Students’ perceptions of the relevance of mathematics in an Ethiopian preparatory school

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Preface

This PhD dissertation in mathematics education is a case study of students' perceptions of the relevance of mathematics in a selected school in Ethiopia. This dissertation contains nine chapters. Seven chapters are about the research project beginning from a theoretical framework through to a discussion of the results of the project. The first and last chapters contain additional elements. The first chapter presents some background information about the study and last chapter contains my personal development as a mathematics education researcher.

Many individuals have contributed to my development into that role, especially through what I have learned by undertaking the research project reported here. It is difficult to cite people by name when the number of supporters is so great, as is the possibility of missing some of the important people who gave me such vital support. I thus apologize in advance to anybody I may have failed to recognise.

My deepest gratitude goes to my supervisors, Professor Simon Goodchild and Professor Olav Kristian Gunnarson Dovland. The completion of this work would have been impossible without their kind and tireless support. I deeply thank Professor Markku Hannula for his critical comments and suggestions in my 90% seminar, and afterwards when we met at Volda University College. I also would like to thank my former colleagues at Volda University College who made these occasions possible.

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My deepest gratitude goes to my wife Roza Berhanu Lemma. In my journey, which was full of challenges and adjustments to diverse situations and required much diligence. Her patience and support was irreplaceable. I would like to recognize her incredible support in my success. Finally yet importantly, I thank my parents and my family. Their sustained encouragement brought me to this milestone in my life.

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Abstract

This dissertation reports on a study, carried out in an Ethiopian context, of students' perceptions of the relevance of mathematics. The participants are preparatory school students who are looking forward to university studies. Engeström's model for analysing and describing activity is central for the study, especially in interpreting data in order to expose the students' perceptions of relevance.

I chose a mixed approach, where both qualitative and quantitative methods are used. I undertook a pilot study to test the methods and explore the context for further data collection in the main study. The pilot study employed only qualitative methods, namely interview supported by classroom observation. The results indicated that students' perceptions of the relevance of mathematics had multiple characterisations. I used the results of the pilot study to design a questionnaire, which I used in the main study. The main study, which I undertook one year after the pilot study, has two components, survey and interview.

The varying degrees of positive responses of students to the identified characterisations of students' perceptions are set out. Students perceive mathematics' relevance in different ways: as useful in everyday life; as giving a fresh perspective on life; as giving an identity; as having exchange value; as useful in an unknown future and as useful in other school subjects. The students also appear to form a national identity with respect to the mathematics curriculum. The students' perceptions of the relevance of preparatory mathematics to future study and to the other subjects are among the most significant results of this study. The students' perception that mathematics has exchange value is significant in its motivational effect.

Some of the results are related to the peculiar features of the Ethiopian sociocultural context. Students inventively attach meaning to the mathematical concepts using the local artefacts. The local community mediate their perceptions of relevance of mathematics. There is gender difference in the influences, which students receive about future choice. The implications of the study in general for the teaching and learning of mathematics, for the research community of mathematics education, and for the mathematics curriculum in Ethiopia are also set out.

Contents

1 Background of the study

1.1 Introduction

In this dissertation, I present a case study of students' perceptions of the relevance of mathematics in a selected preparatory school in Ethiopia. The data were collected in two occasions. In the academic year 2009-2010 (2002 E.C.[1],), I collected data for a pilot study. I undertook a second round of data collection in 2010-2011.

In order to enable the reader to understand the evidences and interpretations of the findings, I present a range of social and cultural issues related to Ethiopia. These considerations are also important because the study uses the theoretical perspective of cultural historical activity theory, which emphasises social and cultural issues and the historical context of any study. Thus, I also present some historical issues associated with the introduction of education in Ethiopia. A consideration of such issues may also help the reader to relate the study's findings to other settings.

This chapter initially presents the motivation for undertaking the research, followed by an outline of the historical background to education in Ethiopia and the Ethiopian sociocultural context. Then, I set out the Ethiopian school system before I present an outline of the chapters in this dissertation. Finally, I provide concluding remarks.

1.2 The motivation of this study

I started my research project as an integral part of my enrolment in autumn 2009 in the PhD programme in Mathematics Education, Faculty of Engineering and Science, University of Agder. The research is motivated by my experience as a teacher at various levels. I taught mathematics at the three levels in Ethiopia: primary, upper secondary, and university. From my experience as a teacher and my interaction with colleagues, I perceived that students of upper secondary school had a low motivation to engage in mathematics. They also question why they learn it.

I presumed that the students would be motivated to engage in mathematics if they perceive that it is relevant to them. As a result, I became interested in investigating students' perceptions of the relevance of mathematics, based on the premise that perceptions of relevance influence motivation. It is important to examine the relevance of mathematics to students' future studies because the students are at the transition period between school and university and nearing the stage where they will choose their future careers. The students' experiences with mathematics will affect their choices and decisions about their futures (Eccles & Wig-

[1] E.C. stands for Ethiopian Calendar.

field, 2002). In their lives outside the school, students may use mathematics or encounter mathematics in their everyday life and their society.

Since the students had earlier experience of learning mathematics before enrolling preparatory, the relevance of mathematics could be with respect to this earlier experience. These were my focuses initially. In the process of the study, especially during the pilot study, a new interest emerged, that of the relevance of mathematics to the other school subjects because the students often mentioned the other school subjects. In explaining the relevance of mathematics to everyday life and to future study, students compared the relevance of mathematics with the relevance of other subjects, which may or may not use mathematics. Some students also used other school subjects, which use mathematics to explain mathematics' usefulness in everyday life and to future study. They also compared engaging in mathematics with that of other school subjects. Thus, the relevance of mathematics to the other school subjects could be important for the students.

Reading the related literature, supervisory meetings, summer schools, and course discussions at the University of Agder gave me the opportunities to think more deeply about perceptions of relevance of mathematics and motivation. It helped me to see this area of inquiry in the wider context of belief research. My participation in conferences and seminars opened up more opportunities to delve more deeply into this area. There are numerous studies in belief research in mathematics education, showing that its importance is well known (Leder, Pehkonen, & Törner, 2002). Some of the studies rather prefer to use the term affect as a major area of research and include belief (e.g. McLeod, 1992; McLeod & Adams, 1989). This is set out in Chapter 3.

Those studies mostly focus on Western cultures, and we need to know more about students' perceptions of relevance in different cultural contexts. The current study helps to answer the need to explore beliefs in the field of mathematics education in an Ethiopian context. Examining students' perceptions of the relevance of mathematics to their future goals has significance for mathematics education community, because presently we know little about upper secondary students' perceptions of the relevance of mathematics to their future goals. This lack is particularly pronounced in the context of developing nations such as Ethiopia.

Studying students' perceptions of the relevance of mathematics to everyday life has significance for the mathematics education community, as so little is presently known about preparatory students' perceptions of the relevance of mathematics to the world beyond the classroom. Again, this lack is especially pronounced in the context of developing nations such as Ethiopia, where the students' exposures to advanced technology is limited. The relevance of school subjects to the out-of-school situations influences students' motivation of engaging (e.g. Miettinen, 1999). Similarly, we know little about upper secondary students' perceptions of the relevance of mathematics to the other school subjects, particularly, in the context of developing nations such as Ethiopia.

The research questions addressed in this study are:

1. What are the characteristics of Ethiopian preparatory students' perceptions of the relevance of mathematics to their future goals?
2. What are the characteristics of Ethiopian preparatory students' perceptions of the relevance of mathematics to everyday life and their society?
3. What are the characteristics of Ethiopian preparatory students' perceptions of the relevance of their prior experiences of mathematics to their present experiences of mathematics?
4. What are the characteristics of Ethiopian preparatory students' perceptions of the relevance of mathematics to other subjects?

From my point of view, beginning with research into students' perceptions of relevance would enable further investigation into the prevailing problems in mathematics teaching and learning in Ethiopia. This study could serve as a starting point for further investigation of mathematics classrooms, particularly in relation to students' perceptions of mathematics and issues of the relevance of mathematics in Ethiopia. It could also be used as a reference in investigations, which aim to address learning mathematics in a foreign language; misconceptions; gender difference; the preparation of teaching materials such as the textbook in Ethiopia.

1.3 Historical background of education in Ethiopia

This section provides a brief description of the historical context of the introduction of western-oriented education in Ethiopia. It sets out about the shift from traditional education and a brief description of the historical and sociocultural context of the country.

Both Christianity and Islam were introduced early in Ethiopia (Wagaw, 1979). By the 4th century, the country was already a Christian state (ibid). There has been traditional education associated with these two religions, and church education was widespread in much of the country (ibid). Church education used Ge'ez, an old language that was an official language of Ethiopia before 1270, when Amharic replaced it (ibid). Both use the same alphabets. The Ge'ez Language has now been restricted to use in Ethiopian Orthodox Church worship and education. The traditional education associated with Islam uses the Arabic language. As the later chapters make clear, there is a belief that meeting the challenge in understanding these languages helps to overcome the challenges in school.

In Ethiopia, the second half of the 19th century was characterised by maintaining sovereignty from colonial powers, endeavouring to modernise the country, and re-establishing diplomatic relationships that had been suspended for two centuries (Wagaw, 1979). Modern education was introduced in Ethiopia around the beginning of the 20th century (ibid). In 1908, a modern school was opened in Addis Ababa, the capital (Hoot, Szente, & Mebratu, 2004). It was named after the Emperor, Minilik II, who ruled the country in that period. Minilik also introduced new technologies in the same period, with a railroad established between Addis Ababa and the port city of Djibouti (ibid).

Modern education was not in line with the country's needs in some ways (Wagaw, 1979). Many of the subjects taught were languages such as Arabic, English, French, etc. (Wagaw, 1979). Though the local languages such as Amharic and Ge'ez are taught as subjects, the language of instruction was not any of the local vernaculars. One reason for not using Amharic was that the language did not assimilate scientific language well (ibid). The lack of assimilation is because of centuries of isolation since the 1630s that followed religious conflict, which involved the Portuguese Jesuits and resulted in the expulsion of the Portuguese Jesuits from the country (Wagaw, 1979).

Many of the Ethiopian scholars of earlier generations are products of traditional education, mainly Ethiopian Orthodox Church education (Serbessa, 2006). Initially, church education was exclusively for males (Hoot et al., 2004), but reading the Ge'ez alphabets and numerals was later available to female children as well. Some children of Orthodox Christian background learn to read the Ge'ez alphabets and numerals before they go to modern schools. Ge'ez numerals continue to be in use in the Ethiopian calendars, Amharic literature, and church manuscripts.

In spite of the fact that education was considered as a gateway to getting job, some parents were sceptical about the modern education in respect of maintaining cultural values (Wagaw, 1979). The clerics also expressed concern about maintaining Ethiopian values in the modern education system, a worry that is also shared by some scholars (Wagaw, 1979). While the study will not delve too deeply into the details of this issue, it is important to understand that the modern education system was introduced in a contradictory context of coping with a modernizing world on the one hand and maintaining cultural values on the other.

The historical situations I presented here form part of the context in which today's students find themselves. The discussion in this section provides a context to students' explanation of their perceptions of mathematics' relevance and the analysis that the succeeding chapters present (see Chapters 7, 8, and 9). This description also facilitates the reader's own interpretation of the results both in Ethiopia and in comparative settings.

1.4 The Ethiopian sociocultural context

This section sets out the cultural, economic and social issues that are relevant both to schooling in the Ethiopian context and to the development of students' perceptions of relevance. I start with a brief description of the two traditional institutions in the Ethiopian culture, Edir and Equb.

Edir is a social institution where members gather to discuss issues related to social problems. Particularly, they contribute money every month, and on the death of a member or siblings, they arrange a mourning ceremony. This ceremony includes a funeral and lasts for three or more days. Members are provided with support that includes provision of money on the death of a member or a sibling. Edir is led by elected board members. There are also Edir, which are for women only.

Equb is also a social institution, with a financial focus, to which members contribute a fixed amount of money periodically (usually weekly) and the names of members are drawn in a lottery. The one who wins will take the money that was collected for that draw date. Those who won will no longer have their names in the lottery, but they must continue to contribute money. In case a member contributes double the regular amount, then s\he continues to be in the lottery until s\he wins a second time. Every member collects the amount of money, which is the same as the total amount s\he contributed. The lottery drawing only provides an opportunity to collect the money earlier than other members do.

Ethiopian culture dictates that older people care for younger people, who in turn respect and obey the elder. It encourages a tendency that 'the elder is right.' At the same time, there is a sense of parenthood and caregiving from all elders of the society. Though the government is secular, the Ethiopian society is generally religious. Children are encouraged to go to church or mosque, and there is deep respect for and reliance on religious teachers. There is also a tendency in Ethiopian society to respect, trust, and rely on schoolteachers, which might be due to the esteem in which the society has traditionally held religious teachers.

In traditional Ethiopian society, there is typically a marked difference in gender roles. The female has a direct responsibility to mentor and transfer cultural values to children. Girls are encouraged to engage in domestic chores, after school, while boys are given other tasks. In some low-income families, students, especially boys, are expected to earn some money and support themselves and their families. In other families, the student participates in the family business.

On the other hand, Ethiopia is a poor country. According to the Central Statistical Agency (2018), GDP per capita is US$255.04 for 2006–2007. In Ethiopia, the use of advanced technology that either employs or results from higher mathematics is limited. Direct access to digital tools such as cash machines or computers is not usual. Except in a few places, service in small businesses and public transport, to which students have frequent access, is still manual. This situation appears to limit the possibility for the students to experience what mathematics can do.

The statistics from Central Statistical Agency shows that urban unemployment rate for 2012 is 17.5 %, while the most recent literacy rate, for 2009–2010 is only 36%. It is not clear how the Central Statistical Agency defines literacy precisely, but from my experience as a teacher who participated in the literacy campaign, I can relate the everyday understanding of the term in the country. One is labelled as literate if one has basic reading and writing skills.

This introductory background highlights the Ethiopian context, enabling a richer understanding of the way that the theoretical framework introduced in Chapter 2 is used to analyse students' perceptions of relevance and interpret their words. Chapters 7 and 8 demonstrate how the sociocultural issues influence perceptions of the relevance of mathematics. Chapter 9 relies on this background to support its assertion embracing Ethiopia's contemporary situation and cultural heritage.

1.5 The Ethiopian school system

The Ethiopian school system has three levels: preschool**,** primary, and secondary. The primary level includes first through eighth grades. A normal starting age for first grade is six or seven. In general, students are assigned to a particular grade level based on their achievements rather than their ages. It is common to find students whose ages are inconsistent with the majority of the group. Instruction at the primary level is in the official language, Amharic and other local vernaculars (Ministry of Education, 1994). In Addis Ababa, the school language in public primary schools is Amharic, and English is taught as one subject (ibid).

The secondary level has two cycles: the first cycle, which corresponds to lower secondary, includes ninth and tenth grades, while the second cycle, which corresponds to upper secondary, includes eleventh and twelfth grades. The second cycle is referred to as preparatory school. In the public schools, education up until tenth grade is free, but users are expected to share the cost of schooling beyond that level (ibid).

Once at the secondary level, students begin to learn many of the subjects, including mathematics, in English (ibid), though students do not normally communicate in English, which is typically heard only in the classrooms. Even in the classrooms, students usually use Amharic when they ask questions, and in their explanations and responses to the teacher's questions. It is a regular practice of the teachers to explain concepts in Amharic or other local vernaculars so that the student can grasp the concepts that they are teaching (see section 7.3.3). This practice contravenes the language policy of the schools, but remains widespread.

The Ethiopian school system has three national examinations (Ministry of Education, 1994). Students take the first national examination at the end of eighth grade, and those promoted will be assigned to the first cycle of the secondary level. At the end of this cycle, students take another national examination, which determines whether they join the second cycle. Students who do succeed attend preparatory school for two years and then take the third national examination. In the next two subsections, I focus on preparatory schools, and the specific context of Memiru Preparatory School. For privacy reasons, Memiru is a pseudonym given to the school in which I undertook the study.

1.5.1 Ethiopian preparatory schools

Ethiopian preparatory schools are strictly for providing the necessary background for students to attend university. Their preparatory function is an integral part of their names, as it is for the actual school that Memiru represents. The students are divided into social and natural science streams. When the students reach university, they do not attend freshman programs but enrol directly into their particular fields of study. The first cohort of students who were educated in this education system reached university in 2003–2004.

The new system features differences such as four-year programs becoming three-year courses, with some mathematics courses no longer available in some of these programs. Mathematics topics at the old freshman program are now part of the preparatory mathematics.

Table 1.1. Subjects for university entrance examination in social science and natural science streams.

S.N	Social Science Stream	Natural Science Stream
1	Mathematics	Mathematics
2	Civics and Ethical Education	Civics and Ethical Education
3	English	English
4	Scholastic Aptitude Test	Scholastic Aptitude Test
5	History	Physics
6	Geography	Chemistry
7	Economics	Biology

Most of the topics at preparatory were not part of the old curriculum at upper secondary. The importance of mathematics to matriculating itself is also reduced, when compared to its previous role as a compulsory subject. Matriculation is now determined by the aggregate of a student's scores in all subjects (see Table 1.1). The score is calculated out of 700, and all subjects carry an equal weight of 100 points in the calculation. Mathematics as a field has more weight because the Scholastic Aptitude Test also contains mathematical reasoning. Students take more subjects than they sit for in the national examination (see Table 1.2). There are some common subjects for the two streams.

Table 1.2. School subjects that preparatory school students take, by stream.

S.N	Social Science Stream	Natural Science Stream
1	Mathematics	Mathematics
2	History	Physics
3	Geography	Chemistry
4	Economics	Biology
5	Civics	Civics
6	Amharic	Amharic
7	English	English
8	Information technology	Information technology
9	Health and physical education	Health and physical education

Once the students are enrolled in one of these streams, they all attend the same subjects and topics for that stream, and neither stream has elective subjects. The students in this group are recognized as the elite of their age group in the context of the Ethiopian school system. These are students, who demonstrated their capabilities through succeeding in two national examinations taken at the end of eighth and tenth grades. They attend preparatory school for two years and then take the third national examination, in which they are likely to succeed, given the high pass rate. Those who succeed in this national examination can join university. There is a distinction between the future studies, which the natural science and social science students can join. In particular, they continue with natural science and social science fields of studies.

The number of public and private higher learning institutions in Ethiopia is increasing, as is the intake rate of public universities. This increase is an important success criterion for the government, and it is widely published in the limited number of public communications media. Moreover, the data for the main study, which includes the survey, was collected three months before national and regional elections. The success in establishing many universities, and the ever-increasing rate of matriculation to university were among the major campaign talking points for the ruling party. Thus, the students in the preparatory school are very much hopeful of attending university.

1.5.2 The Memiru Preparatory School context

Memiru Preparatory School is situated in Addis Ababa. It is similar to other Ethiopian public preparatory schools. As any other public preparatory school, the students at Memiru are divided into social and natural science streams, with far more students being placed in the social science stream (see Table 1.3). There is affirmative action that is in place to favour female students' participation. This allowed many female students to enter the preparatory school with a lower score than their male peers. As can be seen in Tables 1.3 and 1.4, there is a positive development in that the number of female and male students is nearly the same.

The Ethiopian public preparatory schools teach eleventh and twelfth-grade students. They admit students who are assigned by authorities appointed by the government. Mostly, they admit students of non-affluent family background, because affluent parents usually send their children to private, foreign community or missionary schools. The school subjects in these preparatory schools are the same with possible exception that local languages are included in schools outside Addis Ababa.

The teaching of mathematics since 2004-2005 has been through the plasma[2], which has been mandatory for public secondary schools. When I first visited the school for data collection, I was informed by the school officials that the students learn mathematics and most of the other subjects through the plasma. When I started the data collection, the rule seemed to be interpreted rather leniently. Throughout my presence in the mathematics classrooms, the plasma was not in use and the teacher was active the whole period without it. Since the academic year 2009-2010, the enforcement of use of the plasma was relaxed, at least until 2010-2011 during which both the pilot study and the main data collection took place. I will not discuss about the use of the plasma, because it is beyond the scope of this study.

In Ethiopian preparatory schools, the teachers and students use one mathematics textbook for each grade level. Natural science and social science students use the same textbook. It is expected that students will bring their books to the classrooms. They walk long distances to and from school. According to the head of mathematics department, the teachers consider this, and consequently are flexible in enforcing the rule that students bring their textbooks to their mathematics classes. For example, the teacher allows the students to use one textbook for three.

The data collection for the main study took place while the Ethiopian public preparatory schools were undertaking a textbook change. During the interview, some students mentioned about the new textbook. Though examining the textbooks in detail is beyond the scope of this study, some of their features are offered in the data presentation when they are pertinent to the issues raised by the students and to the analysis (see Chapter 7). In order to provide the reader with a sense of the mathematics in preparatory schools, I provide the unit topics of the textbooks (see Appendix 1). Some of the topics are examined in Chapter 7. The mathematics teachers and the experts who prepared the textbook have a natural science background, as is evident from the faculties to which the mathematics departments belong. The students who are in mathematics department at university commonly studied natural science in the upper secondary.

[2] Plasma refers to televised teaching from a central studio broadcast to schools.

The social science students are very few when compared to the natural science students. The number of students in this preparatory school during the pilot study is presented in Table 1.3.

Table 1.3: Number of students in the school during the pilot data collection 2009–2010

Streams	Eleventh Grade			Twelfth Grade			Grand Total
	Female	Male	Subtotal	Female	Male	Subtotal	
Social	299	170	469	158	166	324	793
Natural	526	534	1060	387	578	965	2025
Total	825	704	1529	545	744	1289	2818

In eleventh grade, female students outnumber the male, but in twelfth grade, the reverse is true. Table 1.4 shows the number of students by gender, grade level, and stream during the data collection for the main study.

Table 1.4. Number of students in the school during the main data collection 2010–2011

Streams	Eleventh Grade			Twelfth Grade			Grand Total
	Female	Male	Subtotal	Female	Male	Subtotal	
Social	209	154	363	276	168	444	807
Natural	610	508	1118	511	532	1043	2161
Total	819	662	1481	787	700	1487	2968

The trend in the number of students in both streams is the same. However, the trend in gender disparity has little change, which is in favour of female students with the exception of the number in twelfth-grade natural science stream. This disparity in favour of female students might be due to the affirmative action noted above. When we look at the natural science stream, the trend in gender disparity in twelfth-grade is in favour of male students. Moreover, a smaller proportion of female students pursue natural science in both grade levels: 74% female to 77% male in eleventh and 64% female to 76% male in twelfth grade.

Memiru reflects the religious and other diversity that prevails in Ethiopia to some extent. The students are Christian or Muslim and have urban or rural backgrounds (see Chapter 6). The students at Memiru use Amharic as the primary language of communication. Some students also use other local languages such as Afan Oromo. Students who come from outskirt of Addis Ababa are likely to use Afan Oromo.

Twelfth-grade students have internet access at the school. The internet centre has 25 computers, of which 20 operate effectively. The students are provided with approximately two hours of training. The training is on basic skill of how to browse the web. Since internet connection is not reliable, even this training does not occur regularly. For example, it was not offered at all in the academic year 2009–2010. The internet service is open every day after school ends and during the lunch break, for a daily total of two and a half hours.

As any other public preparatory school, the lessons at Memiru derive generally from the mathematics textbook and the accompanying teacher's guide. Their use is mandatory. The teacher's guides indicate that there is some degree of freedom to adapt to local needs and the specific classroom situation (Federal Democratic Republic of Ethiopia Ministry of Education, 2010a; Ministry of Education, 2001). The teachers informed me that they are evaluated based on their teaching plan and implementation of their plan, which they prepare based on the textbook.

1.6 Description of the chapters in this dissertation

Including this introduction, the dissertation comprises nine chapters. In Chapter 2, I set out the theoretical framework that is used in examining perceptions of relevance and the theoretical stance I take. I discuss some central concepts of sociocultural theory. I then focus on the theory that drives the study, cultural historical activity theory. I also present the central constructs in my study such as perception and motivation.

The theoretical consideration of the affect and belief areas of research forms an integral part of Chapter 3. I attempt to situate my study in these areas of research. I include some studies outside of these research areas, because relevance is not often explored in these areas of research. Since my study is about perception of relevance, I provide a description of what I mean by this. Chapter 4 presents the study's paradigm, design and methodology. I explain why I chose a mixed approach of both qualitative and quantitative methods, where the qualitative methods predominate. The research project had two phases, a pilot study and main study. The pilot study employed qualitative research approaches, particularly interviews supported by classroom observation. Essentially the same procedure was repeated in the main study. In addition, a survey was undertaken as part of the main study.

Chapter 5 presents data and analysis arising from the pilot study undertaken to test the methods and explore the context for further data collection. This chapter presents the data analysis as a descriptive and analytic account of students' perceptions of the relevance of mathematics. The multiple characterisations of perceptions of relevance are presented in three categories.

The main study has two components, survey and interviews. Chapter 6 presents the analysis of the quantitative data arising from a survey questionnaire. The main purpose of the data obtained using the questionnaire is presenting the proportions of students, which hold the different perceptions of relevance. Chapter 7 focuses on the second part of the main study presenting students' perceptions of the relevance of mathematics, from the main data corpus obtained through the qualitative research methods. Some of the data from the pilot study are re-examined in

Chapter 7. The results in Chapters 5 and 7 answer essentially the same research questions and provide a qualitative account of the characterisations of perceptions of the relevance of mathematics. Chapter 7 presents a more in-depth analysis than what Chapter 5 presents.

Chapter 8 comprises a discussion and synthesis of the data presentation and analysis. It brings together the separate analyses reported in Chapters 6 and 7. The results are discussed together with the literature. Chapter 9 presents the study's conclusion, implications, and some reflections. I provide some suggestions for future study. A reflection on my journey from embarking on this project through the final transformation into a dissertation is also part of this chapter.

1.7 Concluding remarks

This study was undertaken in a setting where schooling takes place in an economically and technologically non-advanced society with conflicting historical roots. On the one hand, traditional indigenous education is associated with a longstanding local culture. On the other hand, the new education system is foreign to the society's cultural background. The Ethiopian economic and cultural situation and the historical background of education in the country are likely to have a significant impact on teaching and learning mathematics in Ethiopia, and might well affect the students' perceptions of the relevance of mathematics.

Mathematics can be used in the broader society. Out-of-school examples could be uses of mathematics by students and other members of society, or in the tools and artefacts that any of them use, including the mathematics used in workplaces to which students have direct or indirect access. There is criticism of the gap between school mathematics and the level of a society's development (see Chapter 3). Identifying and closing the gap is beyond the full scope of this study. However, it does suggest that this gap needs attention urgently and requires further investigation.

This introduction provides a description of the school setting and the general background of the Ethiopian context in terms of the sociocultural and historical situations. The purpose is to enable the readers to understand the study's results and the importance of the implications for Ethiopia and beyond. Chapter 7 provides a further description of the context.

2 Theoretical considerations

2.1 Introduction

The focus of this chapter is the theoretical framework that I use in my study. The chapter has five main sections including this section. In the next section, I describe sociocultural theory, which comprises concepts such as mediation and dialectical relations. Cultural historical activity theory (CHAT) is one strand of sociocultural theory (Stetsenko, 2008). In the third section, I will discuss CHAT. I provide an overview of the three generations of CHAT in this third section. In the fourth section, I examine perception and the associated constructs, which are significant in my data analysis. Finally, I provide concluding remarks.

2.2 Sociocultural theory

Sociocultural theory focuses on the social and cultural milieu that facilitates and constrains the individual's psychological development and knowledge appropriation (Roth, Tobin, Elmesky, Carambo, McKnight & Beers, 2004). It is about people's active involvement in sociocultural practices and the inherently social nature of the mental processes that underlie these practices (Lerman, 1996). As individuals engage in sociocultural practices like schooling, they appropriate new knowledge and develop into a new sociocultural entity through a process in which other individuals and artefacts play a determining role (Vygotsky, 1978). Proponents of sociocultural theory warn against a focus on the individual in isolation (e.g. Lerman, 1996; Skott, 2010). It is in the sociocultural milieu that we find the enormous database of the history of development of human thought, concepts, techniques, etc. (Lerman, 1996; Skott, 2010). The individual's mind is dependent on the sociocultural milieu in which s\he lives (Roth, 2007).

It is a central insight that psychological functions develop within the sociocultural milieu and that the development of mental functions and knowledge appropriation is a sociocultural process that is mediated by human agents, tools, and signs (Vygotsky, 1978). Learning mathematics is part of that social process; it is not an individual process, which is accomplished completely by the individual student. It involves the teacher and other students; it involves material resources like textbooks; it involves communication by using language. The students' perceptions of the relevance of mathematics is *mediated* by the sociocultural milieu.

2.2.1 Mediation

Mediation is an important notion in sociocultural theory because it threads between the concepts that are traditionally used to describe the individual's mind and those referring to sociocultural issues (Kozulin, 1998; Vygotsky, 1978). The notion of mediation entails that the demarcation between the individual mind and the sociocultural milieu is artificial (Engeström, 1999; Vygotsky, 1978). Mediation is a process by which human beings master nature and master themselves (Vygotsky, 1978). Through mediational processes, the mind is provided with, and made dependent on, signs and tools (Nardi, 1996; Roth & Lee, 2007). Signs, tools, and other persons mediate human action (Vygotsky, 1978).

According to Vygotsky (1978), the relationship between the acting individual and the object is not a direct stimulus-response situation, but is mediated by tools (ibid). When tools mediate, the target is a material entity (Kozulin, 1998; Vygotsky, 1978); only with the help of tools can an individual undertake practical or physical action (ibid). The students use tool such as the textbook (Engeström, 1987). The textbook contains mathematical entities. It also contains text, from which the students read (ibid). The textbook mediates students' doing of their mathematics classwork and homework. The students use the textbook to write a text in writing their answers to classwork and homework.

Vygotsky explains that there is also mediation by signs. According to Vygotsky, signs mediate mental processes such remembering, comparing things, reporting and choosing. There are signs, which might help to remember what one experienced before or parts of it (ibid). They direct attention to particular experiences (ibid). The school rules such as examinations are signs that come in the students' problems of choice between school subjects. They help them compare the cost and advantage of undertaking a given action and avoiding the other. The division of labour and rules in the school are signs, which might determine the students' reliance on the teacher.

Vygotsky (1978) further notes that mediation by signs and tools are different because they orient behaviour in different ways. He asserts that while tools orient human behaviour externally, sign does it internally. With tools, man influences the object and changes it whereas with the help of sign man influences oneself, but does not bring change in the object (ibid). According to Vygotsky, tool enables man to have control over the object while sign enables man to have control over oneself.

On the other hand, Roth and Lee (2007) assert that mediators can change their roles, so that a tool mediator might become a sign mediator and vice-versa. For example, the textbook can have the role of sign mediation, which might then change into the role of tool mediator (Roth & Lee, 2007). In a school setting, the textbook represents for the students what is to be covered in a given academic year. It defines the curriculum (the school rule) since it provides the content of mathematics for a specific grade level. The textbook might also provide the framework for how we think about learning mathematics; what it requires and what it is for (cf. Kozulin, 1998). Kozulin (1998) asserts that the signs help the mind to establish a framework for interpreting new experience.

Vygotsky (1978) explains that the meaning of an individual's interaction with the *object* and the internalization of the mediational tools are themselves mediated by other persons. Family members may mediate the meaning of the students' interaction with the object that the students experience in their everyday life as well as the internalization of the mediational tools and other cultural artefacts that are available in the local community (cf. Vygotsky, 1978). These internalizations occur in the individual's participations (Vygotsky, 1978). Students internalize the artefacts in their school and out-of-school participations. For example, the students live in a religious society and they internalize the religious artefacts and meanings while participating in the church or mosque.

The students can also have access to some social institutions deeply embedded in the Ethiopian tradition such as Edir and Equb, which I described in Chapter 1. Students' experiences with these social institutions might begin in the family as their parents discuss about these institutions at home. The students internalize artefacts and the rules in these social institutions. Similarly, the students internalize the artefacts in game playing, the rules of the game and the various roles of individual players while they participate in game playing. The artefacts in school, as much as in society, have meanings that students internalize along with their meanings (Vygotsky, 1978). The teacher can mediate the internalization of mathematical language, the school rules, etc. Kozulin writes:

> [T]he mediator selects, changes, amplifies, and interprets objects and processes to the child (1998, p. 60).

In the mathematics classroom, students are exposed to mathematical entities and concepts along with the methods of learning. Following Kozulin (1998), I understand that other individuals such as the teacher interpret mathematical experiences for the students. They could present to the student alternative ways in tackling challenges. These individuals could amplify the important experiences, on which students should focus. They could interpret to the students what it means to be enrolled in the natural science or social science streams. Other individuals interpret to the students what the mathematics topics mean to the students' future studies. The teacher selects one topic instead of the other.

The people in the local community also provide the cultural artefacts and the associated meanings (Vygotsky, 1978). They also provide rules. For example, family members encourage the students to go to church or mosque on particular days. While they teach the students how to behave in the church or mosque, parents emphasize the acceptable behaviours. The religious teachers interpret the rules. They also interpret the processes that are undertaken in the church or mosque services. The religious teachers, family members, peers and teachers facilitate the internalization of processes and artefacts.

Mediation is central to the present study. The mediation of students' interactions with the sociocultural milieu includes the interactions with the *object* (such as learning mathematics and other school subjects). The mediation can be through denying or allowing access (Mellin-Olsen, 1987). The artefacts and other people can deny or allow the students access to the required information about mathematics' connections among others with other school subjects. However, there are drawbacks in capturing the mediational process from students' words. This is set out in the presentation of the methods as well as in the data analysis (see Chapters 4 and 7). On the other hand, the students, their community and the *object* of *activity* are seen as inseparable entities. The next section focuses on this relation.

2.2.2 Dialectical relationship

Dialectical relationship of two things is the mutual constitution of one another (Roth, Hwang, Goulart & Lee, 2005). It is about the mutual presupposition of the two things (ibid). A description or discussion of one presupposes the other. These relationships are dealt in this section.

In sociocultural theory, the individual is viewed as being deeply linked to a certain sociocultural milieu (ibid). In particular, the individual and the community are dialectically related (Engeström, 1999; Roth et al., 2005). Any discussion of individuals presupposes the communities to which they belong and vice versa (Engeström, 1999; Roth et al., 2005). Students' learning of mathematics cannot be discussed and understood as an individual learning that occurs to them as separate beings (Engeström, 1999). They learn by being part of a community of learners (Roth et al, 2005). For example, any one student is learning mathematics as a preparatory school learner, as part of either a community of social science students or natural science students. The learning process and issues associated with it cannot be understood out of this context; all students are part of their groups. The concepts and issues relating to learning of these concepts become meaningful to learners in the social context in which they live, and an investigation of these issues must not view the individual and the social in isolation (Roth, et al, 2005).

The students are also integral part of the Ethiopian society living in an urban village. They interact with this community every day, and their lives are intertwined with the life of the community. They have been internalizing new experiences and meanings as part of this community. Accordingly, the students' attaching of meaning to mathematical concepts and the connection with their other experiences cannot be understood in isolation from the sociocultural context in which they live.

Similarly, the individual and the *object* are dialectically related (Roth et al., 2005). The subject and the object are mutually constitutive (ibid). According to Roth (2007), the motive and the goals are parts of the object (see section 2.3.3). Following Roth et al. (2005), I understand that in talking about students, we consider the object – what the students learn as well as their goals and the motive of their participation in schooling. Particular preparatory students attend to particular set of mathematics topics with the goal of learning mathematics. The students participate in the preparatory school to prepare for joining the university, which is the likely motive for being in the preparatory school. On the other hand, the goals and the motive cannot be understood in isolation from the students; they presupposes the students who are undertaking actions towards the goals, and to realize the motive. An explanation of the school subject such as mathematics presupposes the students who are engaging in the school subject. The learning of particular mathematics concepts involves particular students. Speaking about mathematics learning also presupposes the students who are learning. An explication of the subject and the object of activity in isolation do not give an exact understanding of the situation (Roth et al., 2005).

