to have developed children's mathematical identity and enabled the children to acquire mathematical skills. Primarily, self-perceptions of competence in arithmetic seem to have been formed in childhood through peer-comparison *("because I could do maths better than they did, I felt I was better in maths than them*".)

Memo 2 (The context for this memo is the same as for Memo 1)

There is evidence from the diary data that the *Mathematical experiencing* cycle, in its simple and complex form, is shaped (or influenced) by a number of factors external to the children or students. Children's mathematical reasoning, emotions, self-evaluations, and other forms of reflection are concretely (i.e., involving their sense organs) shaped by factors such as the teacher and what he or she says, mathematics assignments, peers, formal criteria of evaluation, interactions, etc in mathematics learning environments. Also, the *Fostering factors* can be enhanced (e.g., by a supportive teacher) or inhibited (e.g., by a lack of a supportive teacher-student interaction). These factors can be referred to as *Contextual factors* because they are part of the mathematics learning environment. In a nutshell, these factors have a direct influence on *Concrete experiencing*, *Conceptual experiencing* and *Fostering factors*. The *Contextual factors* do not directly influence mathematical identity but influence it through *Conceptual experiencing* (e.g., when students reflect on the factors and on themselves based on these factors). It seems to me that *Contextual factors* (directly needed for *Concrete experiencing*) must be supportive for a *Mathematical experiencing* cycle to result in a positive mathematical identity and to enable children to acquire mathematical skills. If they are inhibitive, the development of a negative mathematical identity is possible.

More on the Mathematical experiencing cycle

The *Mathematical experiencing* cycle, in its simple and complex form, is reflected in the diary and observation data. It is thus undoubtedly a relevant tool for analysing students' narratives of their *Mathematical experiencing*. The question of its theoretical relevance, however, needs to be considered. Specifically, one may seek to understand the extent to which the conceptual tool is compatible with the general literature on mathematical identity. This question fosters me to read extensively this literature and reflect on it. As a result, I find that *experience* has a high frequency of occurrence in this literature, with an emphasis on its essential role in identity development and learning. However, a conceptual mechanism that details this relationship more coherently is lacking. The contextualisation of the *Mathematical experiencing* cycle within the theoretical and empirical literature on mathematical identity is discussed in detail in Chapter 2.