Dialectical relations is a fundamental assumption of my study. The main purpose of presenting this relation is to pave the way to explanation of *activity,* which I set out in the next section.

2.3 Cultural historical activity theory

This dissertation relies on CHAT. Key exponents in CHAT are Vygotsky and Leont'ev, whose works are often referred to as first- and second-generation activity theory, respectively. The development of Engeström's model opened up the third generation activity theory. Once this model was introduced, research employed it as an analytic tool. Roth's work is one example. Roth contributed to its further development (e.g. Roth, 2007). This section has three subsections. The first subsection is prelude to CHAT. The second subsection is about Engeström's model. In the third subsection, I present Roth's contribution.

2.3.1 Prelude to CHAT

In this section, I provide an overview of the first- and second-generation activity theory. The notions of *activity* from Leont'ev and *mediation* from Vygotsky are in focus. The three levels of analysis, which Leont'ev (1979) suggested, are also set out here.

As I set out earlier, Vygotsky is credited for the first generation activity theory. According to Vygotsky (1978), activity is mediated by artefacts. Vygotsky's contribution of mediation is already dealt in an earlier section (see section 2.2.1). Leont'ev is credited for the second generation of activity theory. According to Leont'ev (1979), activity is central to human life; as long as there is life, there is activity. Following Leont'ev, I understand the students as participants of different activities. They had been participating in the activity of schooling long before they were enrolled in preparatory school. Moreover, there had been schooling since time immemorial, long before the students were even alive, let alone learners. Hence, schooling is a historical phenomenon (Roth & Lee, 2007). Following Nardi (1996), I understand that schooling is realized by using language, textbooks, and other artefacts that contain knowledge that were accumulated for years. The textbook contains historical record of concepts that were developed over the years (Engeström, 1987, 1999).

Leont'ev (1979) asserts that activity is the smallest unit of life. Consistent with Kuutti (1996), I understand that focusing on the activities in which the students participate gives an opportunity to understand the context in which the students' perceptions of relevance emerge. Kuutti (1996) stresses:

> An activity is the minimal meaningful context for understanding individual actions (Kuutti, 1996, p. 28).

Leont'ev identified three levels of analysis: activity initiated by motive; action directed towards a goal, and operation conditioned by the situation. He describes the complex relationship between activity, motive, goal, and action as follows:

> [T]he actions that constitute activity are energized by its motive, but are directed toward a goal (Leont'ev, 1979, p. 60).

Leont'ev (1979) explains that activity cannot be divided any further down to smaller units. He maintains that one can see and explicate activity, action, and operation as levels of analysis of activity. According to Leont'ev, operations are conditioned by situations, and they constitute action; actions constitute activity.

In this study, the student is seen as participating in various activities such as schooling and family-life. The interest is on the students' perceptions of the relevance of mathematics as they are participating in these activities, where artefacts, tools, and other people play mediational role. Following Leont'ev (1979), I understand that the students' actions such as attending classes, doing examinations, discussing with peers, and doing classwork that combine to constitute the activity are all energised by the motive of joining university.

The students' actions are directed toward the goals of learning mathematics and other subjects. It may not be possible to understand the activity simply by looking at an individual action (Roth & Lee, 2007). The students' attendance of classes may not be understood in isolation from knowledge of the activity of schooling and its motive. Their goal for attending mathematics classes is to learn mathematics. The action of taking notes is constituted by the operations. In preparation for taking notes, the students take out their exercise books and their pens. These operations might be conditioned by the entry of the teacher into the classroom or by the teacher's utterance. In the current study, the levels of analysis are understood from students' narratives. For example, the motive of the schooling activity, namely reaching university and become capable of solving problems of everyday life, is understood from students' words.

Consistent with Leont'ev (1979), I understand that students' actions that constitute the activity of family-life are also energised by motive. The motive of the family-life activity could be survival of the family, which involves getting a job and establishing a family of one's own. It could also involve supporting the family and siblings. In their participation in this activity, students take goal-directed actions such as engaging in domestic tasks, which might be directed towards the goal of supporting the family. They also undertake school-related actions in the activity of family-life such as doing homework, studying school subjects, and discussing with family members about school tasks with the goal of enhancing the students' personal development. Students' actions are constituted by operations such as paying, entering a taxi or a bus, walking, and writing. In supporting their families, the students might go to the shop and buy some items; they might take out money and pay, which might be conditioned by the shopkeeper's utterance or gestures.

Activity is central to human cognition (Leont'ev, 1979). By engaging in the activity of schooling, students appropriate knowledge during their interaction with the object (Roth & Lee, 2007). For example, in the schooling activity students appropriate mathematical knowledge during their interaction with mathematics; they also form perceptions of the relevance of mathematics. The students have motives, which are consistent with the motives of the activities in society (Roth & Lee, 2007). The students in my study are likely to share the motives of the family-life and the schooling activities. The students form their perceptions of mathematics' relevance in their participations across the diverse activities, where the motives can play important roles.

Vygotsky and Leont'ev are the basis for CHAT and contemporary thought that draw on CHAT are based on their works (e.g. Engeström, 1987; Roth, 2007; Roth & Lee, 2007). In my dissertation, following Leont'ev, the analysis is mostly at action-goal and activity-motive levels. Engeström developed a model of activity. The following discussion focuses on his model and the scope of discussion is limited to my use of the model it does not include the notions of production, consumption, and distribution, which are central to the Marxian fundamentals of Vygotsky's original notion of mediated activity. These concepts are not used in my study partly because I do not intend to focus on students' learning, but to understand their perceptions of relevance as narrated by them (see also Chapter 4).

2.3.2 Engeström's model of extended activity system

Engeström developed a model that elaborates activity further from the beginnings by Leont'ev and Vygotsky (Engeström, 2001; Cole & Engeström, 1993). In Engeström's mediational triangle, the individual or collective participate in an activity that is oriented towards an object. This process is mediated by the artefacts (ibid). When individuals take part in an activity, they undertake actions. These goal-directed actions take place in a framework that consists of, in addition to the artefacts, the division of labour, rules, and community (Engeström, 2001; Cole & Engeström, 1993). Within this framework, the rules mediate between the subject and the community. The division of labour mediates the relationship between the object and the community, etc. (ibid).

In the present study, I adopt Engeström's mediational triangle for modelling activity. In Engeström's mediational triangle, the students as actors in the activity of schooling interact with the object. Their mathematical knowledge is measured by the examinations, which is part of the rules in the schooling activity. According to the school rule, the students should take the mathematics examinations. The Ministry of Education or the authorities who decide about who will go to university, is part of the community. Though these authorities are not directly involved in the school, they are represented by the school administration, which enforces the rules set by these authorities.

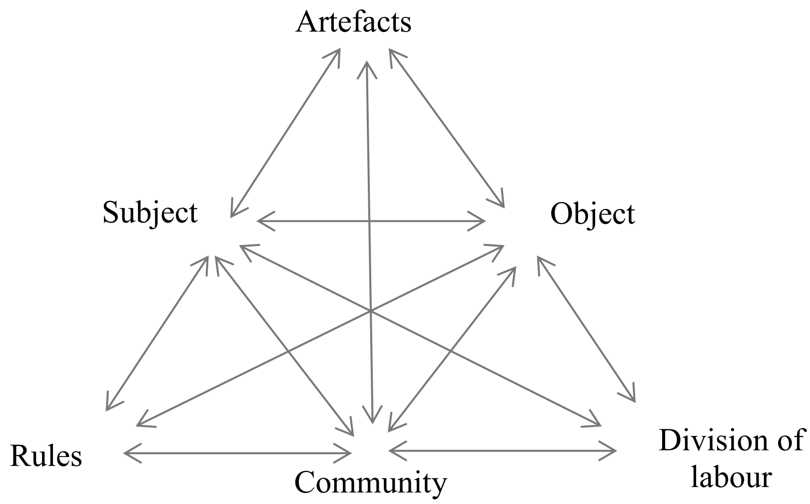


Figure 2.1. An activity system adopted from Engeström (2001)

In the triangle, the double arrows represent the dialectical relationship between the components of the triangle (Engeström, 2001). There could be two activity systems, which interact with each other, and the participants might experience contradictions between these activity systems (Engeström, 2001). Figure 2.2 represents two activity systems: the school activity system and the family-life activity system.

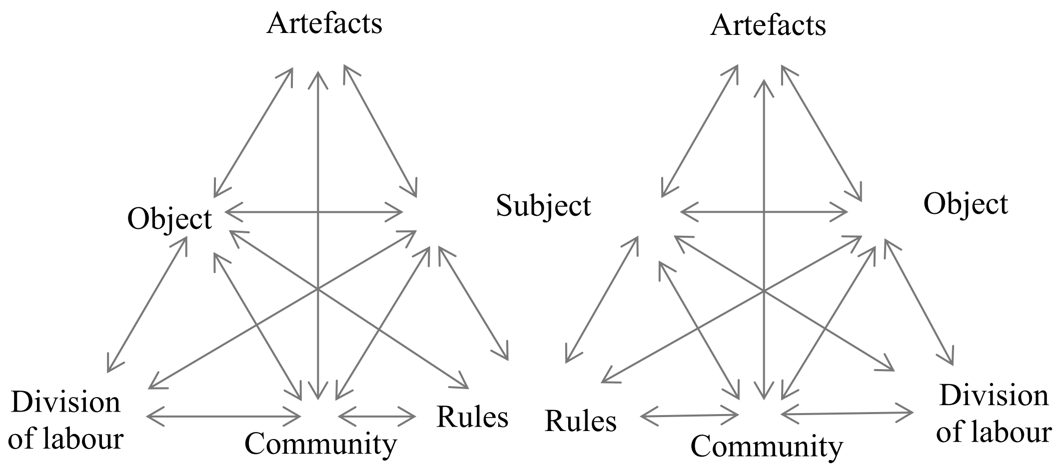


Figure 2.2. Network of activity systems adopted from Engeström (2001)

This model, proposed by Engeström, is the core of third-generation activity theory. The student as a subject participates in both the family-life activity system and the school activity system. For the present study, the objects in the two activity systems are different.

The object of an activity system consists of material objects, the motive, and the goal (Roth, 2007). It can also consist of ideas and plans (Kuutti, 1996). The object of the school activity system consists of mathematics, other school subjects, the motive, and the goals. The motive of the school could be producing students who can succeed in the national examination to attend university and become capable of solving problems of everyday life. The school could have goals such as providing adequate knowledge for realizing the motive. The object of the family-life activity system consists of material objects, home tasks, motive, and goals. The society could have a goal of personal development of the students. Everyday experiences are in the object of the family-life activity system. In the family-life activity system, the subject remains to be the student. There might be a different division of labour and rules than are found at school. The female and male students might have different roles in the family-life activity system.

The students in my study are operating in a school, which implements a curriculum that is designed by experts, who are outsiders to the school. The teacher is required to follow the textbook; it is from this textbook that the teacher gives exercise for students. The students also use this textbook for doing classwork and homework. The school rules might force the students to study and give more time for the textbook for the sake of succeeding in the examinations.

The students are stratified as social- or natural-science streams, though they all use the same textbook. The mathematics teacher also classifies the students in terms of, for example, their levels of achievement, and they might have different roles in the mathematics classroom and in their study groups. In Chapter 1, I noted the diversity of students' backgrounds in terms of language, and religion. The students are of Christian or Muslim and rural or urban backgrounds. This might contribute to the formation of diverse communities in the school. On the other hand, there is variation in the cultural traditions and languages in the different parts of Ethiopia. This can have consequences on the students who move from schools in other parts of the country.

There might be contradictions that the students experience within and among the components inside each of the activity systems or between the components of the two activity systems (Roth et al., 2004). Engeström explains that there can be contradictions between activity systems or within a single activity system (Engeström, 2001). He asserts that these contradictions should not be considered as negative phenomenon, but rather be understood as possible sources of change. Engeström states:

> Contradictions are historically accumulating structural tensions within and between activity systems (Engeström, 2001, p. 137).

Participants in an activity system might experience tensions (Jaworski & Goodchild, 2006). In an article, Jaworski and Goodchild (2006) describe a research project in which schoolteachers and didacticians collaborate. Building on Engeström's model, Jaworski and Goodchild (2006) explain that tensions/ contradictions are sources of change in an activity system relating to a school setting. Similarly, Roth et al. (2004) elaborates the possible contradictions within and among activity systems. Roth et al. (2004) explains that there could be contradictions between as well as within the components of an activity system. There could also be contradictions between the components of two activity systems (ibid).

The students in the present study are likely to experience tensions or contradictions. They are likely to experience tensions/ contradictions between the division of labour at school and that of the local community. The students might experience them between the objects of school and out-of-school activities as well as within the object of schooling activity. They might also experience between the object and the artefact of schooling activity. I understand the tensions/ contradictions to be sources of development of some of students' perceptions of relevance. They might also be sources of students' motivation (see Chapter 8).

In my study, the data I have does not enable to provide an accurate distinction of the students' experiencing of tension and contradiction. I prefer to use both terms, and my assertions about them are conjectures. CHAT is used in school settings (e.g. Roth et al., 2004; Roth & Lee, 2007) and in workplace settings (Roth, 2007). In particular, Engeström's model is used in both school and out-of-school settings. In addition to his use of Engeström's model, Roth contributed to the development of the third-generation activity theory, which is set out in the following section.

2.3.3 Roth's contribution to third generation activity theory

Drawing on CHAT, Roth's study has some constructs such as motivation that are used in affect and belief areas of research and are relevant to the current study. On the other hand, identity, which is used in the research that draws on sociocultural theory, is also a construct that is highly relevant to the current study. Roth's work integrates these constructs and emotion into an activity theoretic framework.

Roth employs Engeström's model extensively and demonstrated that the model can be utilised in the workplace (Roth, 2007) and at school (Roth et al., 2004). Roth (2007) investigated the role of emotion, motivation and identity in the activity of a fish hatchery and in the use of mathematics in the hatchery. He draws his work essentially on Vygotsky's and Engeström's works, and relies mainly on Damasio for neuroscientific evidence about the relationship between emotions and cognition. According to Roth the purpose of his paper is:

> (a) to provide evidence ... that shows how emotions are integral to what people do and know in the workplace in general, and in workplace mathematics in particular; and (b) to propose a way in which emotions and the associated dimensions of motivation and identity can be incorporated into CHAT as part of its third generation expansion and development (Roth, 2007, p. 41).

Roth is critical of the position that emotion, identity, and motivation are accorded in the literature. He shows using empirical evidence and earlier studies that they are spread throughout an activity and that they mediate actions that are understood to realize the motive of the activity. He explains, based on neuroscientific studies, that mental faculties responsible for cognitive actions are associated with emotions (cf. Damasio, 2010). Damasio reports that emotion is integral to human cognition. Emotion and cognition are deeply related and they influence each other (ibid).

Roth (2007) explains that emotion can be integrated within activity theory at the three levels of analysis depicted by Leont'ev (1979). These three levels are condition – operations; goal – actions, and motive – activity (see section 2.3.1). According to Roth (2007), emotion can be a condition for certain operations. Students might undertake certain operations out of anxiety. Emotion can appear at the action-goal level also (Roth, 2007). Roth explains that the person's emotional state determines practical actions as well as the person's use of reasoning in the decision about how to act. Moreover, Roth stresses the importance of the notion of emotional valence in practical actions (see section 2.4.2).

Roth (2007) assert that the third level of analysis where emotion can come in is motive – activity. According to Roth, the motive for any activity is intertwined with emotion. Individuals prefer to participate in activities, from which they expect to derive some emotional payoff in the end (ibid). Students might prefer to participate in school or out-of-school activities (such as game) depending on some emotional payoff they expect to derive out of their participation.

Roth (2007) explains that there are collective aspects of emotions. These aspects of emotions are shared among members of a group where individuals contribute in shaping these emotions (ibid). According to Roth, our knowledge of emotion is mediated by the sociocultural situation including the people around us, which facilitates our learning of these emotions as we interact with them (ibid). Roth asserts that motivation and identity can also be integrated to human activity. Roth states:

> Motivation and identity are not independent constructs but are derivative, an integral aspect of an activity system in general, and emotion—which is centrally involved in the shape of practical actions and practical reasons—in particular. Motivation and identity build on the motive, goals, and associated emotional valences available in practical action and practical reasoning (Roth, 2007, p. 54).

Motivation is an integral part of human activity (Roth, 2007). According to Roth, the individual craves for maximizing positive emotional valence and minimizing negative emotional valence. Roth explains that identity is also integral to human activity, that individuals' identities are understood from their actions.

Roth (2007) bases his study on ethnographic data that he collected using interviews and observation in the workplace. He also used devices for measuring emotional reactions such as sound intensity in order to understand participants' emotions and compare it with their words and his own observations. Roth was part of the activity himself during the study period. My relation, as an interviewer, with the schooling activity is set out later (see section 4.3.3.2).

In another paper, which Roth co-authored, the significance of activity theory in understanding teaching and learning is emphasised (Roth & Lee, 2007). The scholars undertake a review of the literature on sociocultural theory with special emphasis on activity theory. They also used a story from a teacher's practice and from students' participation in an activity in which students frame their own goals. Roth and colleague examine seventh-grade students engaging in an environmental activity in their society. The study shows the advantage of students' participation in an activity that is familiar and useful to their own society, where students have the freedom to choose their object of activity and their tools and instruments. Roth and Lee assert that:

> Students learn neither to memorize content matter to prepare for the next academic level nor merely for the purpose of passing tests or obtaining grades. Rather, the students learn science (and other culturally valued content matter) (Roth & Lee, 2007, p. 194).

According to Roth and Lee, the students have the opportunity to appropriate the use value than the exchange value of the lessons. They state that members of society, such as environmentalists, participate in the activity with students by guiding them. The society also values the students' work, and the knowledge the students generated was stored for future reference (ibid). The students were thus motivated to engage in the tasks (ibid). Roth and Lee (2007) provide examples where students who were labelled as unmotivated in the classroom turned into active participants in the environmental activity. They state:

> when students are judged to be unmotivated, they really are following differing objects or motives from those officially sanctioned from a CHAT perspective (Roth & Lee, 2007, p. 213-214).

According to Roth and Lee, the students' motivation should not be judged based on tasks, which are presented to students with goals and motives. The students should rather be allowed to set or change goals (ibid). This is consistent with Mellin-Olsen (1987) and Miettinen (1999), which are set out in Chapter 3.

Roth's work emphasized the importance of the concepts of structure and agency in understanding issues associated with learning. The components of an activity system are set out in section 2.3.2. According to Roth and colleagues, the components of an activity system form the structure (Roth et al., 2004). Agency is the power, which an individual has, to take action (Roth et al., 2004). Students participate in the schooling activity by being their own agents; while the structure creates a situation, which can constrain and empower the students (Roth et al., 2004). The components of the activity system can mediate the interaction between the student and the object through influencing the student's agency (ibid). These components form the structure in which the perceptions of relevance might be formed (see Chapter 8).

The present study uses Roth's work as a basis to investigate students' perceptions of relevance using Engeström's model. Consistent with Roth, in my study activity is the unit of analysis. In addition to his use of Engeström's model, Roth (2007) explored motivation. This construct together with perception and identity are set out in the next section.

2.4 The central constructs in a sociocultural context

This section outlines the constructs that are central to this dissertation. Perceptions of relevance will be examined through the theoretical framework described above. There are constructs that emerged from the overview of the literature and the analytic process, and are associated with perceptions of relevance. These constructs are motivation and identity. I examine these constructs here together with perception.

2.4.1 Perception

In this section, I provide a description of the term perception. Since I explore perception of relevance, the term is key in my study. I follow Vähämaa and Härmälä (2011) in my attempt to provide a description of the term and Vygotsky (1978) in my attempt to provide the historical development of the construct.

The term perception is used in the literature in mathematics education in wide-ranging contexts. In the literature of mathematics education, however, a definition of the term perception is rarely available. One example of an available definition is Vähämaa and Härmälä (2011). They investigated perceptions of mathematics, where the participants are university students. Based on an earlier work, Vähämaa and Härmälä (2011) define perceptions as follows:

> [L]inguistic constructs, communicable to others that individuals hold about objects both of the social and inanimate world (Vähämaa & Härmälä, 2011, p. 70).

Vähämaa and Härmälä assert that their focus is on the socially communicable perception of mathematics. Even so, they then emphasise that sensory perception is required for the formation of the socially communicable perception.

The dictionary provides a meaning of perception, which shows that perception is close to encountered experience and thus to the sociocultural context. Random House Webster's College Dictionary provides the following meaning of perception:

> The result or product of perceiving, percept (Random House Webster's College Dictionary, 1997, p. 966).

The same dictionary provides a meaning of perceive as follows:

> To become aware of, know, or identify by means of the senses (Random House Webster's College Dictionary, 1997, p. 967).

Many studies, which explore the relevance of mathematics, use the term perception. These studies do not give reason for their use of the term. However, I understand that the closeness of the term to the encountered experience, and the need for both sensory perception and socially communicable perception fits their purposes than the other terms in belief research such as attitude, belief and conception. I present Phillip's descriptions of these terms in section 3.2.1. The use of the term perception in the literature about the relevance of mathematics focuses on the students' exposure to some experiences (e.g. Flegg, Mallet, & Lupton, 2012, Masingila, 2002, Sealy & Noyes, 2010).

I agree with Vähämaa and Härmälä when they assert that the sensory perception is required for the formation of the socially communicable perception of mathematics. Though Masingila is not explicit about it, she attempts to expose socially communicable perception. I understand that, consistent with Vähämaa and Härmälä, she needed to use the term perception because both sensory perception and socially communicable perception are important. As set out in section 3.3.3, the participants in Masingila (2002) were required to document their daily practices, which involved mathematics. These required sensory perceptions. Then, they communicate it to others. Such need for both sensory perception and socially communicable one is apparent in Flegg and colleagues' work as well (see sections 3.3.2 and 3.3.6). I chose to use the term perception for the same reason. That is, both sensory perception and socially communicable perception are important in the students' exposition of the relevance of mathematics, and the term is closer to the encountered experience.

On the other hand, activity theory demands the historical development of constructs (Roth & Lee, 2007). I attempt to give a glimpse of the historical development of perception. Perception generally means forming a representation of the outside object in the brain by using the sense organs (Vygotsky, 1978). According to Vygotsky, perception occurs as a natural mental function in any child's development. Later with the help of tools, signs, and human mediators, it changes into a cultural function (ibid). The transformation into a cultural function enables the individual to attach meaning in the face of new experiences in a given context (Vygotsky, 1978). Vygotsky asserts:

> A special feature of human perception – which arises at a very young age – is *perception of real objects*. This is something for which there is no analogy in animal perception. By this term, I mean I do not see the world simply in color and shape but also as a world with sense and meaning. (Vygotsky, 1978, p.33).

I understan that Vygotsky's description of perception has the two aspects of being sensory and socially communicable. Based on Vygotsky (1978), and Vähämaa and Härmälä (2011), I understand that the meaning and sense that people make of their encountered experiences are socially communicable; people share it with others. Hereafter, when I mention perception I am referring to the socially communicable one.

Following Vygotsky (1978) in this study perception is understood as attaching meaning and making sense of an encountered mathematical experience. Consistent with Vygotsky I understand that when students encounter a mathematical experience, they not only form a mental representation of the mathematical concept, but also attach meaning and make sense of it in terms of its relevance to their future goals, to their lives and its application in society. The students' perceptions of the relevance of mathematics is understood as resulting from a mediational process.

According to Vygotsky (1978), memory and attention are implicated in sensory perception. The students' attention is involved in the socially communicable perception also (ibid). It is assumed that the signs (the rules, division of labour, language, etc.), which they internalized with the help of others, could determine their perceptions (particularly, perceptions of relevance). Other individuals such as the teacher are likely to mediate the students' perceptions of relevance through amplifying the importance of the experiences, interpreting them, and directing students' attention to the experiences (cf. Kozulin, 1998, Vygotsky, 1978). Mediation is set out in section 2.2.1.

Following Philipp, I acknowledge that beliefs can influence perception (particularly, perception of relevance). Philipp (2007) notes:

> [B]eliefs might be thought of as lenses through which one looks when interpreting the world (Vygotsky, p. 259).

Consistent with Philipp (2007) the meaning that students attach to encountered experiences may well be influenced by the lenses of beliefs through which they look at their mathematical experiences. I understand belief as a construct, which is formed in the sociocultural situation students find themselves, particularly, in the activities in which the students have been participating. Attitudes are viewed similarly.

The formation of students' perceptions of the relevance of mathematics takes place in a sociocultural milieu comprising other people, textbook, the curriculum, the language, and mathematical entities. The discussion above makes clear that the formation of perception of the relevance of mathematics and mathematical concepts is a mediated process. The signs can mediate perceptions of the relationship between the learning of *preparatory mathematics* and the mathematical concepts and their own situations such as the other school subjects, their future aspirations or their out–of–school life. For example, the school curriculum, the division of labour, and school community, etc. as signs can mediate the student's perception of relevance. Consistent with Kozulin the students' familiarities with the school and out–of–school sociocultural context, in which they undertake actions, are the sociocultural prerequisites for the students' formation of perceptions of relevance. The signs mediate through bridging between these sociocultural prerequisites and the new experiences (ibid).

As I will expose in Chapter 4, during the interviews the students were demanded to tell about recent and current experiences of learning mathematics. The interview situation involves reflecting on experiences and speculating about the future. Following Kozulin (1998) and Vygotsky (1978), I assume that these reflections and speculations implicate memory and attention, as the students tell their stories using their memories of experiences. Their peers' utterances and the discussion of artefacts direct their attentions to particular experiences of their own or part of their experiences. This is dealt in Chapter 4 and further in the analysis.

In this section, I attempted to present what I mean by perception. Since my focus is on the meaning that students attach to the relevance of mathematics describing the term perception provides the basis for the description of perception of relevance in section 3.1. In Chapter 3, I set out the use of the term perception in studies situated in affect and belief areas of research and those studies, which explore mathematics' relevance (see sections 3.2.5 and 3.3.6). The other focus of my study is motivation, which I present next.

2.4.2 Motivation

In this section, I provide a theoretical discussion of the construct of motivation. The intention is to give a sense of how I understand motivation in my data set with respect to the activity in which the students participate. My presentation focuses on the construct from CHAT perspective.

Motivation is described as the inclination to choose one action instead of another (Hannula, 2006, Roth, 2007). According to Roth, individuals make choices between the different actions available to them in order to achieve a goal. Roth explains that the inclination to choose one and avoid the other relates to emotion, particularly to emotional valence, stating that:

> Motivation arises from the difference between the emotional valence of any present moment and the higher emotional valence at a later moment, to be attained as a consequence of practical action... [M]otivation is an effect of emotion, related to the promise of increases in emotional valence by the completion of one action rather than another (Roth, 2007, p. 60).

Students are likely to engage in mathematics if it promises them emotional reward (cf. Roth, 2007). Roth (2007) asserts that the choice of actions is inherently dependent on the emotional valence of the action, which can be negative or positive. Students engaging in mathematics can be to please those who set the goals for them. Their successful engaging can bring pleasure or emotional safety (Roth, 2007). In order to attain the emotional reward that results from achieving the goal, individuals might suppress some of their current emotions or be willing to undergo emotional hardships (ibid).

Motivations can occur at activity – motive and action – goal levels (Roth, 2007). Students may choose between participating in the schooling and other activities available to them. For example, on particular day where there is a ritual/festivity in the Church students may decide to go to church instead of going to school. On the other hand, students who came to participate in the schooling activity may decide to attend to a lesson in another classroom instead of attending to the lesson in their own classroom. When students sit in a library or their home to engage in a school task, they might pick one of the school subjects. Following Roth, I understand that while doing homework or studying a school subject is a conscious action, picking one of the school subjects can be influenced by the students' emotional relationship with the school subject.

In this section, I attempted to describe motivation in the context of CHAT. Consistent with Roth (2007), I attempt to understand motivation as being integral to the activities, in which the students participate. The analysis chapters of my study report that the perception of the relevance of mathematics can be a motivational factor in students' engaging in mathematics; both of them being integral to the activities (see Chapter 7 & 8). There are studies on motivation, which draw on cognitive or social cognitive theories. These studies together with the theories are set out later (see section 3.2.4).

2.4.3 Identity

The construct of identity is examined in this section. The data of the current study exposes students' sense of identity. The different aspects of the construct are set out.

Identity is an important construct in mathematical cognition (Roth, 2007). According to Roth (2007) as long as there is activity, there is an acting individual, and the individual's identity is integral to the activity (Roth, 2007). Roth et al. (2005) describe identity as:

> Who we are with respect to ourselves and others. … [It] is made and remade as activity is enacted and when individuals participate in multiple activity systems (Roth et al, 2005, p. 3).

Roth et al. (2004) distinguish between social identity and personal identity. They state:

> our social and personal identities continuously produced and reproduced in activity. Who we are in relation to others and as we experience ourselves change as part of continued participation within and across activity systems (Roth et al, 2004, P.62.).

In my study, the students seem to form aspects of identity as they participate in the school and out-of-school activities. It can be personal identity where the individual student as an acting subject recognizes her/himself as such (Roth et al., 2004). The student can also have social identity where the other members of the community recognize her/him as such (ibid). For example, the other students or the teacher recognizes the individual student as a high achiever. Roth and Lee (2007) suggest a third aspect of identity, collective identity, which the individual holds as a member of a group. The students in my study belong to social or natural science streams (see Chapter 1), and they recognize themselves as mathematics learners as members of these groups.

According to Roth, the artefacts, rules, community and division of labour mediate students' identities (e.g. Roth et al., 2004). For example, the division of labour in school mediates the students' identities. Some students may try hard to find solution, while others could be dependent on those hard working students. The students might recognize each other as such. Similarly, there can be division of labour in the family-life activity in engaging in mathematics, where students get support from family members. The school rules, which enforce the significance of success in examinations, can mediate the students' personal as well as social identities (ibid). In addition to the school rules, which also enforce the adopted curriculum, the school and out-of-school artefacts mediate who the Ethiopian students are. I agree with Roth in the view that identity has aspects that can change depending on the sociocultural milieu (Roth et al., 2004; Roth et al., 2005). Particularly, the individual's identity can change as the individual moves from one activity system to another (Roth et al., 2004). The changes can also be due to changes in the components of activity systems (ibid).

Following Roth, I set out a description of identity and its place in Engeström's model. The current study investigates students' perceptions of the relevance of mathematics and diverse characterisations of perceptions of relevance emerged. Among seven characterisations of perceptions of relevance reported in the main study, the two relate to identity. Characterisations relating to identity emerge in both categories of perceptions of relevance: relevance relating to school experiences (see section 7.4.3.5) and relevance relating to the out-of-school experiences (see section 7.4.2.4).

2.5 Concluding remarks

Drawing on CHAT, I use the concepts in Engeström's model to describe the situation of students' perceptions of relevance in the Ethiopian context. A description of the Ethiopian context is available in Chapter 1, and an additional description from students' words is given in Chapter 7. The utilisation of the concepts including mediation, tension/ contradiction, structure and agency are set out in Chapter 4 and in the analysis chapters.

In Chapter 7, I attempt to expose perceptions of relevance as resulting from mediational processes. In Chapter 8, I attempt to expose the role of tensions/ contradictions, structure and agency. As will be set out in Chapter 4, these expositions are based on students' words, and in few occasions I attempt to support it from my own observations, overview of the textbook and conversations with the teachers. The identified mediators are also presented to the students in the questionnaire, allowing students to certain form of social engagement. For example, the mention of the artefacts in the questionnaire directs the students' attention to their experiences in the activities. Chapter 4 also exposes the limitations in using the model.

In this Chapter, I described the constructs that are central to my study: identity, motivation, and perception. My study is influenced by Roth's use of Engestrom's model. There is difference in our focuses. In my study, the focus is on perception of relevance. There are also some evidences in my data about relationships of perceptions of relevance with motivation. I look for evidences of possible relationships with motivation from the literature.

3 An overview of the literature

3.1 Introduction

This chapter presents an overview of some of the literature in affect and belief areas of research in mathematics education. Some theoretical reviews inevitably arises in the context of the empirical studies (Dowling & Brown, 2010). The affect and belief areas of research involve studies on students' attitudes, beliefs, emotions, motivations and perceptions. I also examine some of the studies about students' identities and relevance of mathematics.

There are two factors, which guided the literature overview. The first is the study's basic research questions and the rationale behind them. As it is set out in Chapter 1, the study is motivated by lived experience as a mathematics teacher, and the intuition derived therefrom that students become motivated to learn mathematics when they perceive it to be relevant. I thus reviewed some of the literature that might inform my personal experience, seeking evidence for and against the hypothesis deriving from my experience. As a result, the initial focus was predominantly on students' perceptions of relevance to their present and future lives and their motivation. The second factor is that the analysis of the data collected during the pilot study coincided with the literature review. This revealed the importance of other notions such as identity.

The focus of my study is perceptions of mathematics' relevance. Thus, another issue, which my study is concerned with, is relevance. Throughout this dissertation, the term relevance is used to mean 'connection.' This meaning is consistent with this dissertation's goal of investigating perceptions of mathematics' relevance.

The term used in the literature may not necessarily be relevance. The overview of the literature paid attention to the variety of terms used. I attempted to include studies, which deal with mathematics' connection with other school subjects, everyday life and future goals. Attention is given to the variation in the other terms as well. For example, other terms are used instead of everyday life, which includes real world, real life, and out-of-school life. Similarly, I attempted to find studies, which deal with the various aspects of mathematics' connection with other school subjects, not just mathematics' usefulness.

As the study focuses on affect and belief research areas, I offer a concise, introductory description of these areas of research. Some of the terms such as 'beliefs' do not have clear, universally accepted definitions (Roesken, Hannula, & Pehkonen, 2011). This lack of agreement also exists in the use of a number of terms in belief research (McLeod, 1992; McLeod & McLeod, 2002; Skott, 2010). The literature in mathematics education that focuses on affect and belief is published under a variety of titles. The keywords as well as terms the studies use in their research questions or purposes of the studies also vary. In the search for the relevant literature in journals, books related to the areas of research and handbooks of mathematics education, I paid attention to the variability in the use of terms. This overview focuses on the concepts in research reports in mathematics education that are included when searching for key terms such as affect, attitude, belief, conception, perception, view, etc. The term perception is used in the literature in affect and belief areas of research. The term is used in the literature to refer to the socially communicable one, which I set out in Chapter 2 (see section 2.4.1).

My study explores students' perceptions of the relevance of mathematics. The meaning, which students attach to the *connection* that mathematics has to the diverse aspects of life, is what I call perception of the relevance of mathematics. The main purpose of the chapter is to set a context for my investigation of this issue in the affect and belief areas of research. To this end, this chapter has two main sections. The first section is an overview of affect and belief areas of research, which ends with a subsection about perceptions in affect and belief areas of research. The second section is the relevance of mathematics, which ends with a subsection about perceptions of the relevance of mathematics. The chapter closes with concluding remarks.

3.2 An overview of affect and belief areas of research

Studies undertaken in the affect and belief areas of research in mathematics education, receive particular attention here. I start with providing background to the areas of research. Then, I set out some of the empirical studies. Since my study has some results about gender, I provide a brief overview of the studies on gender. This is followed by the subsection about students' motivation. The last subsection is about studies in affect and belief areas of research, which used the term perception.

3.2.1 Background to affect and belief areas of research

In this section, I examine the focuses of affect and belief areas of research in their history in mathematics education. I highlight some issues of concern in the field including the naming of the area of research. I provide descriptions or definitions of some of the terms that are in use in these areas of research. Then, I set out the attempts made to construct a framework, which characterise students' beliefs. I start with providing a glimpse of the structure of affect as conceptualized in that field.

The role of affect in mathematics education has been studied since the 1960s (e.g. McLeod, 1992). The structure of affect has been a debated topic (McLeod, 1992; Hannula, 2011). McLeod (1992) reviewed the empirical studies undertaken in this area of research, and explained affect as depicted by Figure 3.1.

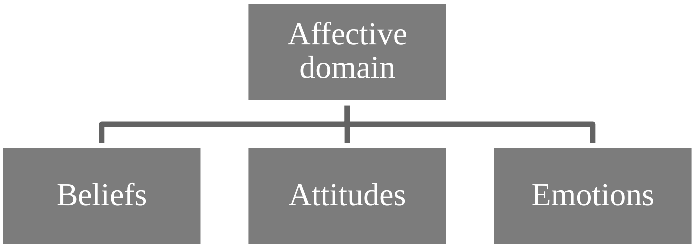


Figure 3.1. The categories of affect (McLeod, 1992)

He draws a distinction between beliefs, attitudes, and emotions in terms of their levels of intensity and stability, such that the level in intensity increases and stability deceases as one moves from beliefs to emotions.

There has been variation in the focus of affect and belief areas of research in mathematics education over the last decade (Hannula, 2011). McLeod and McLeod (2002) indicate that the focus on belief research has been changing with changing theoretical perspectives, the research method used, and with the technology available for research. Mathematical beliefs, which are regarded as incorrect – or misconceptions – were the focus of earlier affect and belief areas of research (Op't Eynde et al., 2002). Later, mathematical anxiety and attitudes moved to the forefront (Zan, Brown, Evan, & Hannula, 2006).

There are some concerns about the affect and belief areas of research in mathematics education. The divide between cognitive and affective research has been a problem in mathematics education research and has come in for regular criticism (e.g. McLeod, 1992). The limited number or total absence of researchers focusing on one another's work was a particular concern (McLeod, 1992). He suggests:

> [R]esearchers who focus on affective issues need to be more aware of … [and] contribute to research on cognition [and vice-versa] (McLeod, 1992, p.590).

The concern about the view on emotions in relation to cognition in the affect and belief areas of research was better addressed in studies that are more recent (e.g. Roesken et al., 2011). Emotions are becoming a central subject in these areas of research (see section 3.2.2).

Another concern is about the attention given to sociocultural context. The belief area of research is criticised for giving little attention to social and cultural context in which the individual is situated (e.g. Skott, 2010). Lerman (2002) asserts that situating belief research in a sociocultural context will enable a better interpretation of individuals' words. Op't Eynde, De Corte and Verschaffel (2002) also explain that

> [Beliefs are rooted in and are] function of the broad social-historical context in which students find themselves (Op't Eynde et al., 2002, p. 26).

There is also concern about an agreed theoretical framework (McLeod, 1992). The issue of an agreed theoretical foundation for affect research continues to be a focus of debate (Di Martino & Zan, 2011; Hannula, 2011). The lack of a theoretical framework that shows the relationship between belief, emotion, and attitude is one reason for the absence of accepted and clear definitions of terms used in these areas of research (Di Martino & Zan, 2011). Hannula (2011) contributed a framework for affect research in mathematics education, which he describes as a "meta-theoretical foundation" (p. 43). It is intended to facilitate the incorporation of sociological and psychological constructs in integrating emotion, motivation, and cognition (ibid).

There is also problem in naming the area of research. There are numerous studies, which use the name belief research (Leder, Pehkonen, & Törner, 2002). There are other studies, which use the name affect as a major area of research and include belief research as part of it (e.g. McLeod, 1992; McLeod & Adams, 1989; Zan et al., 2006). McLeod's (1992) categorization of affect is set out earlier in this section. According to Zan et al. (2006), studies on beliefs are parts of the affect area of research. The framework for affect, which Hannula (2011) provided includes belief research.

Several terms are commonly used in affect and belief areas of research, and as set out above, there is concern about the absence of accepted and clear definitions of terms in these areas of research (Leder, 2007; Mason, 2004). Philipp (2007) defines some of the terms, using both the literature and lexicography to support his definitions. Because of these dual sources, Philipp refers to them as "definitions/descriptions" (Philipp, 2007, p. 258). Philipp states:

> Affect—a disposition or tendency or an emotion or feeling attached to an idea or object. Affect is comprised of emotions, attitudes, and beliefs (Philipp, 2007, p. 259).

Philipp's definition/description of affect is consistent with McLeod (1992). Philipp describes/defines emotions and attitudes as follows:

> Emotions—feelings or states of consciousness, distinguished from cognition. Emotions change more rapidly and are felt more intensely than attitudes and beliefs. Emotions may be positive (e.g., the feeling of "aha") or negative (e.g., the feeling of panic). Emotions are less cognitive than attitudes.
> Attitudes—manners of acting, feeling, or thinking that show one's disposition or opinion. Attitudes change more slowly than emotions, but they change more quickly than beliefs. Attitudes, like emotions, may involve positive or negative feelings, and they are felt with less intensity than emotions. Attitudes are more cognitive than emotion but less cognitive than beliefs (Philipp, 2007, p. 259).

Though Philipp describes/defines emotions and attitudes as components of affect, he acknowledges that they have cognitive nature as well (ibid). Philipp also describes/defines beliefs as follows:

> Beliefs—psychologically held understandings, premises, or propositions about the world that are thought to be true. Beliefs are more cognitive, are felt less intensely, and are harder to change than attitudes. Beliefs might be thought of as

> lenses that affect one's view of some aspect of the world or as dispositions toward action. Beliefs, unlike knowledge, may be held with varying degrees of conviction and are not consensual. Beliefs are more cognitive than emotions and attitudes (Philipp, 2007, p. 259).

Consistent with McLeod (1992), Philipp's definition/description of affect included beliefs. Nevertheless, Philipp asserts that there are different views about beliefs among researchers (cf. McLeod & McLeod 2002). In particular, Philipp states:

> although beliefs are considered a component of affect by those studying affect, they are not seen in this way by most who study teachers' beliefs (Philipp, 2007, p. 259).

According to Philipp, researchers who study teachers' beliefs usually consider beliefs as part of both affect and cognitive domain (cf. McLeod & McLeod 2002). McLeod and McLeod (2002) review the literature on beliefs, and explain that in some studies beliefs are situated in the affective domain, while other studies locate them in the cognitive domain. There is also a view that regards beliefs as both affective and cognitive (ibid), the position that McLeod and McLeod (2002) themselves take. On the other hand, beliefs are strongly held and are hard to change (McLeod, 1992). Furinghetti and Pehkonen (2002) asserted that it is vital to acknowledge that some beliefs are open to change.

Another construct, for which Philipp provided a definition/ description, is the construct conception. He states:

> Conception —a general notion or mental structure encompassing beliefs, meanings, propositions, rules, mental images and preferences. (Philipp, 2007, p. 259).

There are other terms used in the literature in the affect and belief areas of research. I presented some of the terms that I found frequently in my overview of the literature in these areas of research.

A number of attempts were made to characterise beliefs (Op't Eynde et al., 2002). Based on a review of the empirical studies undertaken in belief research in mathematics education, McLeod (1992) divided beliefs into four categories (see Figure 3.2).

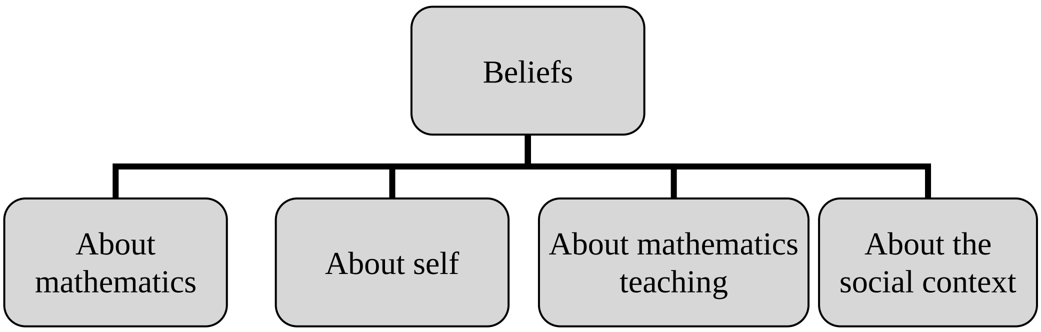


Figure 3.2. McLeod's (1992) categories of beliefs in mathematics education research.

After reviewing the literature on belief research, the Op't Eynde group constructed a framework. There are three categories in this framework, which characterise students' beliefs. They merged the two categories in McLeod's model, namely, 'beliefs about mathematics' and 'beliefs about mathematics teaching' into "Object (Mathematics education)" (Op't Eynde et al., 2002, p.27). The three categories of beliefs are further divided to elaborate the framework more fully (Table 3.1).

Table 3.1. A framework of students' mathematics-related beliefs (Op't Eynde et al., 2002, p.28)

1. Beliefs about mathematics education a) Beliefs about mathematics as a subject b) Beliefs about mathematical learning and problem solving c) Beliefs about mathematics teaching in general
2. Beliefs about the self a) Self-efficacy beliefs about mathematics education b) Control beliefs c) Task-value beliefs d) Goal-orientation beliefs
3. Beliefs about the social context a) Beliefs about social norms in their own class - the role and the functioning of the teacher - the role and the functioning of the student b) Beliefs about socio-mathematical norms in their own class

Both McLeod and the Op't Eynde group address the social aspect of beliefs in mathematics education, with the latter placing particular emphasis on the social context. However, they do not address sufficiently and explicitly the significance of the cultural context within which the mathematics classroom and students are situated.

There are notable criticisms on belief research. Skott (2010) presents a review of the literature on this area of research and provides a theoretical commentary. He explains that the problem with belief research partly lies in the fact that it focuses too much on the individual. Skott adopts Sfard's two concepts of objectification – reification and alienation – and regards beliefs as resulting from objectification. Skott notes that:

> Objectification has its advantages. It increases the effectiveness of communication and constitutes the basis for accumulation of experience. However, it also has its drawbacks. Objectified entities, Sfard says, are the result of an ontological collapse, as the discursive construction of the object is disregarded, and the object itself is mistakenly conceived as belonging to a mind-independent, perceptually accessible reality (Skott, 2010, p. 196).

Skott suggests new directions for belief research. According to Skott, various participation patterns emerge from instructional practice. Following the teacher's pattern of participation provides a better opportunity to understand the contribution to instructional practice than documenting teacher's beliefs (ibid). Skott's review focuses on the research and literature concerning teachers. His theoretical commentary is based on the already rich Western literature about teachers' beliefs.

In this section, the focus was on affect and belief areas of research in mathematics education. The intension was to provide background to these areas of research. Some of the concerns about these areas of research were also set out. The belief area of research and studies, which are explored in this area of research, give the background to situate the current study (e.g. Op’t Eynde et al., 2002). Some of the relevant studies write about both affective and cognitive issues without naming the area of research the study is situated (e.g. Fennema & Sherman, 1977). Motivation is dealt in both affect and belief areas of research. There are notions such as emotion, which are dealt usually in affect area of research. On the other hand, Roth (2007) states that motivation derives from emotion. Some of the empirical studies about the notions explored in these areas of research including attitudes, beliefs, emotions and motivation are examined in the following sections.

3.2.2 Studies in affect and belief research

This section introduces some of the empirical studies in the research areas affect and belief. The focus is on those studies, which pay attention to the relevance of mathematics as well as to attitudes, beliefs, and emotions. The section also focuses on use of terms in those studies.

There are concerns about the view on emotion in the affect and belief areas of research. The view that emotions are negative factors that influence behaviour is often criticized (e.g. Roth, 2007; Schlöglmann, 2003; Zan, Brown, Evans, & Hannula, 2006). According to Zan et al. (2006), one reason for this assumption is the constructivist stance that the early influential figures in affect research adopted.

In the field of mathematics education, the view towards emotion in relation to cognition has changed over the years (e.g. Schlöglmann, 2003). Schlöglmann (2003) indicates that there is a lack of clear delimitation between affective categories in mathematics education research. He discusses the literature on affect research in mathematics education and developments in neuroscience, suggesting that ideas and insights from neuroscience can help to overcome the limitations in making distinctions between these constructs.

There are empirical studies in affect and belief areas of research in mathematics education, which show that emotion and cognition are related (Di Martino & Zan, 2011; Roesken et al., 2011). Roesken et al. (2011) investigated Finnish secondary school students’ mathematical beliefs. They used a Likert scale type questionnaire. The questionnaire was constructed using items that are used in previous studies, including items from the self-confidence scale of Fennema and Sherman (1976). The scholars used factor analysis to explore the data and interpreted the data in the belief theory framework adopted from Op’t Eynde et al. (2002) that is set out in section 3.2.1. Roesken et al. (2011) identified seven dimensions that characterised students' beliefs, which they labelled from F1 to F7:

> ability (F1), effort (F2), teacher quality (F3), family encouragement (F4), enjoyment of mathematics (F5), difficulty of mathematics (F6), success (F7) (Roesken et al., 2011, p. 504).

Roesken et al. (2011) identified F7 as an emotional dimension. They did not identify a dimension for motivation. Their results are consistent with the framework proposed by Op't Eynde et al. (2002) in many ways, though their emotional dimension does not appear in the framework.

Di Martino and Zan employed grounded theory in their study of students' attitudes (Di Martino & Zan, 2010, 2011). They used essays to investigate Italian primary and secondary students' attitudes towards mathematics. The students described their relationships with mathematics in essay form (ibid). Di Martino and Zan (2011) exposed the importance of emotion in the students' mathematical cognition. They explain that attitude plays between emotion and cognition. Di Martino and Zan (2010) identified three dimensions of students' attitudes. These are:

> emotions, vision of mathematics and perceived competence (Di Martino & Zan, 2010, p. 39).

These three dimensions are interrelated and mediated by the teacher (ibid). According to Di Martino and Zan (2010), the level of stability of students' attitudes encourages intervention in order to change negative attitudes. Di Martino and Zan (2011) attempted to find evidence that links emotion and beliefs, the model proposed in Di Martino and Zan (2010). They explain that:

> The proposed model of attitude acts as a bridge between beliefs and emotions, in that it explicitly takes into account beliefs (about self and mathematics) and emotions, and also the interplay between them (Di Martino & Zan, 2011, p. 480).

Though Di Martino and Zan (2011) are about attitudes, they are also concerned with beliefs.

There are papers on attitudes, which pay attention to the relevance of mathematics (e.g. Fennema & Sherman, 1976). Fennema and Sherman developed an attitude scale based on a Likert scale to measure students' attitudes towards mathematics. Their questionnaire consists of the following scales: attitude toward success in mathematics; mathematics as a male domain; mother (m)/father (f); teacher; confidence in learning mathematics; mathematics anxiety; effectance motivation in mathematics; and mathematics usefulness (Fennema & Sherman, 1976). Fennema and Sherman have a scale, which reflects an underlying dimension of beliefs. This scale is about the usefulness of mathematics. They state:

> [T]his scale is intended to measure students' beliefs about the usefulness of mathematics currently and in relationship to their future education, vocation, or other activities (Fennema & Sherman, 1976, p. 326).

Similar to Di Martino and Zan (2011), this scale in Fennema and Sherman shows the overlap of studies on beliefs and attitudes. Moreover, the scale is an example of the attention, which some studies about attitude give to the relevance of mathematics. On the other hand, Fennema and Sherman (1976) show that perceptions of the social context are given emphasis and they appear in three separate scales. However, there are no scales, which relate the cultural context and students' learning.

Some of the literature about students' beliefs stress the importance of beliefs in exposing the relevance of mathematics (e.g. Presmeg, 2002). Presmeg explains that everyday life experience of mathematics and the mathematics students learn at school could be linked through examining students' beliefs about mathematics' nature. The details of this work is exposed in section 3.3.3. There are also studies, which examine beliefs and motivation (e.g. Kloosterman, 2002). Kloosterman investigated beliefs about mathematics and learning the subject. He suggests that students' beliefs and motivations should be considered together in eliciting ways of motivating students to learn mathematics (see section 3.2.4).

In affect and belief areas of research, the students' likes or dislikes towards mathematics is often interpreted as attitude towards mathematics (e.g. McLeod, 1992). Roth (2007) on the other hand interprets such constructs as emotions. Roth does this by supporting the interview result with an instrument, which measures participants' pitch of voices. He used the terms to describe emotional valence in relation to engaging in mathematics. The studies concerned with emotions, other than Roth's, are in the affect and belief areas of research. Roth's work, which I already set out in Chapter 2, differs from the studies in these areas of research examined here, as his research draws on CHAT and is situated in the workplace whereas the others are situated in school settings.

Some of the available literature about students' beliefs and attitudes examine the relevance of mathematics, but are limited to the usefulness of mathematics. Some of these studies stress the influence of belefs on perception of relevance (e.g. Presmeg, 2002). In the empirical studies presented here, there is overlap in the use of terms. McLeod (1992) stresses the difficulty of making a distinction between studies about attitudes and studies about beliefs. The distinction between attitudes and beliefs is vague (see Fennema & Sherman, 1976; Di Martino & Zan, 2011). According to Fennema and Sherman (1976), beliefs and attitudes are related in that there are beliefs, which underlie the students' attitudes.

3.2.3 Studies on gender in mathematics education

The research dealing with gender issues has a long history (e.g. Fennema & Sherman, 1976, 1977, 1978; Forgasz, 1992; Grevholm, 1996; Kloosterman, Tassell, Ponniah, & Essex, 2008). This section presents an overview of the studies on gender difference in mathematics education.

The issue of females' participation and performance has long been a concern in mathematics education research (e.g. Fennema & Sherman, 1976, 1977, 1978; Grevholm, 1996). Fennema and Sherman investigated attitudes towards mathematics among sixth- to eighth-grade students (Fennema & Sherman, 1978) and among ninth- to twelfth-grade students (Fennema & Sherman, 1977), using attitude scales as part of a project that focused on gender disparity in mathematics achievements. Fennema and Sherman (1977) indicate that there is variation in the secondary students' perceptions of others' attitudes towards the students as mathematics learners. They write:

> Boys perceived more positive attitudes about themselves as learners of mathematics from their mothers (3 schools), and fathers (2 schools), but not strongly and consistently from their teachers. (Fennema & Sherman, 1977, p. 68).

There is gender difference in mathematics performance and participation in mathematics courses among secondary school students, which is in favour of male students (Fennema & Sherman, 1977). The scales in Fennema and Sherman's instrument are set out earlier (see section 3.2.2). The issue of gender-related stereotypes towards the students as mathematics learners received attention in the expectancy-value model as well (e.g Eccles & Wigfield, 2002). In particular, the students' perceptions of gender-related stereotypes is one component of the expectancy-value model where it is depicted as motivational factor (ibid). The studies focusing on students' efficacy beliefs also paid attention to gender issues (e.g. Pajares & Miller, 1994). Pajares and Miller (1994) assert that gender has influence on students' performances, which is largely indirect. In particular, gender influences self-efficacy and students' self-efficacies in tern influence their performances (ibid).

While gender difference in mathematics is still rampant in many countries, gender difference in mathematics performance is diminishing in other countries over time (e.g. Grevholm, 1996). There are even cases where females outperform males (ibid). Grevholm examines the participation of women in Sweden in mathematics education. She reports that females are outperforming boys in major examinations. The problem was participation in mathematics education because the female participation rate had been relatively low (ibid). She explains that there is a gender difference in favour of men in participation in mathematics and related disciplines. Moreover, although there is improvement of women's participation in other areas over time, hardly any improvement was seen in mathematics, and in some cases, the situation was worsened (ibid).

Studies that are more recent also show a decline in the participation of females in mathematics in some countries (e.g. Vale, 2008; Leder, Forgasz, & Taylor, 2006). Vale (2008) investigates the findings of studies that focus on gender difference in Australasia. She found some evidence that shows a gender difference in participation in mathematics. Vale (2008) also explains that the decline in female students' participation in mathematics is accompanied by a decline in interest. Another Australian study reported that gender difference was identified in the participation of voluntary competitions (Leder et al., 2006). Leder et al. (2006) examined participation in voluntary mathematics competitions and in advanced mathematics courses that usually serve as a prerequisite for tertiary education. The results show that there is lower participation of females in both cases. The females' participation is found to be significantly lower in the case of the voluntary competitions (ibid).

In exploring students' perceptions, the focus of Kloosterman et al. (2008) was also gender, mathematics and its learning. The participants are secondary school students and pre-service teachers. Their results indicate that the students have beliefs of mathematics as being gender neutral. Kloosterman and colleagues reported that female students than male students hold this belief more strongly. In a study report under the title "Gender and perceptions of mathematics achievement amongst year 2 students," Forgasz (1992) also reports that there is variation between the teachers' perceptions of male and female students mathematical abilities. She asserts that whether the classroom is male-dominated has influence on female students' perceptions of their abilities. The perceptions of their abilities of mathematics may not affect their performances (ibid).

The literature about gender focuses on differences in students' perceptions, abilities, stereotypes and participation. Many of the research reports about gender difference in mathematics education, including those referred to above, pay particular attention to the gender difference in influences of others. What I miss in those studies is the influences of siblings. In my study, these influences are important because usually parents did not have the level of education that their children have and siblings have influences on mathematics-related decisions.

3.2.4 Students' motivation

The focus of this section is motivation. The earlier reviews indicate that motivation was not prominent as a category of affect (e.g. McLeod, 1992). However, it is gaining significant attention in affect and belief areas of research over the last two decades (e.g. Hannula, 2011; Op't Eynde et al., 2002). One of the three Op't Eynde and colleagues' categories of students' mathematics-related beliefs is 'beliefs about the self' (see section 2.3). This category is often identified as 'motivational beliefs' (Op't Eynde et al., 2002). In his recent framework, Hannula (2011) divides the affect related to mathematics into emotion, motivation, and cognition.

Motivation is an important construct that affects performance (Hannula, 2006). According to Hannula, motivation is understood as

> The inclination to do certain things and avoid doing some others (Hannula 2006, p. 165).

There are various theories of motivation, including self-determination theory and expectancy-value theory. Self-determination theory is a theory of motivation, which asserts that motivation can be understood by considering the basic psychological needs of human beings (Deci & Ryan, 2000; Reeve, Ryan, Deci, & Jang, 2008). This theory identifies the three basic needs of autonomy, competence, and relatedness (ibid). Students need successful relationships with those to whom they are related, such as family and teachers, and they want to be able to act freely or autonomously, to be competent to achieve something (ibid).

According to self-determination theory motivation can be intrinsic or extrinsic (Deci & Ryan, 2000). Deci and Ryan (2000) explain that individuals could engage in tasks for the sake of the tasks themselves, such as enjoying them. This is called intrinsic motivation (ibid). The individual might also engage in a task to achieve something that is external to the task (ibid). They call such motivation an extrinsic motivation (ibid).

Hannula (2006) considers motivation as being central to mathematics learning and having a part in regulating emotion. Hannula also suggests how motivation can be enhanced, through meeting needs, stating that:

> The basic needs of autonomy, competence and social belonging [by creating] a classroom [situation] that emphasises exploration, understanding, and communication instead of rules, routines and rote learning... focusing on mathematical processes rather than products (Hannula, 2006, p. 176).

As set out above, self-determination theory emphasises the satisfying of the three basic needs of autonomy, competence, and relatedness. Social belonging in Hannula (2006) is equivalent to relatedness in self-determination theory (e.g. Deci & Ryan, 2000). These three needs are considered important resources in understanding students' behaviour (ibid).

Expectancy-value is another theory of motivation. It was developed by Atkinsen, and further developed by Eccles and colleagues (e.g. Eccles Barber, Updegraff, & O'Brien, 1998; Eccles & Wigfield, 2002). Eccles and colleagues' model pays attention to the sociocultural milieu but it is limited to gender stereotypes, subject stereotypes, social classes, and ethnicity, particularly to the students' perceptions of these variables and their influence on students' motivation (ibid).

The model explains that the expectations of success, its cost, its attainment value, its utility value, and its intrinsic value all influence students' motivation towards engaging in a task (Eccles et al., 1998; Wigfield, Hoa, & Klauda, 2008). That is, the students' motivation is influenced by their expectations of succeeding in performing the task, the cost that their engagement might incur, the importance that the student attaches to the task, and its utility in achieving some goals (Eccles et al., 1998). The cost might arise when students have to choose between different school tasks and other school-related engagements available for them or when they have to choose between various courses of action (ibid). According to Wigfield et al. (2008):

> Attainment value also deals with identity issues; tasks are important when individuals view them as central to their own sense of themselves... When one intrinsically values an activity, the person does it because it is enjoyable, not as a means to another end (Wigfield et al., 2008, p. 171).

They add that the utility — the relevance of the task to the student in terms of its use in the students' future plans — is a motivational factor in engaging in a task (Wigfield et al., 2008).

Wigfield and Eccles (2000) undertook a review of their and their colleagues' previous works. This review focuses on students' motivation in engaging in school subjects including mathematics. They assert that students' perceptions of the importance of mathematics influences their motivation of choice of the subject. This work is examined in section 3.3.2.

The students' engagement in a task also relates to its relevance to the other aspects of students' lives (e.g. Brophy, 1999). Brophy (1999) explains that students' motivation in learning is affected by the relationship between the tasks presented and the students (e.g. Brophy, 1999). Brophy (1999) considers interest and appreciation to be significant aspects of motivation, and emphasises the importance of understanding the value students give to the subject of study. He places particular importance on perceived relevance of the learning experience. Brophy (1999) is critical of the little weight given to the value aspect of motivation. Brophy stresses that we have to find ways, which allow students to value the potential utility of the material they learn for their own lives. Students should value the tasks properly rather than merely enjoying them (ibid).

I set out earlier that Kloosterman (2002) investigated students' beliefs about mathematics and learning the subject. Kloosterman draws on cognitive theory and employed interviews as a research instrument. He also used questionnaires. Kloosterman (2002) stresses the importance of students' perceptions in their motivation to engage in mathematics (cf. Roth, 2007). Kloosterman states that:

> individuals only put forth effort when they perceive that effort will result in fulfillment of their personal goals (Kloosterman, 2002, p. 248).

I set out in Chapter 2 about Roth's statement that motivation derives from emotion (see section 2.4.2).

There are studies that relate motivation with students' prior experiences (e.g. Pajares & Miller, 1994; Usher & Pajares, 2009). Drawing on social cognitive theory, Pajares and Miller (1994) investigated the relationships between students' self-efficacy beliefs, prior experience, gender, and their performances in mathematics. The students who participated in this study were undergraduate students. They explain that students' interpretations of their prior experiences are more significant than the actual experiences in affecting students' performances (ibid). For Pajares and Miller (1994), self-efficacy beliefs better demonstrates students' motivation to engage in mathematics.

Consistent with Pajares and Miller, Usher and Pajares (2009) assert that students' self-efficacy beliefs influence their motivations. Pajares and colleagues' investigation of student's self-efficacy beliefs also sees mathematics in isolation. Their focus is on the student's perceptions of their prior and current performances in mathematics as predictors of the individual's motivation and behaviour (e.g. Usher & Pajares, 2009). Usher and Pajares (2009) do not see the possible role of the other school subjects. Pajares & Miller (1994) consider students' perceptions of their performances and the influence on the current. However, they fail to examine how students' perceptions of mathematics-related school subjects can relate with performances in mathematics and vice versa.

The literature shows that perceptions of relevance of mathematics is a motivational factor for engaging or not engaging in mathematics. The literature also shows that there are other motivational factors, which includes expectations of success and emotional valence. As a result of the overview of the literature about motivation, my presumption is challenged. I presumed that motivation is always positive. However, motivation is not always a positive construct; for example, extrinsic motivation might negatively affect intrinsic motivation (Deci & Ryan, 2000). This might result in a lowering of the individual's overall motivation (ibid). Studies on motivational influence of perceptions of mathematics' relevance to other subjects are rare. For example, Michelsen and Sriraman (2009) examined a limited aspect of motivation, namely, interest, only. The studies examined above mostly draw on cognitive or social cognitive theories, and are often criticised for paying little attention to the sociocultural aspects of the student's life (e.g. Roth, 2007).

3.2.5 Perception in affect and belief areas of research

I present an overview of the studies in affect and belief areas of research, which use the term perception as a title of their studies. I also present those studies, which use the term, even though it does not appear in the title of their studies. In addition, I attempt to expose the use of the term in relation to the other constructs in belief research. Some of these studies are examined earlier in this chapter. I examine some more studies about perception in this section.

The term perception is used frequently in affect and belief areas of research (Fennema & Sherman, 1976; Forgasz, 1992; Kloosterman et al., 2008; Nickson, 1992; Op't Eynde et al. 2002). In some of the studies, perception is the main subject (Forgasz, 1992; Kloosterman et al., 2008; Vähämaa & Härmälä, 2011). Vähämaa and Härmälä undertook a comparative study of students' perceptions about mathematics. They suggest that students' perceptions have deep connection with the culture. I further examine Vähämaa and Härmälä in section 3.3.6. I set out Kloosterman et al. (2008) earlier in section 3.2.3 and Forgasz (1992) in section 3.2.4.

Some studies that deal with gender issues in mathematics education focus on students' perceptions (e.g. Fennema & Sherman, 1976; Forgasz, 1992; Kloosterman et al., 2008). In some of these studies, the term perception is used in relation to students' abilities or personal competence (Forgasz, 1992; Kloosterman et al., 2008). Among the nine scales, which Fennema and Sherman (1976) designed to measure students' attitudes, the three are focusing on perceptions of students. They are about the student's mother, father and teacher, in particular, concerning her/his perception of their encouragement, interest and confidence in the ability of the student. Fennema and Sherman's instrument is set out earlier (see section 3.2.2).

There are other research concerned with the nature of mathematics (Dossey, 1992). Dossey (1992) surveyed the literature in mathematics education with the aim of investigating conceptions about the nature of mathematics. Dossey (1992) examined both the historical development and the contemporary conceptions of teachers and their influence on learning mathematics. He suggests that the nature of mathematics should be central to mathematics education and research in this field. He uses the terms perception as well as conceptions. He indicates that the perception of mathematics is different for people in the mathematics domain and those outside it, explaining that,

> Perceptions of the role and nature of mathematics held by [the] society have a major influence on the development of school mathematics curriculum, instruction, and research (Dossey, 1992, p. 39).

There are, however, studies that do show that the perceptions and beliefs of students about mathematics and learning can in fact affect their classroom practices and performances (e.g. Kloosterman, 2002) and the classroom culture (e.g. Nickson, 1992). Nickson (1992) examined mathematics classroom culture, focusing on the literature and empirical studies. According to Nickson (1992), the perception of the nature of mathematics determines the role of the students in the mathematics classroom. Nickson explains that research suggests that perception of mathematics influences classroom interaction and classroom interaction in turn influences the mathematics classroom culture. The term perception is used in the description of beliefs about the social context (e.g. Op't Eynde et al., 2002). According to Op't Eynde and colleagues, students' perceptions of the roles of the teacher and themselves as well as the mathematics classroom norms exposes students' beliefs about the social context.

Mulat and Arcavi (2009) show that the perception of students about learning mathematics is important for success. Using interviews, Mulat and Arcavi (2009) examined the success stories of post-secondary students of Ethiopian-Israelis in order to understand the students' perceptions of the causes that contributed to their achievements in mathematics. Their findings indicate that, among others, students' interests, motivation, and perceptions of the importance of mathematics changed in the new environment of the university and contributed to their success. Student identity becomes associated with motivation and achievement (ibid). Mulat and Arcavi (2009) paid significant attention to the sociocultural milieu, but give little attention to the associated emotional issues.

The problems in the use of terms in affect and belief areas of research persist in the studies, which employ the term perception. In some of the studies, certain words are used interchangeably. Vale and Leder (2004) used other terms synonymously with perception in their report on, "student views of computer-based mathematics in the middle years" (p. 287). For example, they use beliefs and perceptions interchangeably when talking about mathematical competence. Nickson (1992) also uses beliefs and perceptions interchangeably.

The focus of the overview of the literature in this section is affect and belief areas of research, and the use of the term perception in these areas of research. Some of the literature in affect and belief areas of research examine the relevance of mathematics (e.g. Fennema & Sherman, 1976; Presmeg, 2002). The term perception is also often used in studies focusing on relevance. The studies, which explore the relevance of mathematics, are set out in the following section.

3.3 The relevance of mathematics

This section offers an overview of the literature on relevance of mathematics. It has six subsections. They are presented in this order: the purpose of relevance and scope of the term; mathematics' relevance to other disciplines; mathematics in everyday life, relevance of mathematics to students' goals and students' identities. I finally present the section, perceptions of relevance. The subsections are mainly about the particular perceptions of relevance identified in my study, and it is the main purpose for examining the literature about these specific topics. The other purpose is examining the relationship with motivation.

3.3.1 The purpose of relevance and scope of the term

In this section, I focus on two issues. I expose some of the purposes of exploring mathematics' relevance. I also present the scope of the term relevance in some of the available literature in mathematics education.

The issue of relevance of mathematics has been a focus of attention in mathematics education research. Their purposes vary. One of the purposes for the focus on the relevance of mathematics is its importance in setting a context for mathematics concepts (e.g. Greer, Verschaffel, &

De Corte, 2002; Rojano, 2002). The focus on the relevance of mathematics can also be to improve the school curriculum and pedagogy of mathematics (e.g. Sealy & Noyes, 2010) or improve the curriculum of mathematics such that it will be useful for the other disciplines, which use mathematics (e.g. Flegg et al., 2012). It can be finding ways, which help to relate students' out-of-school experiences with mathematics offered at school (e.g. Presmeg, 2002) or closing the gap between them (e.g. Masingila, 2002). Another purpose can be to enhance students' interests in learning mathematics (e.g. Michelsen & Sriraman, 2009).

The relevance of mathematics can be presented in the mathematics classroom using word problems (Greer et al., 2002). The Greer group reviewed the literature on word problems and found that the idea of using word problems to enable students see the application of mathematics was contested. They are critical about the way that situations are modelled in the presentation of word problems. In particular, they mention that the mathematics classroom culture, teachers' beliefs, and the lack of criticality in modelling the situation in textbooks, examinations, etc. shape students' beliefs about word problems. Greer et al. (2002) assert that professionals and researchers in the disciplines that are related to mathematics also shape the students' beliefs about word problems. They state that the larger culture of the society that embraces, among others, the education system and educational policy can influence the students' beliefs about word problems.

The scope of the term relevance in mathematics education varies. It ranges from a narrower view such as relevance to students' real-world experiences (e.g. Darby, 2008) to a wider scope such as relevance to students' various aspects of life (future goals and everyday life) (e.g. Michelsen & Sriraman, 2009). In some of the studies the term relevance might not be of much importance (e.g. Greer et al., 2002; Michelsen & Sriraman, 2009), while in others it is a key term (Darby, 2008; Flegg et al., 2012; Sealy & Noyes, 2010).

The overview of the literature relating to relevance has a wider scope because in my study relevance has a broad range. It relates to various aspects of students' lives, from relevance to other school subjects, to everyday life and future goals. Relevance is described as 'connection' in some studies (e.g. Darby, 2008). Flegg et al. (2012) used the term connection often interchangeably with relevance. On the other hand, in this overview of the literature, I included studies, which use other terms instead of relevance. The terms used are diverse, which includes use, application and connection. The overview of the literature about relevance to the various aspects of lives are set out in the following sections.

3.3.2 Mathematics' relevance to other disciplines

In this section, I present an overview of the literature that focuses on the relevance of mathematics to other disciplines or other school subjects. Some of the studies I examined are not about school subjects. They are about courses in other *disciplines*, which the students take at university. Thus, I use disciplines instead of school subjects.

The relevance of mathematics to the other disciplines is examined in the literature (e.g. Flegg et al., 2012; Michelsen & Sriraman, 2009; Rojano, 2002). Flegg et al. (2012) investigated first-year engineering students' perceptions of the relevance of mathematics. Flegg et al. (2012) intended to make suggestions about changing the mathematics curriculum so that it would be more relevant to engineering students. They used mixed approach. They collected data from Australian students through interviews and questionnaires. They used the term relevance without describing or defining it. They often used other terms such as connection, relation and importance interchangeably with the term relevance.

The results of Flegg et al. (2012) show that most of the students have perception of the relevance of mathematics to their fields and future engineering career, with varying levels. Some of the students do not perceive that learning mathematics is relevant for engineering. Others perceive that learning mathematics is relevant for their study of engineering, but do not necessarily perceive that it is relevant for future career. There are students who perceive that it is relevant for future career. Their results about future use of mathematics are not limited to the use of the mathematics concepts but also includes the use of mathematical arguments to communicate effectively (ibid).

According to Flegg et al. (2012), the lack of connection between theory and practice in the mathematics courses may influence the students' perceptions of the relevance of mathematics. The difference in the departments to which those who teach mathematics and those who teach the other disciplines belong is seen as one source of the problem against offering a relevant mathematics (Flegg et al., 2012). They stress the importance of making links in order to enhance the students' perceptions of relevance. They suggest that there should be collaboration between the departments of engineering and mathematics. This collaboration is towards designing mathematics curriculum for engineering students (ibid).

Michelsen and Sriraman (2009) report results from a project undertaken in Denmark and Germany. The project's goal was to

> investigate on how upper secondary students' interest in the subjects of mathematics, physics, chemistry and biology might be improved by increased instructional interplay and integration between the subjects (Michelsen & Sriraman, 2009, p. 231).

Michelsen and Sriraman's current report focused on eleventh-grade students of Denmark. They used a Likert-type questionnaire to collect data and analysed the results using a three-dimensional model, one dimension of which is interest in particular content. They state that another dimension is the "learning setting," which they describe as:

> the characteristics of a specific learning setting that causes a situational interest in the topic and promote and support a shift from catching interest to holding interest. (Michelsen & Sriraman, 2009, p. 234).

They recognised the last dimension as "identity". Michelsen and Sriraman (2009) describe identity as:

> the student's affiliation with and valuation of mathematics and science (Michelsen & Sriraman, 2009, p. 234).

Michelsen and Sriraman also stress the influence of relevance on the students' appreciation and interest. In particular, they assert that:

> In order for students to gain an interest and appreciation in science and math, they need to be aware of how these subject areas affect their lives (Michelsen & Sriraman, 2009, p. 243).

They concluded that interdisciplinary instruction has an advantage. In particular, certain interests of students in science subjects can be used to enhance their interest in mathematics.

Other studies suggest the importance of other school subjects for setting a context for mathematics concepts. In a book chapter, Rojano (2002) examines "Mathematics learning in the junior secondary school: Students' access to significant mathematical ideas" (p. 143). She reviews the literature and asserts that other subjects can be used in the teaching of mathematics. In particular, she suggests that modelling can be used to connect mathematics and other school subjects. Rojano's work reveals that the teaching of mathematics and research in learning mathematics can benefit from considering the learning of other school subjects.

Motivational studies in mathematics education give little attention to students' perceptions of the relevance of mathematics to the other school subjects. Eccles and colleagues' investigation of the students' motivation using the expectancy-value model are set out in sections 3.2.4 and 3.3.4. For example, in their questionnaire, Wigfield and Eccles (2000) included items, which relate mathematics to the other school subjects. There is one item, which requests the student to compare ability in mathematics with ability in the other school subjects. Wigfield and Eccles did not examine whether the students' perceptions of their abilities in mathematics and in the other school subjects affect each other.

Wigfield and Eccles' questionnaire contains another item, which relates mathematics to the other subjects. This item requests the student to compare the usefulness of mathematics topics and the usefulness of a topic in another subject. The intention of the item is to get students' views of mathematics' usefulness. The need for mentioning the topic in another school subject is for clarifying the meaning of the item. This item does not consider the perceptions of the usefulness of mathematics in the other school subjects. Moreover, the question cannot direct the students’ attention to usefulness of mathematics to society because the example is restricted to self.

The focuses of the studies about the relevance of mathematics to the other school subjects or other disciplines is mathematics’ usefulness. There are few if any studies, which explored the diverse aspect of the connections between mathematics and the other disciplines. There are few studies, which investigate the students' perceptions of the usefulness of mathematics in everyday life through the other disciplines. Moreover, in those studies, which relate mathematics with other disciplines, the inclusion of social science disciplines received very little attention.

3.3.3 Mathematics in everyday life

In this section, I present an overview of the literature that focuses on the connection between mathematics and everyday life. The studies examined in this section are diverse in the sense that the studies are not specific to mathematics. Some are about workplace mathematics.

Bishop (1998a) reviewed studies, which expose mathematics that are used in various cultures. According to him, six mathematical categories apply to the practices of these diverse cultures. They are counting; measuring; explaining; playing; locating; and designing (Bishop, 1988a). He further explains that these categories are also the basis for the historical development of higher-level mathematics (ibid). Bishop (1988b) criticises the adoption of the curriculum of technologically advanced nations by less technological societies. According to Bishop (1988b), work has to be done to narrow the gap between the mathematics curriculum and the level of development of a given society.

Masingila (2002) investigated the perceptions of students and their everyday mathematics practice. The study focuses on middle school students in Kenya. Masingila’s aim is to understand perceptions of students’ everyday practice of mathematics and then,

> to close the gap between students’ use of mathematics in school and their use of it outside school (Masingila, 2002, p. 30).

In another co-authored paper, Masingila and her colleagues focused on science in addition to mathematics (Masingila, Muthwii, & Kimani, 2011). They investigated perceptions of what counts as a real-life mathematical and science experience. A common focus of Masingila (2002) and Masingila et al. (2011) is on the students’ perceptions of their mathematical experience in their everyday lives. Their central purpose is to establish the relevance of mathematics to students’ everyday experiences. Interviews and journals kept by students are used as methods of eliciting students’ perceptions of relevance. The students’ journals, which are recorded through log sheets, concern students’ experiences of classroom and everyday mathematical experiences (Masingila, 2002) and mathematical and science experiences (Masingila et al., 2011). The six dimensions that are identified in these studies are also consistent with Bishop (1988a).

Darby (2008) studied ways in which teachers are making mathematics and science relevant to students' lives. The purpose of this study is to see how context is set for the students' learning of mathematics and science concepts with respect to the students' real lives. They have the presumption that relevance has a motivational effect. Darby's study includes some participants who teach both mathematics and science. However, Darby (2008) does not expose the relevance of mathematics to the other school subjects.

Miettinen (1999) undertook a review of research projects about connecting learning to everyday life. Drawing on activity theory, Miettinen exposes the problems of schooling with regards to motivation as:

> school learning is characterized by memorization and reproduction of school texts. It is accompanied by an instrumental motivation of school success that tends to eliminate substantive interest in the phenomena and knowledge to be studied (Miettinen, 1999, p. 325).

He proposes networking of the school and out-of-school activities as a solution. Miettinen (1999) sees learning activity as having mediational role between the activities of labour and science. Miettinen suggests that better learning can take place through collaboration with organisations outside school, providing examples from specific projects to substantiate his case. In one vocational school that Miettinen considers, three methods were employed to make links between school and society.

In the first method, at least initially, the teachers had the opportunity to see the real-world connections beyond the tasks while the students did not have (ibid). Miettinen doubts if in such situation the students learn meaningfully with respect to connecting to the situation of the workplace. In the second method, the students studied the activity, which gave them the opportunity to see for themselves the actual connections between the concepts and workplace situations (ibid). The third method involved group work by students and tasks from research and planning projects. Out-of-school activities utilised results of the students' efforts, and in some cases, students earned small payments. Though the students used ready-made formulas, this situation gave the students the opportunity to see the connections (ibid).

Miettinen also reports on a research project on a comprehensive school designed to enable students to learn about issues relating to water and river. Miettinen explains that through participating in a collaborative project that was launched between the water institute and the teachers, the students were able to learn how to use certain methods that were used by the researchers. In his examination of the studies, Miettinen stresses the need for collaboration across organizations in a society. In order to facilitate better learning, he suggests using activity systems as the objects of the learning activity and insists that students need to have a direct experience of the out-of-school activities. Miettinen’s work concerns the learning process in general, not specifically about mathematics, though its findings are certainly important for the challenges in mathematics learning. For example, it acknowledges that making connections with everyday life influences students’ motivation.

There are few studies in belief research, which deal with making connections between everyday life experience and mathematics lessons (e.g. Presmeg, 2002). Presmeg presents a review of two research projects (both secondary and graduate). In the secondary school research project, interviews of students and observed lessons are used to explore students’ ontological beliefs. Her intention is to find ways, which help to relate everyday life experience with mathematics.

The participants in her second research project were graduate students in a teacher education program. This project was inspired by the results of the first project. From the first study, she understood that ontological beliefs about mathematics are difficult to change, and that link between students’ lived experiences and mathematics could be achieved through convincing teachers about the importance of this link. Similar to the case of the high school students, the graduate students’ beliefs about what counts as mathematics, were reported to be difficult to change. However, the graduate students demonstrated a certain amount of progress in their perceptions. In particular, they had broader perceptions of the connection between mathematics and everyday practices.

In addition to the belief about what counts as mathematics (e.g. Presmeg, 2002), there are other challenges in making connections between mathematics offered at school and everyday life experiences. For example, mathematics is not readily available for the students (e.g. Wedege, 2004). Wedege explains that mathematics is hidden in the artefacts, i.e., the textbook at school and the technology of the workplace. Wedege’s paper focuses on adult mathematics education, rather than mathematics learnt at school. However, Wedege’s critical view of the relationship between everyday life experience and mathematics learnt at school is crucial to understanding the gap that exists between them.

The challenges in making connections between mathematics and everyday life experiences is not limited to students. Research shows that student teachers and teachers are challenged when they encounter everyday life connections (e.g. Gainsburg, 2008). Gainsburg investigated secondary mathematics teachers’ perception and practice of making real-world connections in teaching. She employed both survey and qualitative methods. Particularly, she used classroom observation and follow-up interviews to supplement the results from the survey. She explains that the survey was undertaken based on an overview of the literature.

Gainsburg's results indicate that the availability of resources and ability to set tasks with real-world connections are the main constraining factors. Another main constraining factor is the amount of time required. The school rules such as the curriculum and testing are also cited as challenges (ibid). The teachers also limit their use of real-world connections in the classroom because of the difficulty to manage the classroom (ibid). For the majority of the participants, the purpose of making connections with everyday life is to motivate students or capture their interests. The majority of the participants also reported that their purpose is to offer an easier way to understand the mathematics concepts.

In this section, I examined the literature pertaining to the students' everyday life. The terms used in the literature are diverse, which includes real world, real-life, and out-of-school. They also use the terms interchangeably. In my study, I attempt to be consistent with my use of the term everyday life, which I used in my research question. Motivation is not the focus of these studies. Nevertheless, they usually acknowledge that making connections with everyday life influences motivation.

3.3.4 Relevance of mathematics to students' future goals

In this section, I present an overview of the literature that focuses on the connection between mathematics and students' goals. The terms used in those studies may not necessarily be relevance. The terms used includes rationale, value, exchange value and use value.

There are studies, which investigated students' perceptions of the relevance of mathematics to their future goals (e.g. Sealy & Noyes, 2010). Sealy and Noyes (2010) is a report from a project, which explores into geographical patterns of attainment and participation in mathematics in England. They collected data using interviews, classroom observations and questionnaire. Sealy and Noyes compared the perceptions of relevance among students of three schools. They found that the students' perceptions of relevance are different across the schools. They identified three different categories of perceptions of mathematics' relevance:

> (a) usefulness (practical relevance); (b) transferable skills (process relevance); and (c) exchange value (professional relevance) (Sealy & Noyes, 2010, p. 240).

They explain that the variations in the social and cultural situations of students of the three schools as well as the differences in social context of the schools are responsible for the differences in the students' perceptions of relevance. According to Sealy and Noyes (2010), the mathematics curriculum and its pedagogy should be framed in accordance with the three different perceptions of relevance, which students of the different schools and different sociocultural backgrounds have.

In his book “The Politics of Mathematics Education,” Mellin-Olsen (1987) writes about the notion of rationale. According to him, the student has some rationale for engaging in learning mathematics. He notes that

> [The rationale] comprises the logic of the individual according to the social setting he is related to (Mellin-Olsen, 1987, p. 157).

He explains that students might engage in a task because of the instrumental use of mathematics, in particular, to achieve another goal. This justifies knowledge as an instrument for success in examinations, certification, etc. Mellin-Olsen (1987) identifies this rationale as the I-rationale (instrumental rationale). Students could also engage in a task because of the social importance of that task (ibid). The students’ rationale for engaging in mathematical tasks could be the future or current social importance that the tasks or the concepts have (ibid). Mellin-Olsen describes the usefulness of mathematics beyond school as the social rationale or S-rationale. He explains that these two rationales influence one another in motivating the students to engage in learning mathematics. A combination of I- and S- rationales drive students to learn (ibid). He posits that the teacher needs to investigate students’ activities in order to help them to engage in learning mathematics. The students could be deprived of an activity when deprived of the S-rationale for it (ibid).

Black, Williams, Hernandez-Martinez, Davis, Pampaka, and Wake (2010) investigated students’ identities, in particular, “the relationship between students’ mathematical identities and their career and higher education aspirations” (p. 55). The participants of this study are students of upper secondary, and mathematics is an elective subject (ibid). Black et al. (2010) adopted activity theory, and focused on learning mathematics as an activity. This report is part of a project. The method they employ is interviews, where 40 students participated. However, in this report they focus on two students. Black et al. (2010) assert that the exchange value and use value of mathematics define the motives of students for studying mathematics. According to Black and colleagues, the use value is that mathematics enables one to pursue a ‘vocation’. The exchange value is that mathematics enables one to join the university and obtain an academic degree. The students experience tension between mathematics’ use value and its exchange value with respect to their anticipated study (ibid). According to Black and colleagues, students’ choice of subjects relates to their motive of anticipated studies.

There are studies, which are situated in affect and belief research areas and pay attention to students’ goals (e.g. Eccles et al., 1998; Wigfield et al., 2008). These studies employ the expectancy-value model. According to Eccles et al. (1998), the utility of a task to the student in achieving some goals are important when students have to choose between different school tasks and other school-related engagements available for them. Wigfield et al. (2008) also assert that the relevance of the task in terms of its use in the students' future goals has influence on students' motivation. The details of expectancy-value model including the motivational influence of the value aspect of a task are set out in section 3.2.4.

The relevance of mathematics to students' goals is the focus of this section. Though various terms are used in the literature, I understand them as relevance. The motivational influence of the relevance of mathematics is also acknowledged in the literature.

3.3.5 Students' identities

I provide a brief overview of the literature about students' identities. The literature and empirical studies I set out in this section mostly fall outside of the belief area of research. The focus instead is on studies, which draw on sociocultural theory. The reason is that there are limited study on students' identities in belief research in mathematics education.

Identity is an important construct in sociocultural studies (Holland, Lachicotte, Skinner, & Cain, 1998; Lave & Wenger, 1991; Roth, 2007; Roth et al., 2004). Identity seems to be considered a sociocultural substitute for beliefs or attitudes in belief research (Hannula, 2011). There is a growing demand for a shift in focus to the social aspect in affect and belief areas of research in mathematics education. Lerman (2002) emphasises that research in teachers' beliefs should be directed towards viewing the individual's beliefs in a sociocultural context so as to allow notions such as identity to be incorporated into the belief area of research.

There are studies in belief research about teacher identity (e.g. Frade, Rösken, & Hannula, 2010). A research forum in 2010 examined the relationship between identity and belief research, including motivation. It mainly focused on teachers' professional identity (Frade, Rösken, & Hannula, 2010). Identity is dealt in some works of belief research (e.g. Chapman, 2002; Lerman, 2002). These works focus on teacher's identity. They are evidences of growing interest in the social aspect in belief research. On the other hand, students' identities received little attention in this area of research.

There are empirical studies on students' identities in the field of mathematics education that draw on sociocultural theory (e.g. Black et al., 2010; Nasir, 2002; Nasir & Saxe, 2003). Nasir (2002) gives an overview of the studies undertaken in different cultural domains and their relation to learning mathematics, notably the roles of race, culture, and goals in mathematics learning. She uses evidence from two studies on African-American students. She demonstrates the relationships between goal, identity and learning, which she depicts in the figure below.

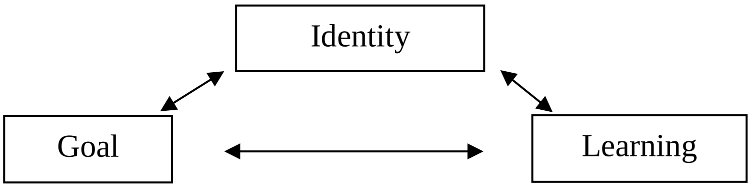


Figure 3.3. Bidirectional relations between identity, learning, and goals (Nasir, 2002, p. 239)

Nasir explains that goal, identity, and learning create one another. The bidirectional arrows between the pairs of constructs indicate these relationships (see Figure 3.3). Nasir (2002) explains that the close link between identity and learning is useful in examining students' success. Nasir explains that the students establish a sense of identity as learners in relation to their African-American cultural background. Nasir also explains that the students learn better, when the tasks are related to their sociocultural background, such as playing dominoes and basketball. She makes clear that identity mediates learning. Nasir explains that goals emerge as members participate in cultural practices.

Nasir and Saxe (2003) undertook a similar study that also investigated African-American students' ethnic and academic identities. The students' ethnic identity is examined with respect to a specific cultural domain within the larger American culture, where the students participate in the American school system, which employs curriculum designed for all American schools (ibid). Nasir and Saxe (2003) reported that the students experience tensions between how they are situated in the school and out-of-school cultural practices.

As set out in section 3.3.4, Black et al. (2010) also investigated students' identities. They assert that there is change in students' identities. This change is implicated with the change in motive or emergence of a new motive (ibid). The students perceive that mathematics has both use value and exchange value (ibid). These perceptions relate with the students' identities; in particular, students' identities influence students' perceptions of use value and exchange value of mathematics (ibid). They examined students' personal identity, and to some extent the social aspect. The focus of Black et al. (2010) is on what the students aspire to study and what they want to become in the future.

There are other studies, which pay attention to identity though their main agenda is not identity. There are studies, which focus on students' perceptions of relevance and pay attention to identity (e.g. Flegg et al., 2012). There are others, which examine identity while exploring ways to enhance students' interests through making link between mathematics and other school subjects (e.g. Michelsen & Sriraman, 2009). These studies are examined earlier (see section 3.3.2).

In this section, I focused on the literature about students' identities, which draw on sociocultural research in mathematics education. Though there are studies that focus on teacher identity, student identity has received little attention in affect and belief areas of research. Research on student identity is usually situated in the sociocultural domain of research. On the other hand, the studies that draw on sociocultural theory pay attention to students' identities but deprive it of affective aspects such as emotion and motivation (Roth, 2007). Though motivation is not main issue of their investigations, these studies acknowledge that identity is a motivational factor for engaging in mathematics. The studies address students' personal identities. They also address collective identity. What I miss in these studies is national identity.

3.3.6 Perceptions of relevance

In this section, I re-examine the connections between mathematics and students' aspirations, everyday life and other school subjects as perceived by the students. I also examine possible interrelationships between these perceptions of relevance.

There are some studies, which are about the relevance of mathematics, and use the term perception of relevance in their titles (e.g. Flegg et al., 2012) and use the term perception of relevance in their statement of the reports' purpose (e.g. Sealy & Noyes, 2010). Flegg and colleagues explored first year engineering students' perceptions of the relevance of mathematics to the other courses, which engineering students take and to the career, which these students aspire (see section 3.3.2).

The students' future studies and careers are associated with their identities (e.g Black et al., 2010; Flegg et al.; 2012; Michelsen & Sriraman, 2009). According to Flegg et al. (2012), many of the participants have identities with respect to specific fields of engineering. What I miss in Flegg et al. (2012) is that if the students have mathematical identity, and if they have, whether the mathematical identity relates to the other identities. Michelsen and Sriraman exposed that the students have identities with respect to mathematics and science school subjects. According to Michelsen and Sriraman, students' future studies as well as careers have significant roles in the students' identities. However, they did not expose clearly, if the identities are distinct for each of the subjects. We do not know whether these identities (if distinct identities exist) have relationships.

Black et al. (2010), on the other hand, investigated students' identities, in connection with aspirations of future study and career (see section 3.3.4). Black and colleagues assert that their exploration of the students' mathematics-related identities involves exploring perceptions of the relevance of mathematics to the students' future aspirations. Sealy and Noyes (2010) identified exchange value as the students' perceptions of relevance. Sealy and Noyes' study is about the relevance of mathematics to students' future study and career aspirations. They did not pay attention to the other school subjects.

Flegg et al. (2012) pay attention to the other subjects or courses. For example, they wrote about a student's perception of mathematics' relevance to physics. However, they fail to examine the relationship of physics with engineering. This could be useful since the focus of their study is on the connection between mathematics and engineering. It could help understand if physics has a mediational role.

Some of the studies expose relationships of the students' perceptions of the relevance of mathematics to their future careers with their experiences of everyday use of mathematics (e.g. Sealy & Noyes, 2010). Michelsen and Sriraman also expose that usefulness of mathematics in everyday life and its usefulness in other school subjects are interrelated. In particular, other school subjects can be used to show usefulness of mathematics in everyday life (ibid).

In some of the studies I reviewed here, there are relationships between perceptions of mathematics' relevance with the other constructs in affect and belief areas of research. Sealy and Noyes (2010) exposes that students' perceptions of mathematics' relevance shapes their attitudes towards mathematics. The findings of Michelsen and Sriraman (2009) also show that students have positive attitudes towards the connection of science and mathematics. Presmeg (2002) explains that students' beliefs influence their perceptions of mathematics' relevance.

There are studies, which expose students' perceptions of mathematics, still pay attention to perceptions of mathematics' relevance (e.g. Vähämaa & Härmälä, 2011). In their paper, which explores into university students' perceptions of mathematics, one of Vähämaa and Härmälä's three research questions is about perception of mathematics' applicability. In particular, they compare perceptions of Norwegian and Finnish university students. They employed both qualitative and quantitative methods. First-year students from diverse disciplines participated in the study. There is a difference in the students' perceptions of mathematics within and across the two cultures (ibid).

They assert that most of the Norwegian students have a perception of mathematics as concrete while there is diversity in the perceptions of the Finish students. They use the term perception; however, do not use the term relevance. They also use other terms interchangeably with applicability. For example, they use the term applicability and usefulness interchangeably. They expose perception of mathematics' usefulness as one aspect of students' perceptions of mathematics. According to Vähämaa and Härmälä, students' perception that mathematics is useful, may facilitate their learning of the subject.

The description of *relevance* in the studies, which I presented here, is consistent with this dissertation's goal of investigating perception of relevance. The terms used in the literature are diverse, which includes rationale, value, etc. Usefulness is one aspect of the relevance.

3.4 Concluding remarks

The overview of the literature focused on the research areas in affect and belief as well as the research about the relevance of mathematics. I attempted to provide a sufficient context to the central issue of my study – students' perceptions of the relevance of mathematics.

The literature supports my assumption that students become motivated to engage in mathematics when they perceive that it is relevant to them. Many of the studies, which deal with relevance, acknowledge that students' perceptions of the relevance of mathematics are motivational factor for their engaging. However, for most of these studies, motivation is not the reason for their focus on the relevance of mathematics. On the other hand, studies about the relevance of mathematics at upper secondary are scarce in the literature in affect and belief areas of research. Moreover, the studies usually focus on a single aspect of relevance, which is mathematics' usefulness.

Studies about students' identities and the relevance of mathematics are scarce in affect and belief areas of research. There is little work done in affect and belief areas of research that draw on sociocultural theory in general, let alone on cultural historical activity theory. On the other hand, the studies, which are situated in sociocultural research, give significant attention to the sociocultural milieu in which the student is situated. These works, however, pay scant attention to the affective aspect (Roth, 2007).

I highlighted some of the concerns and criticisms in the affect and belief areas of research. I acknowledge the criticisms against this area of research. I do not promise to avoid these problems in my study. I rather attempt to follow the sociocultural theory, which gives attention to the context in which the individual is situated. I mentioned that the students' beliefs, attitudes, etc. are often studied drawing on cognitive and social cognitive theories. I also set out the descriptions of these constructs of beliefs, attitudes, etc. However, I do not see attitudes and beliefs as held by the individual student in isolation. They cannot be viewed in isolation from the social and cultural milieu the students are situated. I view these constructs as results of mediational processes in the students' history of participation in the school and out-of-school activities.

Belief research focuses mainly on Western society. The sociocultural context of the typical Western society offers a very different situation from realities of non-Western societies. The present study contributes to belief research by focusing on a currently under-researched context, the Ethiopian context.

4 Methodological issues

4.1 Introduction

This chapter is about the paradigm in which my study is situated, the methodology and design of the study. The choice of research methods is based on the research questions and the theoretical perspective (Bryman, 2008). I chose a mixed approach using both qualitative and quantitative methods, where I principally used qualitative methods, particularly, group interviews. The students' expressions of the connections between mathematics and their school and out-of-school experiences are understood as their perceptions of the relevance of mathematics.

Data were collected at two different periods. The first data collection was conducted for a pilot study, which used group interviews. The data analysis resulted in diverse characterisations of perceptions of relevance. These results were used to construct a questionnaire. The main study was undertaken one year later, and it employed both methods.

This chapter is structured as follows: At the outset, I explain the paradigm in which this study is situated, followed by the methodology and design of the study. The methodology of the study focuses on the qualitative and quantitative methods chosen for collecting and analysing data. It also includes the reasons for these choices. Then, I explain about the authenticity and trustworthiness of the study. This is followed by the sections about limitations of the study and ethical considerations. I close the chapter by concluding remarks.

4.2 The paradigm in which this study is situated

The set of beliefs that distinguish the present study's view is consistent with the interpretivist paradigm; the focus is on meaning (Bryman, 2008). The goal is to understand students' perceptions of the relevance of mathematics and characterise these perceptions of relevance. I make ontological and epistemological assumptions, which are also consistent with the interpretivist paradigm (Schwandt, 1994). I set out these assumptions in the following sections. I start with ontological assumptions.

4.2.1 Ontological assumptions

In this section, I present my ontological assumptions about studying the students' perceptions of relevance. I focus on my assumptions about what counts as students' perceptions of the relevance of mathematics. I also expose my assumptions about how perceptions of relevance emerge.

My study investigates perceptions of relevance that can emerge as a social creation in the relationships within a community or in the relationships of the individual with the community as well as in the relationships with the object (see Chapter 2). The meaning and sense of any new experience is acquired based on the previously appropriated signs (Vygotsky, 1978). Chapter 2 provides a description of perception (see section 2.4.1). Chapter 3 provides a description of perception of relevance (see section 3.1). Perception of relevance is understood as a mediated product (cf. Vygotsky, 1978). Vygotsky asserts that signs mediate mental actions such as retrieval of information, reasoning, thinking, etc. In an interview situation, either the interviewer or a peer group member might mention some mediational artefacts, which will mediate the retrieval of information and further related mental actions. The student could use retrieved information to construct a narrative of perception of the relevance of mathematics. The students might also retrieve the narrative itself.

Consistent with Roth (2007), I understand that students' perceptions of relevance are better understood within the context of, among others, the other students with whom they are attending school and use the artefacts. As it is set out in section 4.3, the data collection and analysis pay attention to these realities. The interviews required that the students reflect on their learning of mathematics with respect to their school and out-of-school experiences as participants of the diverse activities, which utilise diverse artefacts. Similarly, in their completion of the questionnaire, the students were asked to reflect on their learning of mathematics with respect to their school and out-of-school experiences. The questionnaire was intended to enable the student to act in a form of social engagement. There was an attempt to let the questionnaire bring the artefacts and the other people to the student's attention.

I assume that perception of relevance is something that is formed and transformed as members participate across activities (cf. Roth et al., 2004). According to Roth et al. (2004), participation in and across activities form and transform the participant's identity. The students in my study are members of a school with its own organizational structure and set of rules, regulations, and division of labour that are beyond their immediate control (Roth et al., 2004). The school system is dynamic in nature (ibid). As members participate in activities where communities are reorganized and new artefacts are introduced, there will be changes in the activity system (ibid). In their out-of-school lives, students participate in the activities such as family-life, church/mosque and game. Consistent with Roth et al. (2004), I understand that while situated in such a setting, their perceptions of relevance are formed and transformed through mutual engagement with others. Thus, I understand perceptions of relevance as being dynamic.

4.2.2 Epistemological assumptions

In this section, I present my epistemological assumption about studying the students' perceptions of the relevance of mathematics. In particular, I focus on what assumptions I made in coming to know the perceptions of relevance. I also expose what could influence the knowledge obtained.

The interviewee and I have roles in generating the data (Kvale & Brinkmann, 2009). I ask certain questions and I attempted to make sure that the students understood my questions. From this point of view, the interviewees and I co-produced knowledge (Kvale & Brinkmann, 2009). I assume that the students provided accurate information. The question I want to answer in this study, in general terms, is, 'what are the characterisations of students' perceptions of the relevance of mathematics'. I assume that the nature of the interview questions, which derive from the research questions, encourage students to provide accurate information. The interview questions encourage them because the questions do not involve sensitive issues and are clear (see Appendix 4). Moreover, when possible, I used the alternative data sources for checking facts. The data from the alternative sources supported the students' assertions.

Consistent with Miles and Huberman (1994), I understood the importance of my relationships with interviewees in the production of knowledge because of the influence on the generation of data. I attempted to establish a sound relationship within the time that was available for me. I assume that the knowledge produced would be different depending on the relationship, which the interviewer establishes with the interviewees (e.g. Kvale & Brinkmann, 2009). For example, there could be some difference in the knowledge produced if I interviewed students over extended period, which can give opportunity to establish even better relationship with the interviewees. Another person with a better or lesser craft of interview could make some difference in the data set produced (ibid).

I assume that the knowledge produced is context-dependent. Following Geertz (1973) and Kvale and Brinkmann (2009), I took into account contextual issues, which can have influence on the knowledge produced. I understood the importance of providing description of the context in which data are generated and I attempted to provide as much as possible. In addition, I attempted to expose the limitations in the generation of data whenever providing sufficient descriptions of the context are impossible (see also sections 4.4 and 4.5). Consistent with Kvale and Brinkmann (2009), I assume that the knowledge about students' perceptions of mathematics' relevance can be obtained from the students' narratives. In the data presentation, I provide students' stories to expose their perceptions of the relevance of mathematics. I consider the significance of language in the production of knowledge (e.g. Kvale & Brinkmann, 2009). I communicated with the interviewees in a language we both could understand in order to avoid the influence on the generation of the data and the knowledge produced. The same language was used in the questionnaire.

I assume that the knowledge produced is laden with meaning that is shared among students' communities. The purpose of the study is not in search of law, but meaning (Geertz, 1973). I investigated students' perceptions of relevance which they narrate based on the knowledge that they have appropriated in the sociocultural context of the school and the respective communities in which they are situated. I interpreted the data generated from the interviews. I interpreted the students' utterances pertaining to mathematics and the connection to their diverse aspects of lives, which they tell in response to the questions I asked during the interviews, as their perceptions of the relevance of mathematics. In order to explore and expose the students' meanings, their words must be understood first (Janesick, 2000). Following Burton (2002), I searched for meanings that are shared among the students. I interpreted and reported the shared meanings as characterisations of students' perceptions of relevance. However, there are characterisations, which are shared by only few interview groups; even then, I report them. Such meanings may or may not be shared among all communities. The limited time I had with the students did not allow further exploration to decide on this issue.

Similarly, I attempted to make sure that the questionnaire items are clear (see section 4.3.4). The items are constructed based on interviews of students from the same school, and I attempted to let the questionnaire bring the artefacts and the other people to the student's attention. However, limitations exist with respect to the questionnaire (see also sections 4.4 and 4.5). Though I assume that the students are earnest to provide accurate information, I understand that there are occasions where the clarity of the questionnaire items might have made it difficult for the students to provide accurate information (See Chapter 9). In Chapter 9, I provide reflection and possible amendments to some of the items.

In this section, I have presented my epistemological assumptions. I also set out my role in the production of the knowledge about students' perceptions of the relevance of mathematics. I further examine my role in the generation of the data in the next section.

4.3 The design and methodology of the study

In this section, I present the design of the study, the methods used and the rationale for the choice of the particular methods. I expose the qualitative methods of data collection and analysis. Similarly, I expose the quantitative methods of data collection and analysis. I also set out the methods of sampling.

4.3.1 Design of the study

I employed a case study design. I provide a rationale for my choice. I also provide advantages and disadvantages of the design of the study.

My use of the case study design is influenced by Yin (2009) and Stake (1995).

The choice of a research design depends on the research questions (Yin, 2009). The interest in this study is to explore how students perceive the relevance of mathematics. According to Yin (2009), case study suits to such research questions. A case study also suits to studies when the intension is to find some result, which could be used to embark further study (ibid). The case study design also suits to the study's interest in exploring the issue of investigation in the given context (Yin, 2009).

The students are situated in a preparatory school. As I set out earlier, it is an activity system (see Chapter 2). Following Stake (1995), I pay attention to the boundedness of the system. I understand that this system is bounded. The students, who are attending the school, have distinguishing features from the rest of the society in that they are preparing for university studies. They spend most of the day in this school. The students attend to school subjects and engage in related tasks in the school compound. They belong to a certain age group, but are also distinguished from the rest of their age group as they are considered as elites.

Consistent with Stake (1995), I understand that there is a pattern in this system. Every day, the students should be at school and leave the school at a fixed time. In the period they are in the school, it is mandatory to attend subjects that the school offers on regular basis. The school subjects are offered for a fixed period. The students have to follow all the rules in the school such as engaging in mathematics tasks, which the teacher gives them as classwork and as homework. They use textbooks and other artefacts, which assist their learning. They also sit for examinations, which are administered on regular basis.

I selected a single case, a case of Memiru Preparatory School students, because I wanted to get sufficient data from a particular case in the given time available for me. According to Yin (2009), focusing on a single case gives an opportunity to use multiple data sources. Focusing on a single preparatory school gave an opportunity to use other data sources such as the classroom observation. Though it is used in rare occasions, conversations with teachers is also another data source, which I used to support the data from interviews of students. I also collected data using questionnaire.

There are concerns about the results obtained using a single case (ibid). For example, multiple cases offer an opportunity of comparing and exposing differences in the various contexts (ibid). Moreover, there is concern about the generalizability of the results, which I set out later in this section. Such limitations of the study are exposed in section 4.5. The attempt to ensure trustworthiness are outlined in section 4.4.

On the other hand, as I set out in Chapter 1, all public preparatory schools in Ethiopia are very similar. All public preparatory schools in Ethiopia are owned and managed by the government. The government bodies, who are external to the school, design the curriculum, provide the textbooks, recruit the teachers, assign the school administration, allocate budget, and assign the students to the preparatory schools. There is also a government body, which sets the examinations. It sets the entrance examination to the preparatory school as well as the examination that determines the successful completion of the preparatory school. Given the situations set out above and in section 1.5, the general features of students, who attend in this preparatory school, cannot be far different from features of students of other public preparatory schools, particularly, those in urban areas. Thus, consistent with Yin (2009), I believe that focusing on a single case could be sufficient as a starting point, which paves the way for future investigations. The choice of the school is explained in section 4.3.3.1.

Following Stake (1995), I attempted to pay attention to the context in which the students are situated. In addition to the descriptions in Chapter 1, I provide descriptions of the school and out-of-school context using students' own words and my own observations, in section 7.3. This is particularly important given the design of my study. Stake stresses the importance of exposition of the context in studies, which adopt a case study design.

A case study design has its own disadvantages (Yin, 2009). According to Yin, there are concerns, which are often mentioned as disadvantages of case study design. The first concern is its vulnerability to biases. Following Yin (2009), in an attempt to avoid or minimize the chances of biases, I provided relevant evidences available in the interview data as well as from other available sources, which expose the students' perceptions of relevance. I attempted to avoid or minimize the chances of biases in the search for evidences, which expose the students' perceptions of relevance, as well as in the analysis of the data (see section 4.3.3 and 4.3.4). Moreover, I set out my attempts to overcome biases in section 4.4 and the possible limitations in section 4.5.

Another concern is generalizability. I do not attempt to generalize to the population of Ethiopian preparatory students. However, consistent with Yin I attempt to generalize to the propositions that there are certain characterisations of students' perceptions of the relevance of mathematics. The case of Memiru Preparatory School students is not unique. As I set out above given the descriptions of preparatory schools I provided in Chapter 1 and descriptions of the school and out-of-school context, I provided in Chapter 7, one could see that preparatory schools could be very similar. This issue is further dealt in Chapter 8 (see section 8.7).

In this section, I focused on the case study design, where I set out that the case is preparatory students of a specific school. On the other hand, Chapter 2 has made it clear that activity is the unit of analysis. The students' participation in the activity of schooling is the primary focus. The preparatory school is considered as an activity system. Consistent with Yin (2009) the case and the unit of analysis agree. Consistent with Yin (2009), the study's design allowed using a mixed approach. This issue is the subject of the next section.

4.3.2 Mixed approach

The research questions at hand demand a mixed approach of both qualitative and quantitative methods. Following Pring (2004) and Bryman (2008), I adopted qualitative research methods for exploring and characterising students' perceptions of the relevance of mathematics. I adopted quantitative methods for examining their popularity (ibid), that is, to examine how widely the characterisations are held among the students.

Consistent with Pring (2004), the study begins with the qualitative and moves to the quantitative approach. According to Pring, understanding issues of social nature requires the use of qualitative approaches, but that approach limits the generalizability of results and necessitates the quantitative approach (ibid). This is particularly important to generalize the results to the school population. Using both qualitative and quantitative approaches together enables a better interpretation (ibid). Pring asserts that a holistic understanding of the situation is possible through using a mixed approach of both qualitative and quantitative methods.

I undertook a pilot study in order to test the methods chosen, and explore the context. Before conducting the main study, I gave a brief presentation of the results of the pilot study for the mathematics teachers of the school. Based on the experience of the pilot study, I made some changes in the methods. I set out these changes later in this chapter (see section 4.3.3.2).

4.3.3 Qualitative research methodology

In this section, the qualitative research methods and the rationale for employing them are presented. I use the qualitative research methods because it fits the study's purpose (Cohen, Manion, & Morrison, 2007). The study's purpose is to understand students' perceptions of relevance. Understanding and looking for meaning requires engaging with individuals more closely (Denzin & Lincoln, 2000). Qualitative methods also give the possibility of exploring meanings in depth (ibid). This section has four subsections, which are presented in this order: the methods of sampling for qualitative data collection, the interview method of data collection, the method of qualitative data analysis and further analysis using the analytic framework.

4.3.3.1 The methods of sampling for qualitative data collection

I collected all the data from one school, which was chosen for ease of access to data sources, as I had taught at that school for over three years. There were former colleagues who still worked there and facilitated the data collection, including rapid integration and communication with the members of the school community.

Participants were selected in the following manner: first, I approached the department head and informed him about the research project. He arranged a meeting with the mathematics teachers. Then he suggested that we select classrooms where the mathematics teacher is the homeroom teacher. The homeroom teachers are those teachers who have the first line of experience with and responsibilities for each class of students. I agreed with the selection of these teachers because he explained that they had the most thorough knowledge of the students. He selected four such mathematics teachers. I spoke with them about the selection of interview participants and about classroom observation.

I used the natural categories that existed in the school for sampling: gender, grade level, level of achievements, and streams. Each of the four teachers selected three female and three male students of various levels of achievements: high, medium, and low. The teachers selected six students each. As a result, 24 students were selected from four classes. The selected students are from social science stream, natural science stream, eleventh and twelfth grades. I divided the students into eight interview groups such that female students of high, medium, and low achievement from the same class are in one group and the male students of high, medium, and low achievement from the same class are in another group.

4.3.3.2 The method of data collection

In this section, a major focus is on the group interview. The data collection also includes classroom observation. I also set out my role as an interviewer, and the teachers' role in facilitating the data collection.

The intention of using interviews is to see through the participants' eyes (Bryman, 2008). I want to see the relevance of mathematics through the students' eyes. Consistent with Kvale (1996), I am convinced that the interview setting can allow the students to express their understanding of both previous and current experiences and the meaning they attach to their experiences in their own words. Interviews can provide an opportunity to understand the interviewee by creating a conducive and flexible situation (Fontana & Frey, 2000, Kvale, 1996).

I undertook group interviews. I grouped students of the same gender and same class together to create a milieu where the students felt at ease during the interview and to obtain more information through lively discussion, since they shared common experiences in their respective class. One student mentioning a particular episode or concept is likely to remind other students of the same episode or similar instances. Fontana and Frey (1998) assert that there are possibilities of dominance of some participants and resistance by others in the groups. I attempted to curb such situations by addressing each interview question to each member. I attempted to address participants by name and asked for their opinion on the issues at hand. There were still variations in the level of participation within groups as well as across groups partly because of the limited interview time. The effect of these variations on the results obtained is set out in the following section and section 7.2 and section 7.6. I also provide a further reflection in section 9.4.2.

I understand that the mathematical concepts and experiences, to which the students have been exposed, reside in their memories. They formed perceptions of relevance, which they can communicate to others (e.g. Vähämaa & Härmälä, 2011). When a student narrates her\his experiences, s\he retrieves it from her memory and utterances of the other direct the student's attention (Vygotsky, 1978). The student is likely to retrieve elements of the narrative and organize her\his narrative during the interviews. S\he may also retrieve her\his narrative. Her mental actions such as thinking, reasoning, etc., involve the use of artefacts (ibid). The interviewer's mention of artefacts such as textbook and other students' utterances are signs that enable students to remember and expose their perceptions of relevance. Grouping students who share similar school and out-of-school sociocultural milieu is helpful in this respect.

The interviews are semi-structured. Some structure is necessary to ensure that the study's aims are met and may be helpful to elicit responses from shyer students. On the other hand, if interviews were fully structured, I could miss important information that might come from the students' own initiatives. My role as an interviewer was to pose questions; guide them to focus on the issue at hand and then raise further questions based on the earlier responses. Consistent with Fontana and Frey (1998), I attempted to create a balance between being moderator and directing them. Paying attention to the time constraint in the interview session and consequence of missing students' ideas, I directed them to the issues, but I was also cautious not to lead them to specific response (ibid).

I made the interview questions common for all interview groups. However, based on the classroom observation there was variation in the probes of interviews of the different groups. There were also differences in the follow-up questions that arose based on students' responses (cf. Kvale & Brinkmann, 2009). Kvale and Brinkmann explain the importance of paying attention to the impact of the types of questions on the participants' responses. To this end, in my presentation of the main study in Chapter 7, I included the interview questions, which contributed to the data generation.

During the interview, I was conscious of the effect that my role as an interviewer would have on what the students can tell. I paid attention to acquiring students' trust and created a relaxed situation in order to obtain strong data (e.g. Miles & Huberman, 1994). To this end, I started the interview after repeated encounters with the students in order to get used to each other. My first encounter with them was when the teacher introduced me to the class; then I had the classroom observation, before we met to book an appointment for the interviews. I started the interview by describing my history as a student with the intention of laying a shared ground of experience and mutual understanding. I also explained to the students that I was once again a student, and that the conversation would be a student-to-student exchange. I made the interview as flexible as possible depending on the situation; in particular, I followed the students' situations to avoid feeling stressed.

Moreover, the grouping of interviewees from the same class created an atmosphere of ease for them to tell their stories. The interview hardly involves issues that the student may tend to conceal from their peers. The presence of peers rather could enhance obtaining trustworthy data since these students share many of the school experiences such that one student's utterance reminds the others. The interviews were undertaken in their own school. In order to create a better mutual understanding, we spoke in Amharic. The interviews were video recorded to observe any students' gestures and other physical expressions that might be relevant to the study and strengthen the data. Following Miles and Huberman, in these various ways, I attempted to maintain the quality of the data. In securing genuine information and quality data, I avoided asking sensitive and private questions (see section 4.6).

The pilot study confirmed that, with respect to the purpose of the study, the selected method is effective, though with some limitations (see section 4.5). I attempted to find out if some of the results, which were obtained from specific interview groups during the pilot study could be obtained in other groups during the main study. This is in accordance with Miles and Huberman (1994). To this end, I attempted to have diverse interview groups. For example, during the main study, I informed the teachers to include student-groups with predominantly Muslim and rural backgrounds. In addition, I included interview questions, which could encourage the participants to remember their school and out-of-school practices. For example, I asked them to mention the out-of-school activities, to which they have access, the involved artefacts, the rules, their role and other peoples' roles, etc., with the intention of directing their attention to those particular issues (and not leading them to particular responses). I asked them if they find any mathematics in those activities. The intention was to expose supporting and countervailing evidence about the results obtained in the pilot study (Miles & Huberman, 1994). After attempting to amend pitfalls, there were still other pitfalls, which need extended time (see section 9.4.2).

I undertook classroom observations. I video-recorded the mathematics classrooms, once in each of the four classes, from which the interviewees were selected. I did the recording by standing at one corner of the class in front of the students. The recording did not target the particular students who participated in the interviews. The purposes of the classroom observations are to get some ideas to probe students during the interviews and to understand features of the mathematics classroom.

The mathematics teachers facilitated the classroom observations and the interviews. After we met when the department head introduced me to the teachers, I booked appointment with each teacher for the classroom observations. I also met them when they informed me their list of six students each, who they selected for the interview. The teachers gave a brief description of the selected students, then, introduced me to them. I met the teachers at the mathematics department for the classroom observations. Then, walking to and from the classes together with each teacher gave opportunity to talk to each other. We also had conversations when we met in other occasions at the department and in the schools' cafeteria.

I kept field notes. Particularly, I kept records of my conversations with the mathematics teachers. As does the classroom observation, the conversations with the teachers itself generated data. Though these data are scanty, I used these sources as alternatives. Denzin and Lincoln (2000) and Yin (2009) suggest that the use of diverse data sources would give a better picture of the situation and strengthens the results obtained.

The focus of this section is the method of data collection specifically, the interviews, and my role in the data collection. I also presented the role of the classroom observation and conversations with teachers in facilitating the interviews. The use of the scanty data generated from the classroom observations and conversations together with the method of analysis of the interview data is the subject of the next section. The limitations of the method used are exposed in section 4.5.

4.3.3.3 The method of qualitative data analysis

The focus of this section is the method of analysis of the interview data, in which I mostly followed advice from Miles and Huberman (1994). I also used ideas from Kvale (1996) and others. I set out the method starting with the data reduction up to establishing characterisations and categories of perceptions of relevance.

Following Miles and Huberman (1994), I made data reduction through listening to the video-recorded interviews. This was done to simplify the data and obtain focus by deciding on which pieces of data provided the best idea of what each participant is saying (ibid). The data reduction is influenced by the research questions (ibid); it is done with respect to exposing the students’ perceptions of the relevance of mathematics. For each of the group interviews, I made a table indicating the time and a description of the content of what the interviewer and interviewees said. Then, I listened to the interviews again and undertook transcription. In both the data reduction and the data transcription, listening to the interview was followed by translation from Amharic into English.

Despite my attempts to avoid generating data, which have no relevance to my study, there were portion of such data. For example, students told stories about their individual lives unrelated to mathematics learning. Sometimes, I had to wait without interrupting when I felt uncertain and hoped that the student has some related point to make. Such data, which hardly bears any relation to the study, were not included in the transcription. Instead of transcribing the entire data, I followed Kvale (1996) and focused on my purpose. I transcribed the utterances of students that possibly exposed their perceptions of the relevance of mathematics and related issues.

Then, I made further data reduction from the written transcripts; particularly, I undertook coding (cf. Miles & Huberman, 1994). Miles and Huberman (1994) explain that coding of the written transcripts can be undertaken based on the research questions and it can employ concepts that originate from a certain theoretical perspective. In addition to the research questions and the theoretical framework, the choice of codes is also influenced by the literature review. In my study, I adopted the components of the activity systems, namely, community, rules, division of labour, and artefacts from the theoretical framework and used them in coding. The research questions bear terms such as future, other school subjects, etc., and they are used for coding.

Consistent with Miles and Huberman (1994), I attempted to assign labels (codes) as “units of meaning” to pieces of data using words or expressions that accurately describe the specific pieces of data in such a way that people can understand and would likely share its meaning (Miles & Huberman, 1994, p. 56). I included the codes together with the excerpts in the data presentation and analysis in Chapter 7 so that the reader can see my interpretations of the data (see section 7.4).

The excerpts reported in the data presentation and analysis are students’ responses to the interview questions about the relevance of mathematics. The interview questions are listed in Appendix 4. They are also available in the respective sub-categories (see section 7.4). The transcripts from the interviews are understood as students' expressions of the relevance of mathematics. For example, when students responded to the interview question about mathematics’ relevance to other school subjects, they expressed the relevance in various ways. They expressed the relevance as follows: mathematics is useful in other school subjects; students have shared attitude towards mathematics and other school subjects, etc. These are coded, accordingly, as "expressing mathematics' usefulness in other school subjects," etc.

I moved back and forth between the data segments and the tentative meaning I obtained, and made further refinements of the meaning, as suggested by Miles and Huberman (1994). During this process, there were situations, where I undertook recoding. For example, the data segments, which I coded as "expressing mathematics' use in everyday life," were diverse in the sense that the actions/interactions mentioned in the data segments were situated in various activity systems. I gave the following new code names: "expressing mathematics' use in the activities in the society," and "expressing mathematics' use in leisure time activities." I also created two separate codes for mathematics and preparatory mathematics, resulting in four groups of data segments. However, at a later stage of the analysis, those four groups formed the same theme.

After coding was completed, the next step was examining the coded text to obtain themes (e.g. Miles & Huberman, 1994). I followed Miles and Huberman and attempted to do two things. I attempted to relate the coded data segments to the research questions. I also attempted to identify topics, which recur. I grouped the data segments with the same recurring topic into a particular theme. I did the same for those data segments, which relate to a particular research question.

During the analysis, I travelled through the various steps of data analysis to obtain better meaning and strengthen the themes. I often went back to the data transcription and video-recorded interviews. This is followed by attempts to check if the identified themes made sense (e.g. Miles & Huberman, 1994). To this end, I also sent the initial analysis to experienced researchers, and discussed the plausibility of the themes and meanings. Some changes were also made. For example, the segments of data, which were taken from students' stories about inventive use of mathematics in their spiritual lives, were first coded as "using mathematics in spiritual life." However, it made little sense because the segments of data were not about the usual use of mathematics, and experienced researchers suggested, "fresh perspective on life." Then, I re-examined those data to make sense out of them with respect to my research question and the coding. Then, the data segments were recoded as, "expressing mathematics as providing a fresh perspective on life."

I checked if I could find the same themes in the various categories of students. I also made comparisons of the themes across the categories of students. These are consistent with Miles and Huberman (1994). I paid attention to the significance of the differences in terms of the practical importance (ibid). For example, when I examined the differences between the social science and natural science students; or the female and male students, I consider the practical importance of those differences in the teaching of mathematics, or in research in mathematics education (see also Chapters 6, 8 and 9). I attempted to find out why these differences occur and I explored other differences associated with them (e.g. Miles & Huberman, 1994). Particularly, I examined if there are other differences across these categories, which are associated with (or can justify) these differences including differences with respect to the artefacts, the division of labour, the rules, the objects and the community.

I used the themes to establish characterisations of students' perceptions of relevance. Following Miles and Huberman (1994), I further attempted to understand the data segments that formed the particular themes as specific examples of some generality; particularly, as instances of some characterisations of students' perceptions of relevance. For example, the characterisation of students' perceptions of relevance, "mathematics is relevant because it is useful in everyday life" is understood as a generality of the four groups of data segments, which formed the above-mentioned theme. The other characterisations of students' perceptions of relevance were also obtained likewise.

Following Miles and Huberman (1994), I further examined the characterisations of students' perceptions of relevance to find out what underlies in common to a group of these characterisations. I compared, and looked for patterns of relationships among the characterisations. Then, I grouped the characterisations into bigger categories. For example, the characterisation of perception of relevance, "mathematics is relevant because it is useful in everyday life" and other two characterisations are understood as describing "perceptions of relevance relating to out-of-school experiences." As a result, the characterisations of students' perceptions of relevance are presented under major categories.

Figure 4.1 displays the development from coded data segments to the categories of perceptions of relevance. The figure depicts the process as linear and one directional. This is for the sake of simplicity. During the analysis, I often moved back and forth between the coded data segments and the other components. As I mentioned earlier in this section, I even went further back to the video-recorded interviews.

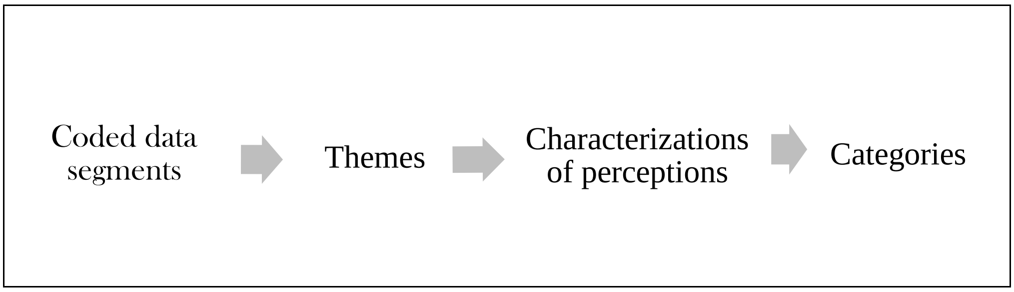


Figure 4.1: The stages of development from coded data segments to categories

I examined relationships of perceptions of relevance with other constructs. There are data segments, which expose students' beliefs, attitudes and emotions. For example, there are data segments, which are coded as "expressing proposition about learning of mathematics" (e.g. Op't Eynde et al., 2002) and "expressing proposition about what counts as mathematics" (e.g. Presmeg, 2002). These expose beliefs. The data segments, which are coded as "expressing emotional disposition," expose attitudes, and those data segments, which are coded as "expressing feelings", expose emotions, in accordance with McLeod (1992). Consistent with Mellin-Olsen (1987) the data segments, which are coded as "expressing the logic for learning mathematics", expose rationale.

There are data segments, which contained evidence of motivation. Following Roth (2007) and Hannula (2006) data segments, which are coded as "expressing comparative inclination," are understood as exposing motivation. I examined the relationships between the diverse characterisations of perceptions of relevance and motivation. I examined for possible ways of relationships including direct or indirect relationships (Miles & Huberman, 1994). I also explored if there is a third intervening variable (ibid). Some of the intervening variables are mediational factors.

I attempted to find out if emotion might have caused motivation (Roth, 2007). In particular, I attempt to find out if students' motivation arises from the difference between the emotional valences (ibid). Following Roth, I understand emotional valence as the students' expectation that accomplishing an action can offer an emotional payoff upon completion. Those data segments, which are coded as "expressing emotional reward or expectations of it" expose emotional valence.

The data segments exposing the constructs attitude, belief, emotion, motivation, and rationale are presented together with those exposing perceptions of relevance because students normally narrated them together. The characterisations of perceptions of relevance and these constructs are presented under sub-categories, which are named after the respective characterisations of perceptions of relevance.

Following Kvale (1996), the analysis took into account my role as an interviewer in the production of the data, and the role of interview questions during the interview in shaping students' responses. Unlike the prepared questions, which are uniform across interview groups (see Appendix 4), the probes varied based on the interview situations such as issues raised by the students, and the respective classroom observations. In such occasions, I attempted to show in the data presentation the context in which the particular data segment is generated. In the data analysis, I have a role in interpreting participants' words and naming the objects as such. My understanding of the interview data influenced the analysis.

Consistent with Miles and Huberman, I paid attention to representativeness. I included nearly all possible categories of the student population in the school. I addressed this issue better during the main study by including interview groups with predominantly students of rural backgrounds and Muslim backgrounds. I also paid attention, in my analysis, to cases, which might not agree with the rest of the data or the rest of the informants both within interview groups and across interview groups (cf. Miles & Huberman, 1994). Miles and Huberman stress the importance of paying attention to contrasting views and contrasting experiences.

The analysis takes into account the use of alternative data sources (e.g. Denzin & Lincoln, 2000, Yin, 2009). In particular, I used data from the textbook. I also used the data, which the classroom observation generated. I undertook the data reduction of the classroom observation, before the interviews to focus the discussion during the interviews. Moreover, I transcribed the data from the classroom observation, which I found to be useful to support the analysis of the interviews. On very few occasions, I used teachers' comments. However, these sources were not used as main data sources (see section 7.3.3).

In an attempt to challenge my tentative conclusions, I took a number of steps, which are suggested by Miles and Huberman. I attempted to follow up surprises. Then, I attempted to reflect, revise my conjecture and find supportive evidence for the revised conjecture (ibid). I also examined outliers and attempted to find out their meanings such as the cases of some particular students' assertions based on the students' backgrounds, which distinguishes them from the rest of the participants. I examined extreme cases. I also re-examined the excerpts of students' stories to find out if they really illustrate the particular characterisation of perception of relevance. These steps are used to interpret the results (see Chapter 8).

I replicated the findings of the pilot study in the same school within an interval of one year using the same instruments with different data sources (e.g. Miles & Huberman, 1994). Following Kvale (1996), I also attempted to get feedback from the students about my interpretation of their words, on the spot, where I sometimes asked if we mean the same thing. Miles and Huberman suggest obtaining feedback from potential users. To this end, I presented the preliminary result to the mathematics teachers of the school before the main study. The teachers were critical of the absence of data about learning mathematics through the plasma. I paid attention to the teachers' comments. As a result, though I did not ask the students to tell me about the plasma, I rather avoided interfering when their story shifts to it. Such data are useful in describing the context of their learning (see section 7.3).

Though the data collection and analysis were undertaken all by myself, I took suggestion from experienced researchers and the school members about the data collection. For example, I sent it to and got feedback from experienced researchers. I am aware that this is not the same as coding by different people. However, it reduces my dominating influence on my study (e.g. Miles & Huberman, 1994). I also received feedback and suggestions from reviewers of my conference papers written based on data from the current study, and participants of the conferences. I analysed the qualitative data further using the analytic framework (see Chapter 2). The next section sets out this issue.

4.3.3.4 Further analysis using the analytic framework

The data were further analysed by using Engeström's model. In this section, I attempt to expose how I employ the model in the analysis. I start with exposing the activity systems and their components.

Students' exposition of their participation and roles in communities, which are governed by rules and have collective motive, which is realized through undertaking sequence of mediated and goal-directed actions, is understood as an activity (Roth et al., 2004). The groups to which the students belong such as their grade level, their stream, their family, peer group are coded as community. The subject represents the actors in the activity, particularly, the student. The object of the schooling activity consists of the entities on which the students act, which includes the school subjects, the goals of learning of these subjects, and the motive. The students are normally seen as the subject, but they can also be seen as part of the community. There are also cases where students explain themselves as receivers of the teacher's or other people's actions. Thus, consistent with Roth et al. (2004), the students can be not only the subject and part of the community but also are in the object of the activity systems. In the school activity system, the rules include coverage of particular contents, the examinations, doing homework and other school-related issues that are mandatory for the student. In the family-life activity, listening and obedience to elder siblings are part of the rule.

Following Roth et al. (2004), the various roles and responsibilities that the members of the community have while interacting with the object are understood as the division of labour. These are coded from the transcript of the interview data. I exposed the roles of students and teachers from the classroom observation. I also exposed some mediating artefacts such as mathematics lessons and the textbook from my classroom observations.

In some cases, the components of the activity systems such as community are obtained from the teachers. I also used the data from the textbook for similar purposes. In particular, I used the textbook in supporting my analysis such as in exposing mathematics' relation with other school subjects as parts of the object of the schooling activity. I used it in supporting my exposition of the relationship of mathematics (part of the object) with the community of the schooling activity (i.e., natural science and social science streams). The mediational role of the textbook is also suggested since it is the source of the lesson.

It is set out in Chapter 2 that there is mediated interaction between subject, object and community. The mediational factors can be captured from students' words when stated explicitly or implicitly. For example, when students state that they do not see the application of mathematics, I understand that the mathematics lessons are being implied as hardly containing the application of mathematics. The lessons are being referred as mediating artefacts, which are assisting students to form their perceptions of the relevance of mathematics. The mediational factor can also be the means, by which the students interact with the community. The rule can be another mediational factor (Kuutti, 1996).

The mediational factor can also be the means by which students, as members of the community, interact with the object. In this case, the mediational factor can be the division of labour. When perception of relevance emerges in the interaction between object and community, the division of labour, rules and artefacts mediate it. For example, in the peer group (which is their community), students engage in mathematics and each student has a role in accordance with the division of labour, one might offer help and the other receives it. There are cases where social science students tell stories of their interactions while engaging in mathematics and the teacher provides them with information or advice pertaining to their stream. The division of labour is such that students are receivers of advice while the teacher provides it. Students' perceptions of relevance emerges in these interactions. Motivation also emerges in similar interactions. Explicit or implicit reference is made in the student's statement about the division of labour in various contexts. Similarly, the artefacts and rules mediate perceptions of relevance and motivation.

Contradictions are also exposed from the data. Any sense of challenge, conflict, struggle, inconsistency, or incompatibility articulated by the students is understood as experiencing tensions/ contradictions. This is consistent with Roth’s exposition of contradictions (Roth et al., 2004). Unlike Roth and colleagues, who primarily used their observations, I rely on the students’ stories to identify the contradictions. Their focus is on both the change in the activity system and the change on the participants, as participants experience contradictions. In the current study, the focus is on students’ experiencing of tensions/ contradictions and the possible effect on the students' perceptions of relevance and motivations.

In my analysis, after exploring and exposing the perceptions of relevance and the associated motivation, I attempt to find out what could have contributed to their emergence, and if tensions/ contradictions can be the basis for their emergence. In understanding students' perceptions of relevance, I attempted to expose the tensions/ contradictions that the students experience in their participations in the activities such as schooling and family life. There could be tension/ contradiction between the objects of the schooling and family-life activities as well as between the language used in school (English) and the language used in the family (Amharic).

The various components of the method of analysis, which I attempted to set out in this section and in the previous section, are utilised in different parts of this dissertation. In the data presentation of Chapter 7, the activities and their components are included in the coding. As set out in Chapters 2, the analytic framework is utilised in Chapters 7 and 8. This is exposed in the introductions of the respective chapters or sections. Dimensions and their properties are used in the data presentation (see sections 7.4.2 and 7.4.3). Their descriptions are available in section 7.4.1. The constructs, which are associated with the characterisations of perceptions of relevance, are also presented as dimensions of the subcategories. A small number of students participated in the qualitative part of the study. I needed a larger sample size to learn about the proportions of positive responses to the characterisations. I used a questionnaire for this purpose. These issues are the focuses of the next section.

4.3.4 Quantitative research methodology

In this section, the quantitative research methods and the rationale for the choice of methods are presented. The subsections of this section, in order of presentation, are the following: the questionnaire; sampling; administration of questionnaire; methods of quantitative data analysis.

4.3.4.1 The questionnaire

The questionnaire is the instrument for collecting quantitative data. In this section, a description of this instrument is provided. A description of how this instrument was developed and the rationales for the actions undertaken in the development of the questionnaire are set out.

The questionnaire is designed based on the results of the pilot study. The analysis of the pilot study resulted in themes that emerged as key statements reflecting the characterisations of students' perceptions of relevance. The students explained the relevance of mathematics, which they expressed as they saw it being used by others or being used in certain situations. They also expressed as they used it themselves. As a result, separate items were set in the questionnaire: 'I see' and 'I use'. Distinct items are also set for 'mathematics' and 'preparatory mathematics'. This distinction is drawn because students expressed perceptions of the relevance of 'mathematics' as distinct from 'preparatory mathematics'. These themed questions were gathered together in groups of four. There are artefacts, and other people, which appear to mediate the formation of the students' perceptions of relevance. There are statements about the mediators, which appeared as questionnaire items.

The questionnaire contains 29 items. There are 28 items constructed for respondents to provide Likert scale type responses. There is one more item, which is a follow up question to one of the items and it is about the students' sources of information about mathematics' use in future study. This item requests students to respond by selecting from the list of possible sources. Each of the 28 items is followed by an open question. The intention of the open questions are to generate data, which can be used to relate to the response to the corresponding questionnaire item in order to undertake a deeper analysis, and to check whether students understood the items. The items and the follow up open questions, together with the questions about students' backgrounds, comprise the questionnaire in full. The questions about students' backgrounds includes information about first language and place of birth. They are also requested to provide information about their religion as well as their mothers' and their fathers' levels of education.

The open questions, which correspond to the questionnaire items, ask students mainly to provide short explanations and examples corresponding to their responses to the questionnaire item. There are some other open questions. For example, the open questions about other school subjects ask students to list the school subjects, which use mathematics and preparatory mathematics. The open questions, which correspond to the questionnaire items, are available in Appendix 3 (see Table 11.4). As can be seen in Table 11.4, the open questions for some of the questionnaire items are the same. However, due to differences in the questionnaire items, the answers to the open questions could be different.

I paid attention to the students' understanding of the questionnaire items, and to the fact that their understanding of the questionnaire items may not be consistent with the meaning, which the item conveys (e.g. Bryman, 2008). To this end, I undertook a number of steps. The questionnaire items were translated into Amharic at the suggestion of the teachers. I consulted the teachers to see if it were possible for the students to read and understand the questionnaire and then respond appropriately in English. The teachers I consulted were sceptical about obtaining reliable responses using English language. The teachers I consulted were biology, English, and history teachers because the mathematics teachers referred me to those teachers as the subjects involve the most reading and writing both in classroom tasks and in examinations.

I sent the English copy of the questionnaire to experienced researchers and obtained feedback. The questionnaire was pilot-tested for clarity and comprehensibility. I first gave both the Amharic and English versions of the questionnaire to two language teachers and two mathematics teachers to test clarity, and asked them how they interpret the items. I asked them to read, reflect, and offer suggestions for possible changes. This feedback was used to rephrase items so that the students would understand them. Then, I distributed the questionnaire to 24 students from the eleventh- and twelfth-grade, natural and social science streams, among male and female students of various levels of achievement. Later, I conducted two group discussions with 12 students, six in each group. The pilot testing was also intended to check the time required to complete the questionnaire, and the adequacy of the space given for responses to the open questions.

The pilot testing of the questionnaire also provided an unexpected benefit. During the pilot testing, some of the students took the questionnaire home and did not do it well. There were two students who gave me back unfinished questionnaires. When I showed them, they took it back and completed it on the spot. Those students who at least started it in my presence did it well, and gave the questionnaire back. On the other hand, some did not give the questionnaire back at all. Among the five students who took the questionnaire home without starting it in my presence, only two returned it back to me.

As a result of the pilot testing, I arranged the items so that the students could see the differences between items, which appeared similar but were actually different. From the pilot test, I did not observe a problem in understanding the items; it was more a matter of paying attention to the differences. For this reason, the final version of the questionnaire grouped questions on the same theme so that the nuances between the questions on the theme would be more striking. I understand that this can be an issue of concern. However, based the feedback of the pilot testing of the questionnaire, I believed that if these questions were put separately from each other, students would not tell the differences or students may consider them as repetitions.

Another issue of concern is that all the questions followed the same format and there were no inverse questions to check consistency of responses. However, as I mentioned above, there were follow up open questions for each of the items. I did not want to have more items, as the students were very conscious of their time during the period of the data collection. A third concern is that the questionnaire was constructed without any attention to earlier instruments in the area. I considered the construction of the questionnaire as an opportunity of learning and I wanted to construct my own, instead of adopting the existing.

Based on the experience in the pilot testing of the questionnaire, I also asked the students to complete the questionnaire in my presence. In cases where students were unable to complete it in my presence, I asked the students to start it in my presence and complete it at home.

In this section, I provided a description of the questionnaire and its development as an instrument for collecting quantitative data. I also provided the rationales for the steps taken in the development of the questionnaire. I provided the rationales for adopting the quantitative method to collect data earlier (see section 4.3.2).

4.3.4.2 Sampling

The categories gender, stream, grade level and level of achievement are used for sampling. The students' gender is already in the students' list, which I obtained from the school. The department head informed me about the classes of each stream and each grade level. The mathematics teachers helped me in deciding the students' level of achievement based on students' scores on a standardized midterm examination. Following Bryman (2008), I attempt to ensure that the sample has a similar distribution as the student population of the school in terms of the categories used for sampling. The sample size is 354 (189 female and 165 male). However, 335 completed and submitted the questionnaires (185 female and 160 male). Table 4.1 presents the number of students in each of the categories of gender, grade level and stream.

As set out in Chapter 1, the school has 1481 students in eleventh grade, 819 female and 662 male (see Table 1.4). Among the 819 female students, 209 are in social science and 610 are in natural science streams. Among the 662 male students, 154 are in the social science and 508 in the natural science streams. There are 1487 students in twelfth grade, 786 female and 700 male. Among the 787 female students, 276 are in social science and 511 in natural science streams. Among the 700 male students, 168 are in social science and 532 are in natural science streams.

There are 27 classes in eleventh grade, 7 in the social science and 20 in the natural science stream. Thus, I picked 120 students from natural science and 42 students from social science. There are 31 classes in twelfth grade, with 10 in the social science and 21 in the natural science.

If I took the class as a sampling frame, it might lead to a sample bias as students from twelfth and eleventh-grade are more or less the same in number (1481 to 1487), but twelfth-grade are grouped in more classes than eleventh (31 to 27). Thus, I chose the classes taught by the same teacher to form one sampling frame. Accordingly, I chose two sampling frames of 211 and 152 students for eleventh-grade social science and six sampling frames for natural science (167, 224, 167,170, 166, and 224 in terms of size). There are six sampling frames for twelfth-grade natural science, with sizes 144,194, 197, 198, 200, and 87. I chose three sampling frames for twelfth-grade social science, with sizes of 100, 180, and 178.

Table 4.1: Number of students participated in the completion of the questionnaire

Streams	Eleventh Grade			Twelfth Grade			Grand Total
	Female	Male	Subtotal	Female	Male	Subtotal	
Social	22	17	39	33	18	51	90
Natural	72	57	129	58	58	116	245
Total	94	74	168	91	76	167	335

The sample size comprises of 12% of the population in each sampling frame. Accordingly, 177 students were selected from eleventh grade. 24 female and 18 male students were selected from social science. 72 female and 63 male students were selected from natural science. 177 students were selected from twelfth grade: 33 female and 18 male from social science, and 60 female and 66 male from natural science.

To select participants from each category of students in each sampling frame, I used students' roll number and class. I wrote every students' roll number and the respective class on pieces of paper. For example, #3, 11_21_F_H designates a high achieving female student from grade 11 and class 21 whose roll number is 3. Then, I drew the pieces of paper randomly. I repeated the drawing of the pieces of paper as many times as the number of students, which I decided to have in one sampling frame. This was done for every sampling frame. The questionnaires were labelled as 1, 2, and 3, for high, medium and low achievers, respectively. The students are informed to write their grade level, stream and gender in the questionnaire. The number of students in each of the categories used for sampling including the levels of achievement are available in Chapter 6.

4.3.4.3 Administration of questionnaire

I used different opportunities to administer the questionnaires. I used periods when students had free time in the classroom and when teachers are absent. I called students to come to the auditorium after class time (class ends at 2:45 pm.), and during their break, which lasts for one hour.

As a result, of pilot testing of the questionnaire, which I set out in section 4.3.3.1, I understood that orientation was required. During the orientation, I insisted on willingness to participate. I also emphasised the distinction of items, which appeared similar but were actually different. I insisted that participants should pay attention to the differences such as 'mathematics' and 'preparatory mathematics' and 'I see' and 'I use'. After the orientation, the students carried out completion of the questionnaire mostly in my presence. There were some, who could not finish on the spot, and were allowed to take it home and bring it in the next day.

There were some problems during the administration of the questionnaire. One problem was lack of clarity in some of the copies of the questionnaire, like missing letters, which occurred when questionnaires were duplicated using a photocopy machine. In some cases, I decided to let the students have the clear copies to double-check, as the problems were minor to correct. Another problem was in connection with the label of questionnaires. They were labelled as one, two, and three, for high, medium and low achievers, respectively. However, there were cases where I was forced to change the labels due to a shortage of questionnaires.

There was also problem of participation, as some students declined to participate in completing it, and in such cases, I selected other students. Some dropped out after they started; others declined to bring back the questionnaires. There were also situations where I identified problems with the completed ones. In all these cases, I attempted to repeat the random sampling. Nineteen students did not return the questionnaires. There were situations where I identified problems with the completion of the questionnaire after the data collection was over, and I discarded such questionnaires. In all I analysed the data I obtained from 332 questionnaires.

4.3.4.4 Methods of quantitative data analysis

In this section, I describe the quantitative method, which I used to analyse the data arising from the questionnaire. I set out earlier that 335 questionnaires were obtained. Before I started the analysis, I examined the questionnaires to make sure that appropriate data are obtained. Three of these questionnaires were spoiled; the students did not mark ten or more items. Then, I discarded these questionnaires. In addition, some students put marks on more than one boxes. In particular, they mark both "agree" and "strongly agree" or "disagree" and "strongly disagree." In such cases, I decided to take the choice, which is closer to the centre.

According to the purpose of the quantitative data, I made the analysis using bar graphs. I used bar graphs to illustrate the proportions of the students' responses to the items of the questionnaire. This method of analysis is described below. The questionnaire also contains questions, which explore students' backgrounds. I also used bar graphs to describe students' backgrounds including religion and parents' level of education.

Bar graphs are useful tools for exploring proportions of students' responses to the items in the questionnaire. The reason is that they accurately depict the number of students who responded positively to the items both in figure and in picture. They do the same for those who responded negatively and those who are undecided. The students in this study might perceive the relevance of mathematics in different ways as explained by the items in the questionnaire. It is important in this study to identify how widely the perceptions of relevance are held by the students. The proportion of students who responded to an item positively shows how widely the respective perception of relevance is held. I used bar graphs in order to examine proportions of positive responses. The bar graphs were made for each of the twenty-nine items.

As mentioned earlier in this chapter, I constructed the questionnaire based on the pilot study, which answered the research questions I posed. Looking at the items in the questionnaire and based on the research questions, I made categories of the items. I used these categories of perceptions of relevance for reporting the proportions of positive responses in Chapter 6, which sets out the details of the analysis. In chapter 6, I also report students' backgrounds using percentages. In Chapter 9, I provide reflections and suggestions about the questionnaire.

4.4 Authenticity and trustworthiness

There are issues of concern in the evaluation of the results in this study. In the first place, it is situated in an interpretivist paradigm. So, the results and the methods used in attaining these results are evaluated based on their authenticity and trustworthiness because the interest is on participants' meanings (e.g. Lincoln & Guba, 2000). In this section, I present what I did in order to ensure authenticity and trustworthiness of the research. I also present what the study lacks, which might affect the authenticity and trustworthiness of the study.

Consistent with Lincoln and Guba (2000) the study is authentic, in the sense that I attempted to give opportunity to the various categories of the student population of the school. The different categories of the student population (across levels of achievement, gender, grade level and stream) were considered for sampling. Following Miles and Huberman (1994), I attempted to obtain data that produced a particular theme in a particular category, in all categories of the student population.

I attempted to ensure authenticity through enhancing the students' awareness about the issue so that they value the importance of the information they provide. I provided all the information they should know about the study in various situations: when I asked them for their consent for classroom observation, and I met the students for the interviews. When I visited the classes for the first time, I attempted to convince them that their contribution is significant in making input to the study and in making possible changes in the mathematics curriculum. The interview setting was arranged in such a way that it gave an opportunity to understand participants better (Lincoln & Guba, 2000), particularly, by letting them know my history and encouraging them to tell theirs. Because of the situation within which the data were generated, the statements of perceptions of relevance are authentic (see section 4.3.3).

Following Miles and Huberman (1994), I used various tactics to interpret my data and verify my interpretations (see sections 4.3.3.3 and 4.3.3.4). For example, I looked for contradicting evidence in my data and examined it carefully to challenge my tentative interpretation. Consistent with Miles and Huberman, I also attempted to produce alternative explanations, which could be rival to my first interpretation. In doing so, I attempted to establish trustworthiness of findings because the tactics give the possibility of exploring meanings in depth (e.g. Denzin & Lincoln, 2000; Miles & Huberman, 1994). This gave the opportunity to deepen the analysis and refine the results (ibid). The evidence from other data sources such as textbook, classroom observation and the teacher supported the interview data and enhanced the results' strength.

In order to ensure trustworthiness, I also presented the results of the pilot study to and obtained feedback from teachers of the same school. The teachers did not express any disagreement to my interpretations of the data. They rather suggested an additional possible source of influence (mediator) on students' perceptions of relevance. In addition, the instruments I used were tested in the pilot study and the possible pitfalls were amended. The setting was also pilot studied. Repeating the interview after a year gave more or less the same result. These situations contributed to the confidence about the trustworthiness of the results.

I attempted to minimize chances of bias (e.g. Miles & Huberman, 1994). I employed the verification tactics to ensure that the results of the study are not influenced by my own biases (see section 4.3.3.3). In particular, I challenged my interpretations (e.g. Miles & Huberman, 1994). This was usually done at the coding stage; at the stage where I was identifying themes from the coded data and while establishing the characterisations of students' perceptions of relevance. I explained the details of the coding process, including when re-coding was made (see section 4.3.3.3). The tactics used to interpret the data and to verify interpretations are further employed even after establishing the characterisations of students' perceptions of relevance (see Chapter 8).

In section 4.3.3.3, I set out that I did the coding all by myself, and I did not use any software for coding nor for any other purpose in my analysis of the interview data. I acknowledged weaknesses (see sections 7.2 and 7.6). I also provided further reflections in Chapter 9. I set out earlier that interpretations of the data are based on my understanding, but I received feedback from experienced researchers as well as from audiences of my presentations at conferences and to the teachers of the school. The analytic framework I adopted also influenced my interpretation. Consistent with Stake (1995), I attempted to allow the reader see the accuracy of my interpretations with respect to the data by presenting my interpretation together with the data. Moreover, other people can reanalyse the data since it is available at the University of Agder.

I attempted to ensure trustworthiness in the research process and findings (Bryman, 2008; Guba & Lincoln, 1994). Consistent with Guba and Lincoln (1994) I articulated the research questions clearly, and described the steps and process of the research. I undertook the data collection with respect to the research questions. In particular, I derived the interview questions from the research questions. My use of the classroom observation for probing during the interview was also in accordance with the research questions. During the interviews, I mentioned the topic of the lesson and used it to illustrate my questions about relevance.

I also paid attention to ensuring reliability. I attempted to ensure that the students could understand the questions, and I made the medium of communication in the local language. As set out earlier the students are preparing for university study after being screened by a national examination, they also sit for another national examination within the intervening two years. Based on this background, I believe that these students can understand my questions and they are knowledgeable enough to articulate what relevance mathematics has to them. The participants were selected and accessed through their mathematics teachers, who (according to the department head) had better knowledge of the students, particularly, about their academic standing.

I have provided the details of sampling procedure and the methods used to collect and analyse the data (see section 4.3.3). I attempted to describe the methods in ordinary language that can be understood by the readers (e.g. Stake, 1995). Using the same research process is likely to provide the similar result with careful attention to the peculiar nature of the sociocultural setting and its dynamics, which might cause differences in the data generated.

The other instrument of data collection was the questionnaire. As in the interviews, I attempted to ensure authenticity with respect to the results obtained from data I collected using questionnaire. Participants were selected from various categories of the student population of the school. I provided the information they should know about the study before I distributed the questionnaires. Similarly, I attempted to ensure trustworthiness. In the questionnaire, students are asked to confirm or reject statements, which are articulated based on the interview data collected from their fellow students. The questionnaire items were validated by the school's language teachers (both Amharic and English). I sent the English version of the questionnaire to experienced researchers, and got feedback. Moreover, the questionnaire items were pilot tested mainly, for clarity of the items. The possible pitfalls were amended, particularly, with respect to better articulation. Some of the items of questionnaire still have limitations (see section 9.4.3).

As in the interviews, I described the steps and process of the research pertaining the questionnaire clearly. I derived the questionnaire items from the interview results, which in turn are derived from the research questions. The questionnaire items are written in the local language so that the students can understand the questions. As set out earlier, based on the students' backgrounds, I believe that these students are knowledgeable enough to provide accurate information. I provided the details of the methods in section 4.3.4.

In general, the results of this study are generalizable to the school population because the participants are selected from the various sections of the school population (e.g. Miles & Huberman, 1994). Moreover, as set out earlier, repeating the study in one-year interval gave nearly the same result. The generalizability to the school population is also due to the generation of the items of the questionnaire. I designed the questionnaire items from the results of the interviews, for which I selected participants from the various sections of the school population. In the interviews as well as in the analysis, I attempted to obtain results from the various sections of the population. However, this attempt was not always successful. There are some characterisations of perceptions of relevance, for which the data obtained are not from the various sections of the population (see section 7.6).

I believe that in a similar setting, one would obtain a more or less similar result. I attempted to enable the reader determine the transferability of most of the findings and the implications of my study to similar settings. I have provided a methodological rationale that I believe is convincing to ensure the trustworthiness of the findings and the implications (e.g. Miles & Huberman, 1994). I exposed the limitations of the study, which the reader should take into account (see section 4.5). This is particularly important given the design of the study (e.g. Stake, 1995). I adopted a case study design, where I investigated a single case.

The interpretation is made in a certain context and a certain time in history (Miles & Huberman, 1994). I attempted to show how the sociocultural context relates with the students' perceptions of the relevance of mathematics. I attempted to provide descriptions of the context that one could use to decide if my findings can be used in their settings (e.g. Stake, 1995). I followed Stake's (1995) suggestions of including reactions from potential users to help my readers use my findings in other contexts. Using the feedback from teachers of the school and from conference presentations, I included contextual issues and teachers' reactions to the students' accounts (see section 7.3).

In Chapter 1, I included the sociocultural and historical context of the country. I also provided the sociocultural context related to the school and out-of-school experiences of the students (see Chapters 1 and 7). The intention of provision of the context, in which the students' perceptions of relevance takes shape, is to help the reader relate the results of this study to other settings (e.g. Miles & Huberman, 1994). Given that the school I investigated is an urban school, the results of this study are transferable to other urban schools in Ethiopia. Since the schools are mostly public and are nearly the same throughout the country, the results, which are mostly emerging in the schooling activity, are likely to be transferable to rural schools of the country as well. The explanations about transferability of the specific results are provided in Chapter 8.

There is variation in strengths among the results. Those variations in strengths are dealt in Chapter 7 (see section 7.6). It will be set out in the analysis chapters that some results obtained from interviews as well as from the survey were removed based on these evaluations (see sections 6.4 and 7.6). In situations where I am not certain about my interpretations of the data due to some limitations of the data, I used words such as "seems," "appears," "may," etc. as appropriate. Moreover, I provide limitations of the study, which is the subject of the next section.

4.5 Limitations of the study

In this section, I present what this study lacks. I also present what I undertook, which can have consequences. I focus on those issues, which might affect the results of the study.

Belief research is often criticised for the methods it employs (e.g. Skott, 2010). For example, what people tell and their practices might not be consistent (ibid). My research might not be any different. For example, no observations of students' practices were undertaken after the interviews. I undertook observations before the interviews and it did not focus on the particular students who participated in the interviews.

As I set out in section 4.3.1, I used a single case. There are limitations in the results obtained using a single case (Yin, 2009). Though Memiru is very similar to other Ethiopian preparatory schools in many respects (see section 1.5.2), there can be difference depending on the variation in the sociocultural context of the schools in the various regions of the country. Though the students learn mathematics at preparatory schools in English language, at earlier grade levels, they learnt mathematics using local vernaculars, and there are variations in the local vernaculars across the regions of the country. There can also be variation in the resources and artefacts available to the students. For example, the availability of internet in rural schools is unlikely.

The selection of the school can also have consequences on the data obtained. As I mentioned above, Memiru can be considered as being a typical of Ethiopian preparatory schools. However, it is not selected for its typical characteristic. As I set out in section 4.3.3.1, the school is selected based on the convenience for data collection in terms of my earlier relation with the school. The students know that I worked there and that some of the teachers are previous colleagues. This can have influence on what the students can tell about their learning of mathematics, particularly if they think that their story has relation with teachers' practices.

The selection of the students could have problem because they are all selected by the mathematics teachers. However, the teachers' selection is based on the students' level of achievements, which could reduce the teacher's personal biases to some extent. Another concern could be the presentation of the preliminary results of the pilot study to the mathematics teachers of the school before the main study. This might influence the selection of the students, and teachers' classroom practices. However, I did not witness differences in the data obtained for the main study from the pilot study, which might relate to any influence of the teachers' selection of the students.

I understand that extensive observations and triangulation with interview data would give a better result (e.g. Denzin & Lincoln, 2000; Dowling & Brown, 2010).Though I attempted to support the interview data with data from supplementary data sources (e.g. Miles & Huberman, 1994); the use of such additional sources is limited. Few comments from the teachers and few classroom observations were used for enhancing the strength of results. The use of contradicting evidence from supplementary data sources were not always possible. I searched for such evidences within my data and I did not visit the field in search of contradictory evidence (e.g. Miles & Huberman, 1994).

Kvale and Brinkmann (2009) suggest that holding extended interviews would give a better picture of the situation and strengthens the results. The students were not interviewed over an extended period. This puts a limitation on the analysis and results of my study. Another limitation is that I did not attempt to obtain confirmation of my interpretations of the data from participants beyond the interview sessions; I did not ask for clarification of their words when I needed as the analysis progressed.

There are also situations where the characterisation of perception of relevance I identified is adopted from the literature but my method differed. For example, I used Roth's description of identity, which he exposes using both observation of participants' interactions and interviews. My study lacks observation of participants' interaction, and others' views are also mostly limited to the teacher's recognition of the student's level of achievement. I interpreted identities from students' own words, which I obtained in a brief interview situation. Similarly, this lack of extensive interviews and following participants' actions and the classroom practices limited the opportunity to expose the mediational processes and tensions/ contradictions, which has repercussions on the results obtained.

There could be some limitation in terms of the coverage of mathematics topics in the interviews. The data was collected during the second half of the first semester. During the interviews, I sometimes used the lessons I observed during this period. The students also usually picked examples of mathematics concepts that were dealt in the classroom in the same period; I also encouraged them to do so. As a result, the mathematics topics covered in the interviews of both the pilot study and the main study are from this period.

There are also some limitations with respect to the questionnaire. Very few students responded to the open questions following the items. Even those who responded rarely wrote with a clear handwriting, which hindered a deeper analysis and an opportunity to check if they understood the questions. There are other limitations with respect to the questionnaire. Unlike the interviews, the questionnaire does not give opportunity of discussion between the students and me, though the questionnaire items are generated based on the results of the interview data (see section 4.3.4). In particular, it provided limited opportunity to check if they understood what they were asked (see Chapter 6).

Though the study has limitations, the data is still strong in that I obtained it directly from the sources. It exposes students' perceptions of the relevance of mathematics. There is variation in the results obtained, which is based on the data generated. In section 7.2, I provide analysis of the data generated, and in section 7.6, a reflection on the data generated. In Chapter 9, I provide a methodological reflection.

4.6 Ethical considerations

I paid attention to ethical issues through the research process. The video recording of the data collection was conducted only after asking the students for consent to be recorded, which they gave by written consent supported by their signatures. They were also asked to get the signed consent of their parents, because some students are under the age of 18.

Students' privacy was maintained during the interviews. I was very careful not to insist when the discussion involves issues of the students' privacy. Some interviewees might be uncomfortable telling some of their stories. I encouraged them not to tell their stories, which might involve private issues. I also requested the teachers for consents to use our conversations.

I informed students everything that they need to know about myself, about the purpose of the study as well as what happens to the data collected including who will have access to the video-recorded data. The video recordings of the interviews and classroom observations are protected under the privacy rules of data secured for research. They were not exposed to any one, except in cases where needed for research purposes. Except for the purpose of analysis, the students' images and recorded voices are not accessible to any person. Some episodes of the recordings might be used in the reporting of the results from this study. The recordings will be destroyed within five years after the completion of the project. The research was registered with the Norwegian Data Protection authority who approved the collection, storage and use of data.

4.7 Concluding remarks

In this chapter, I attempted to address the issues pertinent to the methodology. The case of Memiru Preparatory School students is not unique. It is rather typical given the descriptions of preparatory schools provided in Chapter 1 and descriptions of the school and out-of-school context I provided in Chapter 7.

The questionnaire, which was designed from the interview results, enabled access to more participants. The number of participants allowed some element of generalization. In particular, by using the questionnaire it was possible to explore how widely the perceptions of relevance were held among students. Consistent with Pring (2004) using mixed approach was advantageous; in particular, the questionnaire supplied more meaning that could be explored further qualitatively.

I provide an analysis of the data at the beginning of Chapter 7, where I expose the kind and amount of data obtained (see section 7.2). I also provide reflections on the data obtained, where I attempt to expose the quality of the data, including the strengths and weaknesses of the data (see section 7.6). In section 7.6, I expose which characterisations are based on relatively strong data and which characterisations are based on relatively weak data. A brief description of the characterisations are provided in the respective categories (see sections 7.4.2 and 7.4.3). In Chapter 8, I provide an explanation about the generalisability and transferability of the results. Chapter 9 provides a methodological reflection; possible considerations for future investigations, and the limitations of some of the questionnaire items.

The next chapters provide the data presentations and analysis. Based on its purpose, the pilot study focused on exploring the context and testing the data collection instrument. As I mentioned in Chapter 2, I avoided the use of the activity theoretic approach and the notion of mediation in Chapter 5. The analysis employing this activity theoretic approach and the notion of mediation is set out in Chapter 7, where some part of the pilot data is also re-examined. In Chapter 8, I provide further interpretations of the results using the theoretical framework.

5 The pilot study: Data presentation and analysis

5.1 Introduction

The pilot study was intended to examine the overall setting, test the methods chosen, and explore and expose students' perceptions of the relevance of mathematics in the Ethiopian social and cultural context. Including this introduction, the chapter has four sections. They are presented in the following order. I start with the analysis of the data. Then, I present the characterisations of perceptions of relevance under three categories. Finally, I provide a conclusion.

5.2 Analysis of the data

The qualitative data in this part of study arises from group interviews. Video-recorded classroom observations are also part of this data. The interview data comprises eight video-records. Table 5.1 sets out the sources of interview data, indicating students' stream, sex, grade level and attainment characteristic.

Table 5.1. Sources and amounts of interview data generated in the pilot study

Focus group (FG)	Stream	Informants (pseudonyms)	Attainment characteristic	Duration of interview
A: Female, eleventh-grade	Social science	Beza Meseret Fanaye	High Medium Low	49 minutes
B: Male, eleventh-grade	Social science	Debesh Fikru Essayas	High Medium Low	49 minutes
C: Female, eleventh-grade	Natural science	Mekia Alewi Alewiya	High Medium Low	24 minutes
D: Male, eleventh-grade	Natural science	Abebe Habtu Ibrahim	High Medium Low	42 minutes
E: Female, twelfth-grade	Social science	Ruth Fantu Azenegash	High Medium Low	33 minutes
F: Male, twelfth-grade	Social science	Yirdaw Erikihun Fisiha	High Medium Low	49 minutes
G: Female, twelfth-grade	Natural science	Hayal Netsanet Makida	High Medium Low	30 minutes
H: Male, twelfth-grade	Natural science	Ahadu Meada Asad	High Medium Low	37 minutes

The table indicates the amount of data in terms of duration of interview. Participants in each focus group are students from the same grade level, stream and are of the same sex. The eight groups are labelled as Groups A to H. The variation in the duration of interviews is mainly due to students' willingness to proceed. Prior to the interview phase, I undertook video-recorded classroom observations in four classes (see Table 5.2).

Table 5.2. Sources and amounts of data from classroom observations of the pilot study

Grade level	Stream	Duration of observation
Eleventh-grade	Social science	24
Eleventh-grade	Natural science	32
Twelfth-grade	Social science	45
Twelfth-grade	Natural science	36

Though the length of one teaching period is 42 minutes, there is variation in the length of the classroom observation. There were diverse reasons for this variation, which includes waiting for the previous teacher to leave and waiting students to come back to class after other activities. Some of the mathematics teachers use extra minutes.

The video recording focused on both the students and the teacher, alternately. When found suitable for the analysis, some data from the classroom observations are included in the analysis to support the data from the interviews. The characterisations of perceptions of relevance, which emerged from the students' stories during the data analysis of the pilot study, are set out in the next section. Chapter 7 presents descriptions of the characterisations. The descriptions of the characterisations, which are no longer available in Chapter 7, are presented in the next section.

5.3 Data presentation and analysis

This section presents the characterisations of students' perceptions of relevance in three categories. The first two categories are 'relevance relating to out-of-school experience,' and 'relevance relating to school experiences.' The third category presents the characterisations of perceptions of relevance relating to prior experiences.

5.3.1 Relevance relating to out-of-school experiences

There are four sub-categories regarding the relevance of mathematics in out-of-school experiences: "mathematics is relevant because it is useful in everyday life;" "mathematics is relevant because it gives a fresh perspective on life;" "mathematics is relevant because it gives a national identity," and "presentation of the utility of mathematics in the mathematics classroom." I set out these sub-categories in this order.

5.3.1.1 Mathematics is relevant because it is useful in everyday life

The students are engaged in learning mathematics even while they participate in the day-to-day life of their society. The students perceive that mathematics is relevant to everyday life. Azenegash says:

> How far I am coming from home... Those who work in the Edir should know mathematics. [Azenegash, FG E]

Azenegash uses her mathematical knowledge in her everyday life. She uses, or sees others using, mathematics in life outside school. She perceives that mathematics is useful in the Edir, the social institution described in Chapter 1. Azenegash's parents are likely to be members of an Edir. Her access to Edir can be through her parents, who might discuss about Edir at home. It might also be the case that students go to Edir to settle the monthly payment for their parents, and thus experience it themselves. Ruth also tells her story of use of mathematics. She says:

> When my mother wants to calculate something, she calls me to do it for her; if she was educated she could have done it herself. [Ruth, FG E]

Ruth is involved in the budgeting of the family's expenditure. Her mathematical knowledge is valued by her mother. From Ruth's smile and tone, as she tells her story, I got the impression that this gave her excitement and pride. Similarly, Ahadu, says:

> In a shop here, when the children go to school, they write for their father the price for a kilo, a half, etc. because he does not know how to calculate. [Ahadu, FG H]

Some students engage in a family business. This involvement gives them the opportunity to experience the utility of mathematics. Ahadu was not participating in the family business but he was able to see the importance from others' involvement. Fisiha works in a woodwork shop with his brother. He says:

> For example, in my job, I measure, I should read the number; in order to cut accurately you should learn numbers. [Fisiha, FG F]

Fisiha is using mathematics in the workplace, where his own participation gives him an opportunity to see the usefulness of mathematics.

The students' leisure time participations such as in games could be important in their perceptions of relevance. Ibrahim mentions:

> … The ball should be spherical so that it can roll. [Ibrahim, FG D]

He perceives that the mathematics he is learning has some use. Beza gives another example where knowledge from the mathematics they learnt is used at the workplace. She says:

> Population size, proportion, death rate, average, etc. are useful in society. [Beza, FG A]

She perceives that the mathematics she is learning at school is relevant to society. When she was asked how she came to know that mathematics has this use for the society, she replied:

> My father works for the statistical agency.

Her father created a milieu in which Beza would have the opportunity to perceive that the mathematics learnt at school is useful in the society.

The students' perceptions of the relevance of mathematics to everyday life is also related to the other subjects. For example, Debesh says:

> There is calculation in geography, business; not [the subject] mathematics but the calculation in these subjects is useful... I think there are subjects, which are related to mathematics. Those subjects have societal values. Thus, your knowledge of mathematics will help you for dealing with those subjects. [Debesh, FG B]

Debesh learns mathematics and other subjects. He perceives that other school subjects involve mathematical ideas that are useful for society. Thus, the usefulness mathematics in society is through other subjects.

The students' perceptions of the relevance of mathematics to everyday life can be a source of excitement. Asad says:

> Last time I saw someone who was measuring all sides of the floor, while he could have measured the two sides and multiply by two. He could have saved time. [Asad, FG H]

Asad was able to appreciate the knowledge that he acquired at school. He displays excitement in his tone and his laughter as he tells his story.

5.3.1.2 Mathematics is relevant because it gives a fresh perspective on life

The students explain that there is a lack of explicit usfulness of the mathematical concepts in preparatory mathematics, but demonstrate the relevance of mathematics from their out-of-school experiences. Students inventively give meaning to the mathematical concepts they are learning. For example, Hayal gives a spiritual meaning. She says:

> I brought the idea of limit to my life and interpreted it as, there is time when life ends; all the things that bother me together with my life in this world, come to an end, and begin the new life in heaven… I have not seen any explicit application [of preparatory mathematics] yet. [Hayal, FG G]

She is looking at her life as a function of time the limit of which leads to a new, timeless life after death that she believes in. Makida, a member of the same interview group, says:

> We do not see applications at this level. The application of mathematics will come in the tertiary level. However, when you think of it, for example, similar to what is mentioned by [Hayal], when I learnt sequence, I learnt that things are in order they do not occur or happen randomly. It is as the saying goes 'there is time set for something' [Solomon's saying from the Bible]. For example, we cannot say 1 then 5; in life also we can't walk immediately after we were born; it goes in steps. Things in life are ordered or they happen sequentially. This is what we learn indirectly. [Makida, FG G]

Religious teachings are important in their perceptions of the relevance of mathematics. The students attend to the religious institutions, as they are part of a religious society. The school curriculum limits the availability of the usefulness of concepts in the mathematics they learn.

5.3.1.3 *Mathematics is relevant because it gives a national identity*

It has been reported above that the students perceive that the mathematics that they learn in the preparatory school has hardly any application in the out-of-school life. In their life in the school as well as outside the school, the students find themselves in incompatible situations. They learn mathematics at school but they perceive that the mathematics they learn is not consistent with the level of society. Ibrahim mentions:

> The mathematics we learn is not used in the society because the society is not a developed society. [Ibrahim, FG D]

He perceives that his society is not at a level where the concepts he is learning in the mathematics classroom would be useful. On the other hand, Abebe, a member of the same interview group is critical about the presentation of word problems with respect to their sociocultural milieu:

> … word problems have to be related to our society, things that we know and experience in our lives. Not in some other society; the names when related to our situation then we do it with interest. When it talks about some world, we do not know – names and places we do not feel that we have any concern about– then it is done in a way we did not understand. [Abebe, FG D]

The adoption of modern education in Ethiopia was set out in Chapter 1. The students are studying a mathematics that is adopted from a technologically advanced society. The students perceive that they learn mathematics, which is relevant to some other society and not to their own society. They form a national identity in relation to mathematics' relevance.

5.3.1.4 *Students' perceptions of the presentation of the usefulness of mathematics*

The students perceive that mathematics' usefulness can be shown in the mathematics classroom in word problems. Meada says:

> [usefulness of mathematics] appear as word problems... Word problems are difficult to understand. However, it is our attitude; our experience with mathematics is that it is playing with numbers. [Meada, FG H]

For the students, word problems are perceived to be difficult because of the student's limited exposure or experience with this approach of learning mathematics. Debesh reports another source of difficulty. He says:

> I like all but word problems are tricky. They use difficult words... or they are difficult to understand. [Debesh, FG B]

He is facing difficulty in understanding the English words embedded in the mathematics word problems. These students are learning in English, but they use it only at school. This difference between school and out-of-school languages may influence students' perceptions of the relevance of mathematics. Abebe tells another story. He says:

> I like word problems, because it involves critical thinking and analysing. [Abebe, FG D]

Abebe sees aspects of word problems that he likes. In one of my classroom observations in Debesh's class (eleventh-grade social science), the mathematics teacher was providing examples about Richter scale and pH value in a lesson about logarithmic function. The examples are available in the textbook as well.

The students' learning of mathematics continues outside the school, as well. Students do their homework at home, naturally. They might receive assistance from family members or the members of the society. On the other hand, the usefulness of mathematics could be experienced at the school setting, in particular in the mathematics classroom. They might also experience the use of mathematics in the school but outside the mathematics classroom.

5.3.2 Relevance relating to school experiences

Six sub-categories, which are about mathematics' relevance in students' lives related to schooling, are in this second section. These are, "mathematics is relevant because it is used in other subjects;" "mathematics is relevant because it is useful in an unknown future;" "mathematics is relevant because it has exchange value," and "mathematics is relevant because it gives an identity." The last sub-categories are "mathematics is relevant because students rely on the curriculum and the teacher," and "mathematics is relevant because it empowers one to make informal decisions." They are presented in this order. Except for the last two subcategories, descriptions of the characterisations reported under this category are presented in Chapter 7. These two sub-categories are no longer available in Chapter 7, and their descriptions are provided as follows.

In their explanations of mathematics' relevance, students fail to give example, reason or evidence for their claims instead, they sometimes justify by referring to the curriculum and the teacher. Their reference to the curriculum and the teacher could be direct or indirect. Such assertions are categorized as, "mathematics is relevant because the students rely on the curriculum and the teacher," or "reliance on the curriculum and the teacher." in shorthand form. As mentioned above this is no longer available in Chapter 7 as a sub-category, but it emerges as part of another sub-category. It emerges as a source of the perception of mathematics' relevance to future studies (see section 7.4.3.3).

Students give their own meaning about learning mathematics and its rationale. This is interpreted as "mathematics is relevant because it empowers one to make informal decisions." It is informal because the students make their own claim, which may not be the formal rationale (or the formal intention) for learning mathematics. These judgments are general to mathematics rather than specific mathematical concepts, though students might give specific examples to elaborate their claims.

5.3.2.1 Mathematics is relevant because it is used in other subjects

Students perceive that mathematics is relevant to the other school subjects. Mekia says:

> Mathematics is useful for physics… In chemistry, we have mathematics. [Mekia, FG C]

Another natural science student, Habtu provides specific concepts of the school subject and mathematics, he is:

> Physics involves numbers, e.g. vectors, but those we are learning now are rarely used. [Habtu, FG D]

According to Habtu, the usefulness of the preparatory mathematics in other subjects is scarce. Beza also gives a specific example about the use of preparatory mathematics, particularly in biology. She says:

> Log, we learnt, is applied in bacterial growth; so it is used in biology. [Beza, FG A]

Beza is a social science student. She is not attending biology classes at the preparatory school, but she provides an example of the relevance of mathematics to biology. Fikru tells the following story:

> In seventh or eighth our teacher said 'mathematics is the king of all subjects'... it has use in chemistry; Richter scale in geography; it is related with all other subjects. [Fikru, FG B]

Fikru perceives mathematics as a crucial subject for all other school subjects. His interpretation of what mathematics is for other subjects is based on this earlier perception of relevance. I have mentioned earlier my classroom observation of a discussion about the application of logarithm functions in Beza and Fikru's class (see section 5.3.1.4). Unlike Beza and Debesh, who are members of the same classroom, Fikru noted that the application of logarithm in Richter scale is in the subject geography. Fikru has long known the relevance of mathematics to the other subjects. His earlier teacher established this connection, which might give him a better opportunity to relate mathematics to other subjects.

Meseret relates her perception of the relevance of mathematics with her stream. She says:

> We are social; we do not use much calculation. This makes us not to pay much attention to mathematics, I think... Other subjects are to be learnt by heart; I take a break with mathematics. I do not allot special time for it. [Meseret, FG A]

According to her mathematics has a different feature from the other school subjects she attends. She does not allot time for engaging in mathematics and chooses to be engaged in other subjects. Only when she feels like she needs a break does she consider studying mathematics.

5.3.2.2 Mathematics is relevant because it is useful in an unknown future

The students are preparing for university studies, and their perceptions of mathematics' relevance is related to their future goals. Habtu says:

> I want to study astronomy and my brother told me that in addition to mathematics, physics is the base. [Habtu, FG D]

In their out-of-school life, the students have the opportunity of being exposed to the future use of mathematics. Habtu's source of information is a family member. The rationale for the students' learning of mathematics can be obtained in their experience outside the school. Yirdaw says:

> What we are learning now, I do not see its application... However, in workplaces I think they use it... We are in the process of development. It is useful for what we will learn in the future, I think. Therefore, we must learn it. [Yirdaw, FG F]

Though the students do not have a first-hand experience with workplace mathematics, they might get that information from other people. The information about workplace mathematics gives them the idea that university study would involve mathematics.

The students explain the future use based on their experience of the interdependence of their current experience of learning, Abebe says:

> I do not know the detail about astronomy and how much mathematical knowledge it requires. Since mathematics is important in our everyday experiences, it would be the same at that level. I think it would be important. [Abebe, FG D]

Abebe used his experience at preparatory to suggest that mathematics would be useful in his future study. Meseret gives an example. She says:

> [Mathematics] is a mother tongue... In economics, there is slope. We learnt it in seventh or eighth [grade mathematics]. We did not know then that it has this use. [Meseret, FG A]

Meseret is using her earlier and current experience to explain that the mathematics they learn now could be useful for future study. Hayal, who wants to study medicine or chemistry, says:

> Science without mathematics? I do not believe that. [Hayal, FG G]

She supplies a general remark about the relation of mathematics with natural science fields. Her perception of relevance appears to relate with her stream, science (natural science) stream.

5.3.2.3 Mathematics is relevant because it has exchange value

The students are supposed to score a qualifying grade to be admitted to university. Success in education and securing a job might well ensure sustaining the lives of students and their families, a process in which mathematics has a significant role. Beza says:

> We used to hear that tenth grade is the turning point for life… Studying any social science would be ok to be a hostess... Mathematics is compulsory. [Beza, FG A]

She aspires to become a hostess, and she perceives that the school, which offers the training, requires social science background of university. She thinks that success in mathematics is important for ultimately becoming a hostess as mathematics is compulsory to get access to the social science fields. Ruth tells a story in connection with her family:

> I wanted to study law but it is five years. I want to study economics ... then I help my parents ... If I do not have the basis in mathematics, I cannot do economics. [Ruth, FG E]

Her responsibility for her parents is important in her perception of relevance. She perceives that learning mathematics is important to her future studies. She has to get a job that enables her to sustain her family and study what she likes. Yirdaw tells a story about the choice of books:

> I want to become a private accountant.... Mathematics books from abroad are better at applications than domestic ones. ... I prefer the domestic ones for success in exams. However, for my interest I prefer the books from abroad. [Yirdaw, FG F]

His perception of the relevance of mathematics influences his choice of books. The books are significant in Yirdaw's endeavour to become a private accountant. Here we see the choice between the books is influenced by a clear need for success. Students have to succeed in examinations, which are based on the textbook. Some students perceive that mathematics has exchange value for all students regardless of their choice of future study. Ahadu says:

> I want to become a doctor… I think that whether one becomes a medical doctor or something else, learning mathematics is part of the process. [Ahadu, FG H]

There are students who are not motivated to engage in mathematics even though they perceive that it has exchange value. Alewi says:

> I am not interested in it but it is required.... I liked polynomial at the beginning ... when I scored poor at the first test, I turned my back to it again. [Alewi, FG C]

Their perceptions of mathematics' relevance are influenced by the rule that they should succeed in examinations.

5.3.2.4 Mathematics is relevant because it gives an identity

Students perceive that mathematics gives them identity. Their identities often relate with their future goal. Debesh says:

> I want to study banking and insurance because it has mathematics and I like mathematics... it is not difficult for me. [Debesh, FG B]

He perceives himself as someone who can do mathematics well. Debesh is recognized by his teacher as a high achiever. On the other hand, Essayas, who is recognized by his teacher as a low achiever, says:

> I want to study law because my brother told me that it does not involve mathematics… economics has mathematics. Therefore, I do not like it. [Essayas, FG B]

He has a sense of identity in respect of mathematics. His brother, whom Essayas says does not like mathematics, is a source of information. Other students' identities can relate with their stream. Ruth says:

> Most social science students do not like mathematics. Only few students work hard. Thus, our teacher always advises us. [Ruth, FG E]

Ruth is a social science student and her teacher recognizes her as a high achiever. Ruth recognizes the social science students as a group whose most members do not like mathematics. Meseret also tells a story relating to her former group and their teacher. She says:

> We had a mathematics teacher… He made us addicted to it. [Meseret FG A]

She perceives that they formed identity as a group. This group of students taught by a specific teacher formed an identity as learners of mathematics who are addicted to it.

5.3.2.5 *Mathematics is relevant because the students rely on the curriculum and the teacher*

The students perceive that mathematics is relevant based on reliance on the curriculum, and the teacher. Azenegash says:

> [The teacher] is our eye... If it were not relevant we would not have been taught... my teacher was telling me, now I realized that it was right: 'when you are walking, it is the shortest distance to travel on the straight path'. He did it for himself. [Azenegash, FG E]

Her earlier mathematics teacher appears to be the source of perception for relying on the curriculum and the current mathematics teacher. Azenegash takes the example that the teacher gave her, which she finds it to be true in her later life. This is evidence for her perception of relevance that the content that the curriculum presents now would be useful.

5.3.2.6 *Mathematics is relevant because it empowers one to make informal decisions*

Students' perceptions of the relevance of mathematics is reflected through their judgments about the purpose of learning it. Erikihun says:

> I want to study language or philosophy... I am doing well in language... Mathematics and most of the subjects we are learning now might not be related to what we learn in the future. However, they help us to identify or know our interest and direct us to the future. We used to learn music; it is not important but if you have the interest then you will know. Some of us may end up in a field that does not involve mathematics at all but others may need it. [Erikihun, FG F]

He has a perception of mathematics' relevance to future study, which is based own meaning about the rationale for learning mathematics.

5.3.3 Relevance relating to prior experiences

Mathematics is one of the school subjects students were attending before they joined preparatory school. The students have perceptions of the relevance of the prior experiences to the preparatory mathematics. I provide a description of the sub-categories here.

The students discussed the relevance of their prior experience of mathematics to preparatory mathematics in terms of an increase in breadth of the same topics. This is categorized as "prior experience of mathematics is relevant to preparatory because they have conceptual connection", which is also referred to as "they have conceptual connection," in short hand form.

The students discussed the relevance of their prior experience of mathematics in terms of the importance of some concepts, which are necessary for learning mathematics at preparatory school. This is categorized as, "prior experience of mathematics is relevant to preparatory because it has vital concepts." The students also discussed the connection in terms of increases in the level of difficulty by comparing learning mathematics at preparatory school with previous grade levels, including primary school. This is categorized as, “prior experience of mathematics is relevant to preparatory because it has become more difficult.”

In their narratives about learning mathematics, students describe the changes in who they are as they join or begin to learn preparatory mathematics, which is interpreted as a change in identity. This is categorised, as “prior experience of mathematics is relevant to preparatory because it tells about a change in identity,” or “change in identity,” in short hand form. The description of students’ reliance on the curriculum and the teacher is set out earlier in section 5.3.2. The sub-categories or characterisations of perceptions of relevance are presented in this order.

5.3.3.1 Prior experience of mathematics is relevant to preparatory because they have conceptual connection

The students compare the development of mathematics across grade levels. They perceive the relevance of mathematics in terms of increase in breadth. Students perceive that their prior experience of mathematics is relevant to the preparatory mathematics as they have conceptual connection. Alewiya says:

> It is the same but it expands from one grade level to the next. [Alewiya, FG C]

Debesh also sees the relevance in terms of the increase in breadth across the years. He considers specific examples:

> Not between what we learnt this year but with previous ones. Logarithms and exponentials have become broader. Rational was in ninth, now broader. In addition, geometry we learnt it before, and now with some additional concepts. [Debesh, FG B]

Debesh perceives that the relationship is not prominent between the concepts they are learning at the current grade level but across grade levels. Ruth gives additional examples:

> It is related; also in other subjects, it becomes broader as we go up. For example, limit was in sequence, now we are learning it as a topic by itself, and broadly. So, they are related. [Ruth, FG E]

According to Ruth, this characteristic is not peculiar to mathematics but similar to other subjects.

5.3.3.2 Prior experience of mathematics is relevant to preparatory because it has vital concepts

The students mentioned the relevance of their prior experience in mathematics in terms of the importance of some concepts that are necessary for learning mathematics at preparatory. Students’ perceptions of relevance are characterised by consideration of some vital concepts. Netsanet gives an example. She says:

> Those concepts coming earlier are the basis for the next. Domain, etc. we learnt before and we use them now. [Netsanet, FG G]

The students perceive that some concepts in preparatory school are vital for other concepts at the same grade level and the next grade level. Meada gives examples for both cases. He says:

> Derivative is derived from limit, and in limit, we had rational function from eleventh grade, so they are related. [Meada, FG H]

Students perceive that there are some topics, which are not interrelated. Fanaye gives an example of some concepts. She says:

> I do not think the polynomial and rational relate to geometry... We started geometry today... We were able to answer his questions because we learnt it before. [Fanaye, FG A]

Fanaye identifies some concepts of mathematics, which are not vital for specific topics of preparatory mathematics.

5.3.3.3 Prior experience of mathematics is relevant to preparatory because it has become more difficult

The students perceive that their prior experience of mathematics is relevant to preparatory mathematics in terms of difficulty level. Fantu says:

> Before it was little, easy; now it is becoming difficult as we go up in grade levels and wide. [Fantu, FG E]

Some students relate the increase in the level of difficulty to their grade level. Azenegash says:

> As our level increases, the subject is correspondingly developing in the level of difficulty.... It was in Amharic before. Now, some similar things but in English. [Azenegash, FG E]

The perception of relevance relates to language. According to Azenegash, English language contributes to the level of difficulty.

The students' perceptions of the relevance of the prior experience of mathematics, which is characterised by the level of difficulty is formed in the students' school and out-of-school experiences. Ibrahim says:

> Our society tells us that it is difficult next. [Ibrahim, FG D]

According to Ibrahim, society draws to the students' attention that mathematics gets difficult as they go up in grade levels. It is also important to note that according to Ibrahim the society is exposed to the school curriculum in some sense. The attachment of academic success as a way of overcoming the individual's and family's economic problems may have contributed to the attention that mathematics received.

5.3.3.4 Prior experience of mathematics is relevant to preparatory because it tells about a change in identity

The students perceive that mathematics tells them the change in their identities. Beza says:

> When I saw that I scored B in mathematics in tenth I did not expect it. Then, I believed that I could perform well in mathematics. [Beza, FG A]

As a preparatory student, she is now learning mathematics in order to attend university. She is recognized by her mathematics teacher as a high-achieving student. Azenegash, who was part of a group of students who worked together, says:

> … Now I departed from my friends... They are in another school... there were clever students who explain to us. We used to discuss while walking home.... I

> do not score well in it and when I miss something, I do not get back to see it again. [Azenegash, FG E]

Azenegash formed an identity as a member of her peer group, which changed when she left the group. Erikihun tells a story about his prior experience:

> I was not working well in grades nine and ten. Thus, I feel that I have missed something from those grade levels. For example, when I am learning trigonometry such as sine, I see that I have missed something before, and I am missing it now again. [Erikihun, FG F]

Erikihun is now paying attention to what he is learning. He is now recognized by his teacher as a medium achiever. Though there is a shift in his identity, he still perceives that he cannot perform well in areas of mathematics that he missed in previous grade levels.

5.3.3.5 Prior experience of mathematics is relevant to preparatory because students rely on the curriculum and the teacher

Students perceive that their prior experiences of learning mathematics is relevant to preparatory mathematics based on their reliance on the curriculum. Fanaye asserts that the teacher is students' source of perceptions of relevance of their prior experience in relation to preparatory mathematics. She says:

> The teacher tells us what we learnt before in relation to the current topic, then we understand that they are related. [Fanaye, FG A]

The teacher is the source of the students' reliance on the curriculum. A member of the same group, Meseret, provides a specific example:

> We began [geometry] today; we were refreshing our memories of earlier grades. We expect to learn new things a bit later; this was how it went in logarithms. [Meseret, FG A]

Her experience with the school curriculum enables her to expect what is coming next. Meseret appear to demonstrate a comparative independence from the teacher as compared to Fanaye who relied on the teacher.

5.4 Conclusion

The students' perceptions of relevance have diverse characterisations. Their perceptions of relevance are formed based on their experiences both in school and in their wider worlds. Table 5.3 summarises the categories and sub-categories that emerged from the analysis of data generated by the pilot study. The sub-categories are characterisations of perceptions of relevance identified in this study.

With respect to the purpose, the methods selected were effective, though with some limitations. The group interview served an important purpose in that students were able to recall their experiences based on the utterances of other students and they appeared to feel free to speak. The pilot study made it clear that the research methods need to be supplemented by other methods so that the research questions to be addressed in full (see Chapter 4). For example, how widely the characterisations of perceptions of relevance are held was not answered. This issue is dealt in the next chapter.

Table 5.3: Summary of categories and sub-categories exposed by the pilot study

Category 1: Perceptions of relevance relating to out-of-school experiences	
	Sub-categories
1.	Mathematics is relevant because it is useful in everyday life
2.	Mathematics is relevant because it gives a fresh perspective on life
3.	Mathematics is relevant because it gives a national identity*
4.	Students' perceptions of the presentation of the utility of mathematics*
Category 2: Perceptions of relevance relating to school experience	
	Sub-categories
5.	Mathematics is relevant because it is used in other subjects
6.	Mathematics is relevant because it is useful in an unknown future
7.	Mathematics is relevant because it gives an identity
8.	Mathematics is relevant because it empowers one to make informal decisions
9.	Mathematics is relevant because students rely on the curriculum and the teacher
10.	Mathematics is relevant because it has exchange value
Category 3: The relevance of students' prior experiences	
	Sub-categories
11.	Prior experience of mathematics is relevant to preparatory because have conceptual connection
12.	Prior experience of mathematics is relevant to preparatory because some concepts are vital
13.	Prior experience of mathematics is relevant to preparatory because it has become more difficult
14.	Prior experience of mathematics is relevant to preparatory because it describes the change in identity
15.	Prior experience of mathematics is relevant to preparatory because students rely on the curriculum and the teacher

* These sub-categories emerged from analysis subsequent to the development of the questionnaire.

I used the results from the pilot study to design the questionnaire. However, the analysis of the pilot study continued beyond that point, and there are themes, which are not included in the questionnaire. The subcategory, "mathematics is relevant because it gives a national identity" emerged subsequent to the questionnaire. I further examine the perceptions of relevance in Chapter 7 using new qualitative data.

6 Analysis of quantitative data arising from the questionnaire

6.1 Introduction

The main study has two components: the survey and interview. In this chapter, I present a quantitative analysis of the survey. As I mentioned in Chapter 4, the survey involved a questionnaire contains 29 items of which all but one was constructed for respondents to provide Likert scale type responses. One item is about the students' source of information about future use of mathematics. Including this introduction, the chapter has four sections. These sections are students' backgrounds, the proportions of positive responses and discussion.

6.2 Students' backgrounds

This section presents respondents' backgrounds in terms of the statistics for the categories of students used for sampling in the completion of the questionnaire. I present proportions, which expose parents' educational backgrounds, participants' religious backgrounds and mother tongue.

Table 6.1. The students' backgrounds in the social science stream sample, with number of students across grade level, gender, and level of achievement

Level of achievement	Eleventh grade			Twelfth grade			Grand Total
	Low	Medium	High	Low	Medium	High	
Female	7	8	7	11	11	11	55
Male	6	5	6	6	6	6	35
Total	13	13	13	17	17	17	90

The number of students across the four categories of students is presented in two tables. Table 6.1 above presents the students' backgrounds in the social science stream. The table below is for the natural science stream (see Table 6.2). The proportion of social science students is notably small; it is 27%, while 73% of the sample of students is from the natural science stream. This proportion in the sample is consistent with the proportion of social science and natural science students in the school population, which is also nearly 27% to 73% (see Table 1.4).

Table 6.2. The students' backgrounds in the natural science stream sample, with number of students across grade level, gender, and level of achievement

Level of achievement	Eleventh grade			Twelfth grade			Grand Total
	Low	Medium	High	Low	Medium	High	
Female	24	24	24	20	20	19	131
Male	20	18	19	19	19	19	114
Total	44	42	43	39	39	38	245

The difference between the proportions of female and male students is small; it is 55% to 45 %, respectively. This proportion in the sample is consistent with the proportion of female and male students in the school population, which is nearly 54% to 46 % (see Table 1.4).

Table 6.3. The students' backgrounds in terms of parents' levels of education

Level of education	% in each level of education					
	Basic	Primary	Secondary	Diploma	Degrees	Not reported
Mothers	10.3	27.8	25.1	8.8	5.7	22.4
Fathers	7.2	15.4	29.9	9.1	16	22.4

A large proportion of the parents do not have a higher level of education (see Table 6.3). More than 63% of the respondents indicated that their mothers do not have formal education above secondary level, and less than 6% of the mothers have university degrees. Their fathers' educational backgrounds are only a little better. More than 52% of the respondents' fathers do not have any formal education above secondary level, and less than 16% of the fathers have university degrees.

Table 6.4. The students' religious backgrounds, with number of students by religion

Religion	Number of participants	% of participants
Christian	276	83
Muslim	44	13
No religion	1	.3
Not reported	11	3

The students' religious background was not used for sampling in the completion of the questionnaire. The students in the sample are largely Christian (see Table 6.4). The proportion of Muslim students who participated in this study is very small (13 %). This proportion may not be representative of the Muslim students in the school. The language background of the students is also not used for sampling but the participants' mother tongue is mainly Amharic. More than 90 % of the participants mentioned that their mother tongue is Amharic.

6.3 The proportions of responses

This section presents the proportions of students' positive responses for each of the items. The intention is to examine how widely the characterisations of perceptions of relevance are held. The proportions of students' responses are calculated as a sum of the percentage for "agree" and "strongly agree." I display the bar graphs for some of the items. The bar graphs for some more items are displayed in Appendix 3. The proportions of responses for each of the items are presented under two subsections: relevance relating to out-of-school experiences and relevance relating to school related experiences. The third subsection focuses on differences across the categories of students. They are presented in this order.

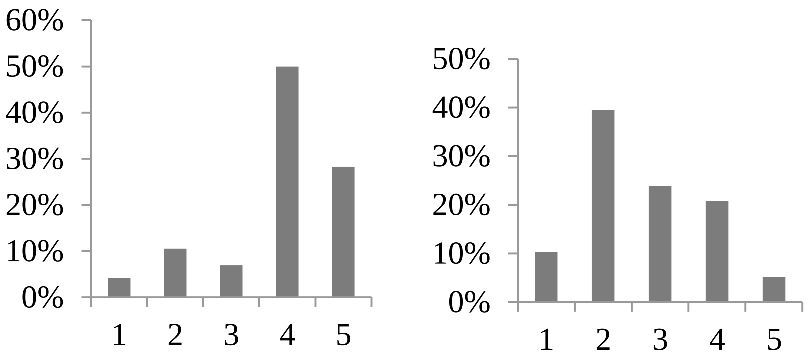
6.3.1 Relevance relating to out-of-school experiences

This section presents items that are about mathematics relating to students' out-of-school experiences. Table 6.5 presents the items and the corresponding proportions of positive responses. The serial numbers (under the column S.N.) indicate the item numbers in the questionnaire.

Table 6.5. Proportions of positive response to the items about out-of-school experiences

S.N.	Items	Proportions in %
1	I see mathematics in the activities in the *society*	78
2	I use mathematics in the activities in the *society*	71
3	I see preparatory mathematics in the activities in the *society*	26
4	I use preparatory mathematics in the activities in the *society*	21
5	I see mathematics in my *leisure time* activities	48
6	I use mathematics in my *leisure time* activities	45
7	I see preparatory mathematics in my *leisure time* activities	21
8	I use preparatory mathematics in my *leisure time* activities	25
9	I see mathematics in *spiritual life*	38
10	I use the mathematics in *spiritual life*	36
11	I see preparatory mathematics in *spiritual life*	15
12	I use preparatory mathematics in *spiritual life*	14

There is a notable variation in the proportions of students' responses to the items about the relevance of mathematics to their out-of-school experiences. As can be seen in Table 6.5, the proportion of students who responded positively to the "society" items are much higher than the responses to the "leisure time" items. The items about "spiritual life" are not widely held.



I see mathematics in the activities in the society

I see preparatory mathematics in the activities in the society

1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree

Figure 6.1: Bar graphs for characterisations of students' perceptions of relevance.

The proportions differ for the "mathematics" and the "preparatory mathematics" items. The proportions of positive responses to the preparatory mathematics items are much smaller. For example, for the item, “I see preparatory mathematics in the activities in the society,” the majority of the participants responded negatively (see Figure 6.1).

Though students rarely responded to the open questions following the items, some provided examples of transactions, and society’s sociocultural heritage such as Edir and Equb, as activities, which employ mathematics (see Chapter 1). They noted that they use or see others using numbers and simple arithmetic in their participation in the activities in the society.

The students mentioned games as leisure time activities, and the use of numbers and simple arithmetic in leisure time activities. Some students also mentioned their engaging in school tasks outside school as a leisure time activity. This is a misunderstanding of the item. These students’ understanding of leisure time activity seems to be whatever one does outside the school, which includes engaging in the tasks of school subjects. This could be one possible reason for the difference in the proportions of positive responses to the items about “society” and “leisure time.” Similarly, in the few responses to the open questions following the “spiritual life” items, the students wrote that they see and use page numbers and verses in Holy books.

In general, the proportions of positive responses to the “preparatory mathematics” items are much smaller than the proportions of positive responses to the “mathematics” items. For the majority of the students preparatory mathematics is not useful in the activities in the society and leisure time activities or they are not sure about it. This suggests a weak relationship between mathematics at preparatory school and the out-of-school life.

6.3.2 Relevance relating to school-related experiences

This section focuses on the questionnaire items that are about students’ school-related experiences. Eight items are presented in Table 6.6. The table also presents the corresponding proportions of positive responses.

Table 6.6. Proportions of positive response to items about school related experiences

S.N	Items	Proportions in %
13	I see mathematics in other school subjects	92
14	I use mathematics in other school subjects	91
15	I see preparatory mathematics in other school subjects	75
16	I use preparatory mathematics in other school subjects	79
17	Preparatory mathematics is useful in my future study	68
19	Preparatory mathematics is useful to get access to future study	63
20	Preparatory mathematics is relevant because it gives an *identity*	42
22	Preparatory mathematics is relevant because it would not have been taught if it were not*.	70

* As set out in Chapter 5, this is interpreted as reliance on the teacher and the curriculum.

The first four items are about other school subjects. The remaining items are about future study; exchange value; identity and reliance. As set out earlier the items are designed based on the results of the pilot study (see Chapters 4 and 5). In Chapter 5, the item “preparatory mathematics is relevant because it would not have been taught if it were not” is derived from the characterisation of perception of relevance, “mathematics is relevant because students rely on the curriculum and the teacher.” The item “preparatory mathematics is useful to get access to future study” is derived from the characterisation of perception of relevance, “mathematics has exchange value.” The remaining items are direct copies of the respective characterisations of perceptions of relevance reported in Chapters 5 and 7.

As can be seen in Table 6.6, the proportions of positive responses to most of the items are very high. Two of the four characterisations of perceptions of the relevance of mathematics to other school subjects are about mathematics in general. In their answers to the open questions following the “mathematics” items, the students stated that they at least use or see numbers in the other subjects. There are no such examples in their responses to “preparatory mathematics” items, partly because the open question asks to mention the subjects, which use mathematics. Students mentioned usefulness in the subjects such as physics, chemistry and economics. More students held that mathematics in general is useful than those held that preparatory mathematics is useful in other school subjects. One reason for this difference can be the wider range of concepts of mathematics in general as opposed to preparatory mathematics.

When we focus on the relevance of preparatory mathematics, we see that the perceptions of relevance to other school subjects are widely held. High proportions of students also hold the perceptions of relevance characterised by reliance, exchange value, and future study. These are very high, when compared to the proportion of students who hold the rest of the items about preparatory mathematics. The item about future use of mathematics differs from the rest of the items in the sense that it asks about the future, which the students have not experienced yet. The proportion of students who hold this perception of relevance is among the highest. There is also one item asking about students’ sources of information about the use of mathematics in their future study. For 64 % of the students the teacher is their source of information. Their mothers, fathers, brothers, sisters, or other relatives are very rare sources.

A very high proportion of students hold that preparatory mathematics is relevant based on reliance on the curriculum and the teacher. Similar to the other items, the open questions following the “reliance” item rarely generated data. These rare responses include usefulness in future study. On the other hand, a considerable proportion of students hold that preparatory mathematics is relevant because it gives an identity. In response to the open question following the "identity" item, a twelfth grade natural science student wrote the following:

> Preparatory mathematics tells who I am by revealing the progress I make in my capability and competence based on frequent evaluations and my achievements.

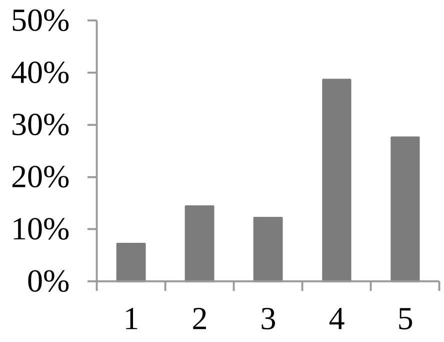
At least one student from each of the categories of gender, grade level and stream gave such responses to the open question. The positive responses to the item are also from students of each of these categories.

Mathematics plays an important part in the students' enrolment into the university (see section 1.5). This can be a possible reason for the fact that the perception of the exchange value of mathematics is widely held. Most of the students perceive that mathematics is relevant to their future study. They rely on the teacher and the authorities behind the curriculum to provide them with things, which are worth knowing.

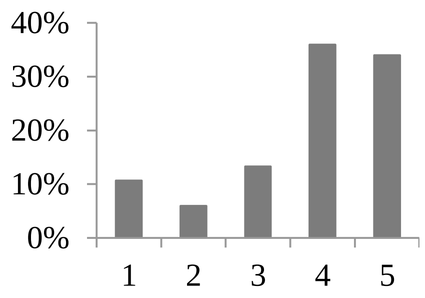
6.3.3 Differences across categories of students

This section focuses on differences in the popularity of perceptions of the relevance of preparatory mathematics across gender and stream. The characterisations examined are about future study and other subjects.

There is gender difference in the characterisation of perception of mathematics' relevance to future studies. In particular, 66 % of the female students and 70 % of the male students held that preparatory mathematics is useful for their future studies (see Figure 6.2). Examining this difference is important because there is already difference reported in Chapter 1 about the gender difference in education and the affirmative action intended to correct it. Chapter 1 exposes that a higher proportion of male students than female students are in the natural science stream.



The distribution of female students' perceptions



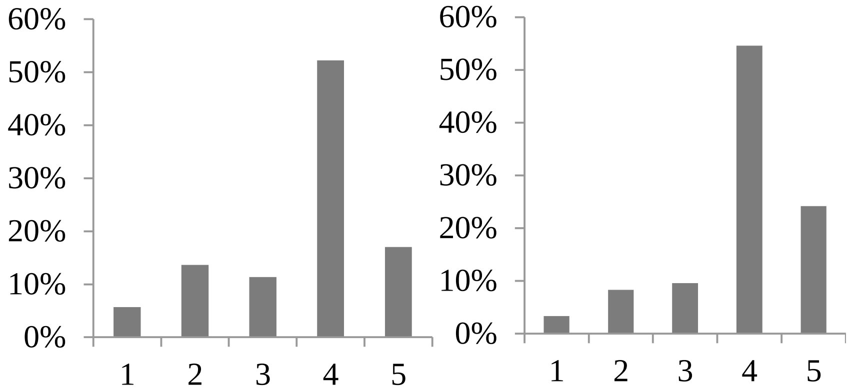
The distribution of male students' perceptions

1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree

Figure 6.2: Bar graphs for distributions of perceptions of relevance characterised by "preparatory mathematics is useful in my future study" across categories of gender.

There are differences in the distributions of some characterisations of perceptions of relevance across the students' streams. Particularly, 69 %

of the social science students and 79 % of the natural science students held that preparatory mathematics is useful to the other school subjects (see Figure 6.3). Similarly, 58 % of the social science students and 72 % of the natural science students held that preparatory mathematics is useful to their future studies (see Figure 6.4).



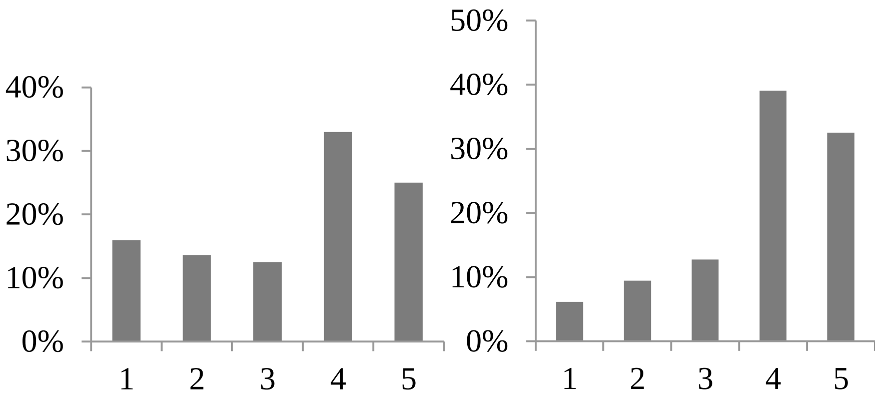
The distribution of social science students' perceptions of relevance.

The distribution of natural science students' perceptions of relevance.

1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree

Figure 6.3: Bar graphs for the distributions of perceptions of relevance characterised by "I see preparatory mathematics in other subjects" across categories of stream.

I consider that examining these differences is important because, I often encountered a perception of relevance among teachers of upper secondary that there is difference across streams in students' perceptions of the relevance of mathematics to other subjects and to their future studies.



The distribution of social science students' perceptions of relevance

The distribution of natural science students' perceptions of relevance

1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree

Figure 6.4. Bar graphs for the distributions of the characterisation "preparatory mathematics is useful in my future study" across categories of streams.

These differences are important because they occurred for two widely held and related characterisations of perceptions of preparatory mathematics' usefulness. Moreover, both differences are in favour of natural science students. These are further dealt in section 8.3.

6.4 Discussion

The students held the characterisations of perceptions of the relevance of mathematics at various levels. Most of the items pertaining to the perceptions of the relevance of preparatory mathematics are not widely held. In this respect, the perceptions of relevance about other subjects, future study and exchange value are significant in that a high proportion of students held them.

Some of the perceptions of relevance, which I expected that the students would hold at similar levels, did not materialise. I expected that the students would hold the items about the activities in the society and items about leisure time activities at similar levels. A misunderstanding of the items contributed to the big differences between the proportions of positive responses to these items (see section 6.3.1 and Table 6.5).

The very low rate of responses to the open questions limited the possibility of substantiating the results obtained from the analysis of the Likert scale items as well as checking whether students understood the items. However, the limited amount of data obtained from the responses to the open questions itself shows that some students have problems in understanding some of the items (see section 6.3.1). For some of the items, it is not possible to be certain that the students responded to the questions, they were asked. Consequently, the results pertaining to the items about spiritual life and leisure time activity are not discussed further in Chapter 8. For a similar reason the items about students' prior experiences and 'making decisions' are not considered in this section. Hence, they are omitted from further discussion in Chapter 8. The results from the survey that will be used includes the items about the activities in the society, the other school subjects, future study, exchange value and identity.

There are issues of concern about some of the results obtained using the questionnaire. This includes clarity of some of the items. Another concern is the very low response rate to the open questions. Such issues are examined in Chapter 9 (see section 9.4.3). The next chapter is a presentation and analysis of the interview data, which was collected parallel to the survey. Some data from the pilot study is also re-examined.

7 The main study: Analysis of qualitative data

7.1 Introduction

This chapter sets out presentation and analysis of the interview data. Some data from overview of the textbook, classroom observation and conversations with the teachers are also part of the data. The analysis of the interviews confirmed most of the characterisations of the students' perceptions of relevance that were already identified in the pilot study.

Some of the results from the pilot study opened up a focus for students' backgrounds in terms of religion and rural backgrounds. Two Christian students who were in the same group provided an example where they inventively used the mathematics concepts to their spiritual lives. The data obtained from this Christian-dominated group initiated interest in the possibility of obtaining similar data among students of Muslim backgrounds. In the main study, one of the groups is Muslim-dominated (two Muslim and one Christian). Similarly, there is another group where all members are students with rural backgrounds.

These diverse backgrounds also helped in providing a better description of the Ethiopian context in relation to schooling. From the pilot study and following presentations of the results of the pilot study at conferences, I understood that describing the context of students using their own words is important (cf. Stake, 1995). Stake stresses the importance of exposition of the context in creating opportunity for better meaning.

Including this introduction, the chapter contains six sections. These sections are analysis of the data, description of the context, data presentation and analysis, discussion and reflection on the data generated.

7.2 Analysis of the data

This section focuses on examining and exposing the kind, amount and sources of data. The main data of this study are obtained from students' group interviews, which comprises eight video-records. Each video-record consists of interviews with a group of three students. Additional data, though little, are generated from other sources, which I set out here.

Table 7.1 sets out the sources of interview data, including duration of interviews. The first column shows categories of students. Participants in each focus group are students from the same grade level, stream and are of the same sex. The eight groups are labelled as Groups A to H. As can be seen in the table the duration of interviews varies. The reason is that students of group B were interviewed in two separate occasions for 24 and 31 minutes. Similarly, students of group A were interviewed for about 24 and 21 minutes. Students of the other groups were not willing for a second interview. Groups A and B are taught by the same teacher. Based on the level of interest he has shown to the study, I assume that the teacher convinced them to participate.

Table 7.1. Sources and amounts of interview data generated in the main study

Focus group (FG)	Stream	Informants (pseudonyms)	Attainment characteristic	Duration of interview
A: Female, eleventh-grade	Social science	Sofia Hale Hadiya	High Medium Low	45 Minutes
B: Male, eleventh-grade	Social science	Bayu Edris Atnafu	High Medium Low	55 Minutes
C: Female, eleventh-grade	Natural science	Beliyu Hanan Weyinishet	High Medium Low	23 Minutes
D: Male, eleventh-grade	Natural science	Akalu Eyasu Fikadu	High Medium Low	39 Minutes
E: Female, twelfth-grade	Social science	Zenebech Hana Beletu	High Medium Low	26 Minutes
F: Male, twelfth-grade	Social science	Melkamu Haleluya Milkias	High Medium Low	43 Minutes
G: Female, twelfth-grade	Natural science	Munaye Fate Tihitina	High Medium Low	30 Minutes
H: Male, twelfth-grade	Natural science	Robel Ayana Selamu	High Medium Low	28 Minutes

The information about urban/rural backgrounds is not included in the table. This background of students is not used as main category of sampling. The majority of participants have urban backgrounds. There are three students, who have rural backgrounds and are included deliberately. In particular, I requested the teachers to come with such students. These students make up focus group E. Similarly, the information about students' religious background is not included in the table. Students' religious background is not considered as a category of sampling in the same level as attainment, stream and gender. However, I asked the teachers to pay attention to the inclusion of Muslim students, which gave opportunity to have a Muslim dominated focus group. Focus group A is Muslim dominated. Sofia and Hadiya are Muslims.

A portion of video-recorded classroom observations is also part of the data (see Table 7.2). As in the plot study, there is variation in the duration (see section 5.2). Section 7.3.3 presents brief summaries of classroom observations.

Table 7.2. Sources and amounts of data generated from classroom observations

Grade level	Stream	Duration of observation
Eleventh-grade	Social science	41
Eleventh-grade	Natural science	33
Twelfth-grade	Social science	35
Twelfth-grade	Natural science	36

The notes of my conversations with the teachers also contribute to the data corpus, though they are so little and are not direct quotations. It is not possible to describe the amount of data obtained from these conversations. Section 7.3.3 presents a description of these data.

The textbook also contributes to the data corpus. Examining the textbook has the specific purpose of exposing the topics that pertain to what students mentioned during the interviews. These data involve four different textbooks, which are the old and the new textbooks for eleventh-grade and twelfth-grade. Sections 7.4.2.1 and 7.4.3.1 provide brief overviews of specific topics and some features of the textbooks. The titles for the units of the textbooks are available in Appendix 1.

In this section, I provided analysis of the data generated. The data obtained from the classroom observations and conversations with the teachers are limited to supporting the data generated from interviews of students. The extent to which I used the textbook is limited to what students mentioned; in some cases, I expose just an exemplar topic.

7.3 Description of the context

The intention of this section is to give a background about the students' situation in the school and outside the school. It has three subsections. The first two subsections are the students' out-of-school lives, and the students' school lives. These subsections are based on students' stories, mostly in response to my request to introduce themselves and tell their history in connection with mathematics learning. The third subsection presents the mathematics classroom observations.

7.3.1 The students' out-of-school lives

In this section, I provide a description of the out-of-school context. The students continue to engage in school tasks outside the school and members of the communities of the out-of-school activities such as the family-life activity have roles to play. In their out-of-school lives, students participate in different activities: family-life, games, work and church or mosque attendance. These issues are the focuses of this section.

The students obtain support and follow-up from family members, usually from brothers or sisters. Edris tells stories about his situation:

> I was good until fourth grade. My sister used to monitor me, 'what did you write today'. She joined the university, and then I became less conscientious. I even repeated grade 4. She came home once a year, she was studying at [a] university. Then, I got out of line; I used to be absent from school. [Edris, FG B]

Edris's story shows the problem the students face in the absence of sustained support and follow-up from a member of the family, who is aware of what the student is learning. Both Edris and his sister are participants of a historically situated activity of schooling, at different points in time. According to the division of labour in the family-life activity system Edris is monitored by his sister and the rules require that she has to monitor her younger brother, and Edris has to be obedient to her.

The students could also obtain support from parents. Munaye's father who had a secondary school education could help her at lower grade levels. The following is an excerpt from her story:

> I like mathematics. … I even learnt simultaneous equations at earlier age at home. I studied it when I was in seventh at home. At school, we studied it in eighth grade. ... My father taught me. [Munaye, FG G]

Individuals who have affiliation to the family take on a role in the personal development of the student as parts of the community of the family-life activity system. Atnafu's story is exemplar. He says:

> In sixth grade my brother-in-law used to help me with school tasks ... my parents are not educated. They just say 'study,' but they cannot help me. [Atnafu, FG B]

Parents are not usually educated in the modern education system. The support they can offer in connection with the students' school tasks can be limited to insisting on the students' engagement. In some cases, students' relatives might take on the role of parents. The following narrative of Beletu can be an example:

> I was born in the countryside. I grew up in Awasa [a town about 300 km south of Addis Ababa] with my uncles when my parents died. I learnt in Awasa until tenth grade, then I moved here [Addis Ababa]... preparatory, I started here. When my uncles came here because of their jobs I came with them. When I moved to Awasa there was a problem. I was enrolled in school by myself. There is a belief in the countryside that females can end up nowhere through education. They insist that a girl should marry rather than sending her to school.... Now, my uncles encourage me and support me in many ways, like pay for me to attend tutorial classes and buy books for me. They do not have enough time to help me in what I learn. [Beletu, FG E]

Her story appears to explain the situation of female students in the rural areas. According to her, the family preferred to let her be prepared for marriage. The rules in the local activity system enforces that she has to obey the elders' will and prepare herself for marriage rather than pursue her education. She resisted preparing for being placed in an activity system, with different rules and division of labour, which may not enable her to pursue her participation in the school activity.

Beletu's participation in the schooling activity came through her own initiative. The uncles who initially attempted to deny her participation in the schooling activity became convinced that it is worthwhile to support her, seemingly after she had demonstrated that she could reach somewhere through education. They supply her with the appropriate artefacts, and access to participation in activities, which enhance her success in the schooling activity. According to the division of labour in the family-life activity system, she is now recognized as a student who needs to have time for schooling and to do school tasks at home or participate in the tutorial support system.

Zenebech tells a story where her role as a student was accepted but the division of labour in the local activity system did not allow her enough time for school tasks. She says:

> I was in a poor condition for studying, because I was in the countryside and my parents are farmers. They are physically weak, and it was my responsibility to undertake home tasks. In eighth grade, I took the exam without any preparations though I had interest to prepare …. I was sometimes absent from school. Ninth and tenth, we rented a room near the school because the school was far from home. When I was in ninth-grade, friends who were living with me did not have a good attitude about school and they made me become like them. I even became worse than when I was at home. In tenth, I came across clever students and I joined them. I improved. Meanwhile, I almost had to withdraw from school because of financial problem, but my friends helped me. When I succeeded in tenth, my brother brought me here and I am living with him now ... until eighth, the school was near our house and teachers were helping me because they knew that my parents were physically weak. [Zenebech, FG E]

Her school and the local activity system worked closely together. The division of labour in the school activity system eased the problem that she faced due to the division of labour in the local activity system.

Both the school activity system and the local activity system were new for Zenebech when she started to live with her friends in ninth grade. Her role changed when she moved to another place and rented a room to live with her friends, a new local activity system. She was no longer a daughter in the new activity system. She was not responsible for taking care of her parents, but only herself. Her new role in the local activity system, which replaced the family-life activity system, was not in favour of her school role.

She was transferred again to a new local activity system where she joined a group of clever students. It was a new community, where her role became engaging in school tasks at home. When financial difficulty threatened her participation in schooling activity, she sustained because of help from members of the new local community. The new local activity system had an appropriate division of labour and favourable rules for her participation in schooling. Her status at school was changed. She was finally able to succeed in one of the major examinations in the Ethiopian school system, and was able to attend the preparatory school.

The students have religious backgrounds, mainly Orthodox Christian and Muslim. When they talk about the future, the students start by saying "if God wills." Some students go to mosque or madrasa, and study the Quran. In some cases, they also study the school subjects. Sofia says:

> On Saturdays and Sundays, we learn mathematics and other subjects in a madrasa near our home.... There are people who teach us the Quran and others who teach the school subjects... Learning the Quran makes you disciplined. [Sofia, FG A]

In the madrasa, there is a division of labour with respect to teaching the Quran and teaching school subjects. This division of labour may not exist in all madrasa, as the tutorial system does not appear to be offered in an institutionalized way. For example, Hadiya, a member of the same interview group, says:

> In ours, we do not learn school subjects... We learn only the Quran [Hadiya, FG A]

In their out-of-school lives, Hadiya and Sofia participate in the same activity, though in different settings. However, the objects of the activities are different in that the learning of school subjects is lacking in Hadiya's case. The third member of the interview group is a Christian. She mentioned that she does not regularly go to church. Some Orthodox Christian teachers at the school mentioned to me that a similar tutorial support system also exists in the Orthodox Church.

The religious institutions have the motive of maintaining the religious values in society. They undertake religious teaching directed towards the goal of transmitting religious values and ideology to the students. The goal of these actions may also be the personal development of the students, a goal shared by the students' parents. The students participate in this activity of attending worship, which includes learning religion and school subjects. These situations appear to give students the opportunity to relate learning mathematics to the religious teachings. Some explain the advantage of studying the Quran for alleviating the difficulty of mathematics. Sofia says:

> There is an assumption that studying the Quran helps you to understand many things easily... for mathematics and other subjects we can understand easily... the Arabic language is difficult so it gives you the strength. [Sofia, FG A]

Hadiya explains further. She says

> It is believed that if you have studied the Quran... it expands your mental capacity. It enhances the capability for understanding. [Hadiya, FG A]

On the other hand, the third member of the same group, who is a Christian, does not agree with this idea. Hale says:

> I do not think that they are related. Religion and mathematics are entirely distinct things. [Hale, FG A]

I insert a personal reflection; I (the researcher) grew up in an Ethiopian Orthodox Christian family. I know that it is a popular belief among Orthodox Christian parents that studying the religious literature, especially the Psalms (which is written in the Ge'ez language) helps their children to be good at school.

The two activities (namely, the school and the religion) are closely connected for some students and are unrelated for others. A possible explanation for the difference is whether the student has access to the religious institutions.

In Chapter 1, I reported that parents and clerics have a concern that modern education may not transmit their cultural and religious values to the students. The parents seem to see letting students participate in church or mosque as one means of maintaining their cultural values. During the data collection there was an occasion where many students were absent from a class because there was church festivity and the students decided to go to the church instead of going to school.

The students participate in the activity of work, the motive of which is earning money, which is realized through taking actions such as making something ready for sale, which is directed towards the goal of selling it. In some cases, the division of labour in the work activity system in a family's subsistence business might affect their role in the school activity system. Ayana's narrative is exemplar. He says:

> Earlier, I was working in our shop. My parents decided to close the shop so that my brother and I could focus on school.... My parents, though not educated, are very keen for our learning. They insist that we concentrate on nothing but education. Because of this view, they have on education; I can say that they have shaped me for the best with respect to my education. [Ayana, FG H]

Ayana's role was changed from securing a daily income for the family to engaging in school tasks. His role in the work activity system ended, which also changed his role in the family. It will be set out later in section 7.4.2.2 that he took the role of calculating the family's expenditure.

The students' out-of-school lives are an important part of the context, in which the students operate. The students' out-of-school lives set out in this section is mostly general. It also has issues, which relate to learning mathematics.

7.3.2 The students' school lives

This section describes the school and mathematics classroom situations that relate to the students' perceptions of relevance. I also explain the significance of the mathematics teacher as narrated by the students and the impact of learning mathematics through the plasma.

The students are required to be in the school compound by 08:15 in the morning and classes end at 14:45. The school day is divided into seven lesson periods. The students have two rest periods a day. They have a 15-minute break after two periods and a one-hour lunch break after the fifth period. Students are allowed to leave of the school compound during the lunch break only. The school has grounds for game playing. They play games such as football and volleyball in the school.

The mathematics classes in this school have between 40 and 50 students, but in lower grades, the class sizes may not be the same. Some students explain their situation in such classes. Atnafu says:

> First to eighth I studied in the same school. I learnt with the same students in all years. The school was very small ... We were about 80 students in a classroom. [Atnafu, FG B]

Another feature of mathematics classrooms is learning mathematics through the plasma. As I noted in Chapter 1, when I started the data collection in the end of 2009, in the four mathematics classrooms I visited, the plasma was not in use. The experience was different in earlier academic years: the students were taught many of the school subjects including mathematics through the plasma. The participants of this study tell stories about their experiences with learning mathematics through the plasma. Melkamu explains his experience with the plasma and compares it to what he could have obtained from the teacher. He says:

> Some teachers encourage us in a way that stimulates us to work hard in mathematics. For example, in tenth, but plasma started after the middle of the year... the teacher was encouraging us very much. He was making us enjoy the subject. [Melkamu, FG F]

The school rule enforces that the mathematics lessons should be on video. The role of the teacher was partly replaced by the video teacher. In that situation, students missed some of the roles that the teacher used to play. The plasma as an artefact mediates the teacher's practices. However, with the same artefact the teachers can maintain some of their roles such as encouraging students to engage.

The students often assert that preparatory mathematics is difficult. The teacher can have roles. Hana says:

> Actually, what makes us believe that preparatory mathematics is not simple is that the teachers tell us that it is difficult for us. They say, 'Because it is new for you it is difficult for you'. [Hana, FG E]

There is also division of labour among the students where some students have a role in supporting the others. Ayana tells the following story:

> I try it at home, and then I ask Robel since we sit together in class. If he cannot do it, he asks the teacher and explains it to me. ... I quickly convince myself that I cannot do it. [Ayana, FG H]

There are also language issues in mathematics learning, which students mention. In his story of handling difficult tasks, Robel, a member of Ayana's interview group, says:

> When I encounter a difficult problem, I carefully read it to understand it better. It might be because of the English language; any way I try hard to understand it. If I still cannot do it, I write the question and I refer to local or foreign books. There are options anyway, internet also. Finally, I ask the teacher. [Robel, FG H]

The instruction of mathematics takes place in a foreign language. The students mention language of instruction as being a source of difficulty in learning mathematics. While English language is the medium of instruction, students use Amharic and other local vernaculars outside of the class. The teachers themselves acknowledge this problem of language and the students' ability to cope with the language. As I mentioned in Chapter 4, I undertook the data collection in a local language because of teachers' advices. Moreover, even in the mathematics classroom, the teachers and students often interact in Amharic (see section 7.3.3).

An important issue, which is worth mentioning in connection with students' school lives, is the textbook. In Chapter 1, I mentioned that there is only one textbook for each grade level. Students mention their experiences with the textbook. Melkamu says:

> There are some topics that we did not cover in eleventh grade, which were important for us. Since we are going to study accounting, etc., it would be very important for us. It is about simple and compound interest, etc. It is surprising that we did not learn this ... it is because of shortage of time; it is at the end of the textbook. The textbook has about 400 pages. Ok, we do not learn two of the units, then, about 350 pages. It is too vast to cover. [Melkamu, FG F]

The teachers also informed me that it is a challenge to cover all the topics of the textbook. The social science and natural science streams use the same textbook. Most topics of the textbook are obligatory for both streams. As it will be set out in section 7.4.3.3, some social science students question the rationale for learning mathematics.

As set out in section 7.3.1, the students have different backgrounds, for example, in terms of religion and rural or urban backgrounds. There could be variation in the cultural traditions as well as in the languages used in the different parts of the country (see Chapter 1). This can have consequences on the students who move to Memiru School from other parts of country. I expected that students experience a conflicting situation. However, the students did not mention such experiences.

7.3.3 The mathematics classroom observations

This section provides a description of my observations of the mathematics classroom situations. I present one of the data reductions in a table (see Table 7.3). I also present a brief description of the remaining three classroom observations in another table (see Table 7.4). I also provide data from my conversations with the teachers. However, I did not have exact quotations from these conversations. We focused on general issues related to the study, and my presentations of the students' perceptions of relevance. The conversations are not about the teachers' practices.

In my classroom observations, I followed if there were any issues, which could be used to probe students during the interviews as well as to expose the features of the mathematics classroom. For this purpose, I undertook data reduction. During the analysis, I revisited the video-records to find out if there can be data to support the data from interviews. So, some more information is extracted from the classroom observations presented here than when it was done to use it for probing.

Table 7.3. Data reduction of observation in a twelfth-grade social science class

Time	Description	Comments
0000	Teacher started by mentioning the topic of the previous day (limits) and asking a question about it. The students responded	The camera focusing on students and the teacher
0120	Teacher gave classwork. Students copy tasks from chalkboard. Some students discuss.	The camera focusing on students
0312	Students copied tasks. The teacher looked at students' solutions.	The plasma TV seen closed
0411	Teacher read an expression, which a student could not read.	The camera focusing on students
0624	A student called the teacher and showed his solution; few others followed.	The camera focusing on students
0925	Teacher solved tasks. She also provided incomplete statements and students responded in a group (as in a choir).	The camera focusing on students and the teacher
1145	Teacher asked a question and a student attempted to respond. The others followed.	The camera focusing on students
1345	After providing solutions to the first two tasks, the teacher asked how they solved the third. Then, she continued solving it; the students were attempting to follow.	The camera focusing on the chalkboard.
1600	Students copied. Teacher mentioned that the remaining tasks were easy. She added that most students had done them correctly.	The camera focusing on students and teacher.
1830	Teacher asked for the solution of the last two tasks. A student responded and the teacher asked how she solved it.	The camera focusing on students
2025	Teacher asked if they understood. They asked for repetition of second task.	The camera focusing on chalkboard.
2500	Teacher gave additional classwork. The students copied from chalkboard.	The camera focusing on chalkboard and students
2700	Teacher looked at students' solutions.	Students curiously show their solutions.
3000	Teacher asked a student to solve a task on the chalkboard. The student solved it.	
3400	Teacher mentioned topic for next class	

Table 7.3 presents the data reduction of the observation in a twelfth-grade social science class, from which focus groups E and F are selected. The table includes some particular actions of teacher and students, and the particular time of observation as well as some comments. The topic was limits of functions, which was also a topic of the previous lesson.

The teacher wrote five tasks on the chalkboard, about determining the limits of functions. First, the teacher gave the students some time to attempt the tasks. Then, she began to check the students' solutions. The teacher solved the tasks, finally. While solving the tasks, she frequently provided incomplete sentences and students responded together (as in a choir). She invited a student to solve one of the tasks on the chalkboard. She asked if the students understood, and she gave particular emphasis to the second task. They asked for repetition. She emphasized that the central idea is factorization, and she listed the major techniques of factorization, which pertain to this particular task. She finished the class by informing them of the topic for the next class. She mentioned that they had already attended to the required prior topic in eleventh grade.

The data reduction of the remaining three classes exposes more or less similar classroom situations. Table 7.4 provides a summary of my classroom observations in the three classes, namely, eleventh social science, eleventh natural science and twelfth natural science.

Table 7.4. Brief summary of observations in the three mathematics classrooms

Grade level and stream	Participating focus groups	Topic and coverage time	Teacher begins with	Teacher ends with
Eleventh Social science	A and B	One-to-one functions.	Introducing types of functions	Asking if things are clear; took attendance
Eleventh natural science	C and D	Rational expressions; decomposing into partial fractions.	Revising previous lessons; ask questions; provide incomplete sentences	Give homework, inform next topic. Respond to a question
Twelfth natural science	G and H	Limits of functions.	Revising the previous lesson, ask questions.	Checking students' solutions.

During the classroom observation in the twelfth-grade natural science class, the topic was the same as the one for the twelfth-grade social science class; namely, limits of functions. The teacher began with revising the previous lesson, through considering an example from the previous lesson. He gave classwork, which he wrote on the chalkboard. The students copied, and were discussing with each other when they were doing the classwork. Some students asked questions and the teacher responded. The teacher did not have time to conclude the lesson because the bell rang as he was checking students' solutions and discussing with individual students.

As presented in Table 7.4, the topic during the classroom observation in the eleventh-grade natural science class was about rational expressions, particularly about decomposing into partial fractions. The lesson was a continuation of the previous class. The teacher started with revising the main ideas of the lesson and went on to solving the tasks that he gave to the students in the previous class. The teacher solved the tasks. The teacher did not check the students' solutions. He invited the student to tell the next step, usually by providing an incomplete sentence that students should complete. Apart from the first six minutes he use for revising the previous lesson, the teacher used nearly all the period for solving the homework both of which are about the same topic, rational expressions. As he finished revising the previous lesson about partial fractions, a student asked a question. The question pertains to the factorization of polynomials. Finally, the teacher gave homework, and he finished the class by mentioning the topic for the next class.

During the classroom observation in the eleventh-grade social science class, the topic was different from the one for the eleventh-grade natural science class. They were in the first unit. According to the students, they lagged behind because the teacher was sick and absent for few weeks. The teacher began the class with a brief revision of previous lesson, which was about functions and classifications of functions. He gave an example and discussed about it. The students listened and copied. The teacher elaborated more in Amharic still using some English and mathematical terms. A student requested the teacher to explain it again because he did not understand the concept about one-to-one function. The teacher started to explain it in Amharic. However, he began to struggle to explain it as fluently as he had done few minutes earlier in English with few Amharic words. He went on discussing the concept in Amharic; he used some English and mathematics terms.

There are some common features in the mathematics classes. During my classroom observation, I observed that the teachers use both Amharic and English language. In all the four classes, the televisions were closed. The teachers come to class with the textbook; the students did not have the new textbook yet. The lessons also involve little connection with out-of-school lives, other school subjects or any connection with future topics within preparatory or students' future fields of studies. For example, the twelfth-grade students use the concept of limit in the next unit, which is about derivatives. However, during my classroom observation, the twelfth-grade teachers did not refer to future use of the limit concept. The participants of the interviews who are from one of these classes complain about the absence of such connections (see Melkamu's and Haleluya's stories in section 7.4). The students also mentioned that the lessons lack rationale for learning of the topics.

Similarly, partial fractions, which the eleventh-grade natural science students were taught, are useful in the integration of rational functions, a topic in twelfth grade. During my classroom observation, the teachers made no such connections. During my classroom observation, I did not hear from the teachers about rationale for learning of the topics. However, the lessons during my classroom observations are mostly continuations of the previous lessons, and I am not sure if the teachers made such connections or mentioned some rationale in previous classes.

I kept written notes of my conversations with the mathematics teachers, and I used some of them as data with the teachers' consent (see section 4.3.3.2). Though I presented preliminary results of the pilot data for the mathematics teachers, they provided their reflections usually when we met individually. For example, the comment about learning mathematics through the plasma came in such occasions, and when I met teachers in the mathematics department and the school's cafeteria. They told about their experiences with the plasma. They told me that there was little time left for them. It was 12 minutes for the teacher and 30 minutes for the video teacher. The teacher has to turn on the television, give a quick introduction in two minutes and leave the floor to the video teacher. In the last 10 minutes, the teacher has to give a concluding remark.

The teachers provided information about the textbook. I obtained information from them about the old textbook; particularly, about which of the units are allocated to the social science stream and those allocated to the natural science stream. The teachers provided information, which are related to the change of textbook. For example, they informed me about gaps that occurred in the transition from the old textbook into the new one. Among others, there are topics, which are no longer available in the preparatory mathematics. These topics include polynomial, exponential and logarithmic functions. According to some teachers, closing the gaps involves some challenge in terms of time, as the textbook is already too broad to cover within the available time.

According to the teachers, the new textbook was not ready at the beginning of the academic year. They received copies of few units of the new textbook as they begin the academic year. They still used the old textbook. For example, they give homework to the students from the old textbook. The students did not have the new copies and they used the old textbook. Some teachers also showed concern about the frequency of change of the textbooks. Other information, which teachers provided is about the availability of tutorial services of school subjects in churches. I obtained this information from Christian teachers.

There are also cases where teachers provided information, which expose the schooling activity. The teachers informed me about the streams, to which the students belong. There are also cases where information about school rules is obtained from the teachers. For example, they informed me about rules that two examinations (mid-term and final examinations) are administered each semester. They also informed me about rules in using the textbook, in particular, that bringing the textbook to mathematics class is mandatory, and that classwork and homework are given to the students from the textbook.

This subsection provided a brief description of the mathematics classroom based on observation and conversation with the teachers. This section together with sections 7.3.1 and 7.3.2 as well as the background information given in Chapter 1 outline part of the sociocultural context of learning mathematics in an Ethiopian preparatory school, and the context in which the perceptions of the relevance of mathematics emerge.

7.4 Data presentation and analysis

The students in this study participate in a network of activity systems. They participate mainly in the activity of schooling. In their out-of-school lives, they participate in the activity of family-life. They also participate in other activities, which are work, game and church or mosque.

I present the analysis in two major categories: relevance relating to out-of-school experiences and relevance relating to school experiences. I present the categories in this order. Each category is divided further into sub-categories. Each category begins with a glimpse of the textbook and ends with a coda. The remaining sub-categories, which are named after the respective characterisations of perceptions of relevance, are dedicated to the characterisations and the associated constructs such as attitude, belief and motivation. Descriptions of the characterisations are available at the beginning of each category.

Each sub-category has dimensions, which in turn have, properties. In each sub-category, I present some of the excerpts of students' stories to illustrate the respective dimensions and their properties. I present excerpts from the same informant, which expose the various dimensions and properties, together; instead of splitting the excerpt among the pertaining dimensions and properties. The intention is to let the reader see constructs associated with perceptions of relevance and relations as stated by the informant. The codes in the curly brackets help the reader to recognize each of these constructs.

In the excerpts, I put the codes in curly brackets as in {codes}. At the end of each excerpt, I write the pseudonyms together with the focus group (FG) names, in a bracket as in [pseudonym, FG A]. The letters represent names of focus groups. Table 7.1 presents these names and pseudonyms. Appendix 5 presents additional excerpts, to which I refer in the current section using numbers. I write the numbers following the participants' pseudonyms, as in pseudonym [number]. In few occasions, I reproduced some excerpts from the pilot study in this section. In such occasions, I add 'pilot' to the names of the focus groups as in FG A_pilot.

7.4.1 Dimensions and properties

The interpretations of students' words exposed sub-categories with several dimensions and properties. At this stage, I will describe these dimensions and properties in general terms, and how they emerge in the data. Then, I use them in the analysis later.

7.4.1.1 Dimensions

This section presents descriptions of the dimensions to the sub-categories. There are eight dimensions. These dimensions are proximity of experience, type of relation, rationale, motivation, beliefs, attitudes, emotion and mediation. I follow the literature in describing these dimensions except for the two. I describe the two dimensions 'type of relation' and 'proximity of experience' based on the data.

Proximity of experience — this dimension refers to whether the experience is first-hand or informed by other sources. It emerges in the data in the students' words which they express as experienced for her- / himself (first-hand experience); experienced in other school subjects; experienced by 'observing' a family member; experienced by reflecting on local culture; experienced by being told (as the textbook, teacher or a family member tells them).

Type of relation — this dimension is about what type of relation that mathematics has with other school subjects. The dimension appears mainly in one sub-category, particularly, in "it relates to other school subjects." It emerges in the data in the students' assertions, where they express how they experience the relation between mathematics and other subjects. They experience the relation in terms of *usefulness* in other school subjects. The students also assert that they experience the relation as having *shared features* with other subjects, where performing in those subjects enhances possibility of performance in mathematics. This shared feature involves students' attitudes. That is, they experience the relation in terms of shared attitude with other subjects. On the contrary, the relation can be negative, where mathematics has a *contrasting feature* from other subjects. This perception of relation exposes beliefs about learning mathematics. They also experience the relation in terms of *competition* among the school subjects for the students' attention and time. Except for "usefulness," this dimension appears only in the sub-category, "it relates to other school subject." Usefulness is available in the sub-categories, "it is useful in everyday life" and "it is useful in unknown future."

Emotions — I follow Philipp (2007) in understanding emotions as feelings. Emotions can emerge in the data in the students' words. Students' assertions such as feeling of surprise are recognized as expressions of emotions. In some cases, emotions can be read from their faces and the changing tone of their voices as they explain absence or presence of mathematics' relevance.

Attitudes — I follow McLeod (1992) in understanding attitudes as emotional dispositions. Attitudes can emerge in the data in the students' words as hate, boring, not boring, like and do not like (e.g. Di Martino & Zan, 2010).

Beliefs —There are particularly two types of beliefs in relation with mathematics, which emerge in the data. These are beliefs about what counts as mathematics (e.g. Presmeg, 2002) and beliefs about learning of mathematics (e.g. Op't Eynde et al., 2002). Following Philipp (2007), students' understandings, premises, or propositions, which they hold to be true, about what counts as mathematics (e.g. Presmeg, 2002) and about learning of mathematics (e.g. Op't Eynde et al., 2002) are recognized as beliefs. They emerge in the data in the students' assertions where they are unable to recognize the mathematics in their own examples, and in their assertions of learning mathematics comparing to learning other subjects, respectively.

Motivation — I follow Hannula (2006) and understand motivation as "the inclination to do certain things and avoid doing some others" (Hannula 2006, p. 165). Students' inclination to engage in mathematics emerges in the data in the students' expressions as "I used to work hard before but now …;" "I consider shifting to subjects which I can perform better;" "I have the motivation to learn specific mathematics topics or concepts;" "I have to work now." The source of the students' inclinations can be diverse. Consistent with Roth (2007) students' inclination can be based on the emotional reward that engaging in mathematics can promise. This emerges in the data as "I engage because I derive pleasure from being successful;" "I engage because I want to avoid feeling ashamed."

Rationale — following Mellin-Olsen (1987) rationale is understood as the logic for learning of mathematics or inclusion of specific mathematics topics such that the student uses them to convince oneself to engage in mathematics. Rationale emerges in the data in the students' assertions about availability or absence of it in the artefacts used for learning mathematics. For example, students mention that the preparatory mathematics lessons are short of rationale with respect to the everyday-life use of mathematics as well as with respect to its use in other disciplines. It emerges in the students' expressions as, comparing mathematics with other school subjects "we do not see any use tracing back in the past or in the future;" comparing mathematics, which does not even state its rationale, with other school subjects, which show their use in everyday life.

Mediation — Mediation refers to the existence of something, which serves as a means of interaction, between the individual and the sociocultural context (Vygotsky, 1978). In particular, they mediate interaction between the individual and the object (Kuutti, 1996). They also mediate the interactions between the individual and the community as well as between the community and the object (ibid). There are particular means, which emerge in the data including signs such as the division of labour and rules (ibid). The manner in which perception of relevance is mediated includes by directing the students' attention (e.g. Vygotsky, 1978) to and providing information about the possible relevance of mathematics (i.e., the connections with the other school subjects, everyday life, etc.). Consistent with Mellin-Olsen (1987) it can also be by denying or allowing the student access to information or explicit exposition of the relevance of mathematics. The manner in which perception of relevance is mediated can also be by availing or depriving the rationale for the particular topics (ibid). Consistent with Engeström (1999) and Kuutti (1996) it can also be by creating an enabling or limiting situation. For example, the artefacts sometimes offer opportunities and might direct the students' attentions to the possible connections of mathematics concepts and everyday life. At other times, they deny opportunities and might direct the students' attentions to the possible disconnections/ gaps between mathematics and everyday life. The artefacts might also direct the students' attentions to the possible disconnections of mathematics through availing or omitting the names of the other school subjects, to which the mathematics concepts relate or by avoiding explicit exposition of mathematics' use in the subjects. Community members can mediate through emphasizing specific experiences, or through interpreting, amplifying them, or else by selecting one instead of the other (Kozulin, 1998).

In this section, I attempted to describe dimensions briefly. These dimensions have properties, which are the subject of the next section.

7.4.1.2 Properties

The properties, which this section presents, include strength of influence, direction of influence and direction of relation.

Strength of influence — it is measured by how convincing the experience is, which is based on the level of specificity of the experience. The more specific the examples, the more convincing the experiences. That is, the students' statements that specific mathematics topic/concept is useful/ not useful for specific purpose or in a specific activity determines if the influence is strong. This emerges in the data as students' provision of mathematical or other experiences, which may or may not involve specific example of mathematics and specific activities or experiences.

Direction of influence — this property is about influences of the mathematical experiences in terms of time, which can be prospective or retrospective. This emerges in the data as mentioning of mathematical experiences learnt prior to preparatory or mathematical experiences learnt in preparatory, and their influence on the prior, current or future learning.

Direction of relation — this property is mainly for the characterisation of perception of mathematics' relevance to other school subjects. It is about whether the direction of mathematics' relation, for example to other school subjects, is one- or two-directional. When it is one-directional relation, it can be from mathematics to other school subjects or vice-versa. This emerges in the data as, 'what is true for mathematics is also true for related school subjects.' It can also be vice-versa. It can also emerge as, 'if a student gives more time for mathematics, then the student gives lesser time for other school subjects and vice-versa.'

These properties and dimensions are used in the sub-categories, which present the characterisations of students' perceptions of relevance (see sections 7.4.2 and 7.4.3).

7.4.2 Relevance relating to out-of-school experiences

In their out-of-school lives, the students participate in different activities. These activities are historically situated and they existed long before the students came into being. These activities are parts of an Ethiopian culture in which there are artefacts, rules, and division of labour. There are also some activities, in which the students might not participate directly, but they obtain information about these activities through other people with whom they participate in other activities. Students might encounter mathematics' use due to their direct or indirect access to those activities.

In this section, three characterisations of perceptions of relevance are reported. Descriptions of these characterisations of perceptions of relevance are provided here. The first characterisation is about students' explanations of the everyday use of mathematics in buying, selling, and transportation. It also includes students' explanations of the use of mathematics in traditional institutions and offices as well as explanations of the use of mathematics in undertaking domestic responsibilities at home such as budgeting family expenditure. These are categorized as, “mathematics is relevant because it is useful in everyday life.” I also refer to this sub-category as “it is useful in everyday life” in shorthand form. The usefulness may not be direct. For example, students mention other subjects, which use mathematics and have uses in everyday life. This is also categorized as mathematics’ use in everyday life.

Students’ inventive use of mathematics to view their lives in a different way is categorized as, “mathematics is relevant because it gives a fresh perspective on life.” On the other hand, students describe the learning of mathematics, which is deprived of usefulness in everyday life, or lacks a rationale in terms of usefulness in everyday life, as a characteristic of learning mathematics in an Ethiopian situation. These are stories, which show their sense of recognition of themselves or their society as such. These are categorized as, “mathematics is relevant because it gives a national identity.” In shorthand forms, I also refer to these sub-categories as “it gives a fresh perspective on life,” and “it gives a national identity,” respectively. Figure 7.1 presents a summary of the sub-categories.

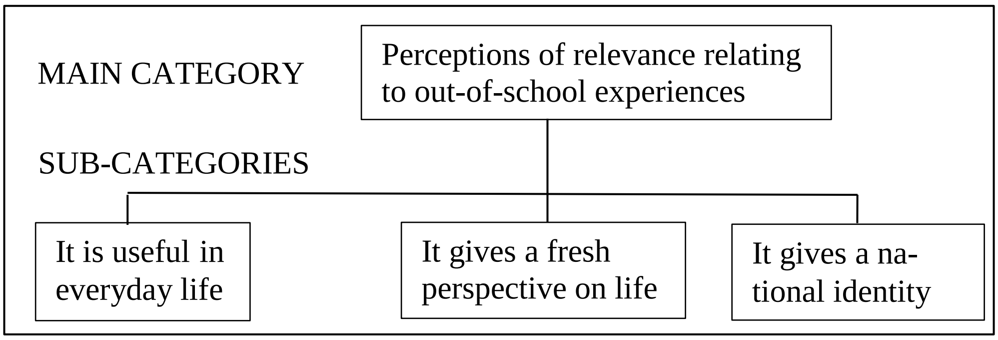


Figure 7.1: sub-categories of perceptions of relevance relating to out-of-school experiences

The sub-categories also present other constructs, which are associated with the characterisations. In Table 7.5, percentage of the contributions of the focus groups (Focus Groups A to H) to each of the sub-categories are presented. As presented in the table, each of the focus group includes three students of the same grade level, the same stream, and the same sex. Some of the interview groups did not contribute to some of the sub-categories at all. For example, only one group contributed to the sub-category, “It gives a fresh perspective on life.”

Table 7.5: Data source for perceptions of relevance relating to out-of-school experiences

Sub-category	Source of evidence (the eight interview groups)	Percentage of contributions
It is useful in every-day life	Focus Group A: Female, eleventh, social science	12.5 %
	Focus Group B: Male, eleventh, social science	12.5 %
	Focus Group C: Female, eleventh, natural science	12.5 %
	Focus Group D: Male, eleventh, natural science	12.5 %
	Focus Group E: Female, twelfth, social science	12.5 %
	Focus Group F: Male, twelfth, social science	12.5 %
	Focus Group G: Female, twelfth, natural science	12.5 %
	Focus Group H: Male, twelfth, natural science	12.5 %
It gives a fresh perspective on life	Focus Group D: Male, eleventh, natural science	100 %
It gives a national identity	Focus Group D: Male, eleventh, natural science	50 %
	Focus Group F: Male, twelfth, social science	50 %

The sub-categories are presented in the same order as in Table 7.5. The section begins with a glimpse of the textbook pertaining to students' stories about relevance to out-of-school experiences and ends with a coda.

7.4.2.1 A glimpse of the textbook pertaining to out-of-school experiences

This section presents a short overview of some selected topics of the textbook because some students spoke about these topics in relation to out-of-school experiences. Some general issues, which provide background to the characterisations of perceptions of relevance reported in this section, are also exposed.

The topics students mentioned during the interviews include statistics and probability. The old eleventh-grade textbook does not have these topics (Ministry of Education, 2006a). However, in the new eleventh-grade textbook, there is a unit about statistics and probability (Federal Democratic Republic of Ethiopia Ministry of Education, 2010b). The new eleventh-grade textbook does not have an introduction, but each unit starts with an introductory section. The introductory section of the unit on statistics and probability provides a historical note about statistics and taxation in another country. The unit does not make clear why the students should learn these concepts. The unit contains tasks, which include the experiments of drawing a ball from a bag; inviting friends; playing cards; soccer games, etc. These are familiar events, which seem to relate to students' lives.

This unit of the new textbook presents other applications of the mathematics concepts. For example, a section about "introduction to grouped data" explains various concepts using data about the number of patients that a doctor sees in a month; the weights of patients in a hospital; students' test scores; circumferences of trees and wheat harvest in quintals (FDREME, 2010b, p. 149). Another section about "measures of location for grouped data" explains various concepts using data about number of items an electronics shop sold; students' test scores and quintals of fertilizers used (FDREME, 2010b, p. 155). These tasks can be important to show to the students the usefulness of mathematics concepts. I report in the next sections that students experience the usefulness of the concepts of this unit to the workplace, which have relevance to the society. However, the sources of information about the relevance are usually the out-of-school activities. In their out-of-school lives, the students either experience it in the workplace, directly or experience it through other people.

As it is set out in the next sections, some students are critical of the mathematics they learn in its ignorance of everyday use of mathematics by comparing with the other school subjects, which they perceive to have everyday uses. Some of the mathematics topics that students mentioned during the interviews are now available in the new eleventh-grade textbook and the twelfth-grade textbook. In particular, the new eleventh-grade textbook contains a unit called, "Mathematical applications in business" (Federal Democratic Republic of Ethiopia Ministry of Education, 2010b, p. 425). The new twelfth-grade textbook contains a unit called, "Mathematical applications for business and consumers" (Federal Democratic Republic of Ethiopia Ministry of Education, 2010c, p. 370). The old textbooks of both grade levels do not have these units. However, some of the topics of the unit about business such as compound interest are available in the old eleventh-grade textbook (see Appendix 1).

There are some features of the textbook, which might not relate to the students' situations. For example, in the beginning of the ninth unit of the new twelfth-grade textbook, there is a picture about currency of different countries (FDREME, 2010c). However, I could not find any Ethiopian currency in the picture. As in the new eleventh-grade textbook, there are historical notes available in the units of the new twelfth-grade textbook, which are not about Ethiopia. The notes include some history about mathematicians.

The students also mentioned the vastness of the textbook as a problem. The old eleventh-grade textbook has 438 pages (MoE, 2006a). The number of pages for the new eleventh-grade textbook is 474 (FDREME, 2010b). The old twelfth-grade textbook has 341 pages (Ministry of Education, 2006b). The number of pages for the new twelfth-grade textbook is 393 (FDREME, 2010c). In both grade levels, the new textbooks have more pages than the old ones probably because more topics are covered in the new ones than in the old ones (see Appendix 1). The eleventh-grade textbook has more pages than the twelfth-grade textbook. This is true for both the old and the new textbooks. This is probably because of the fact that more topics are covered in eleventh-grade than in twelfth-grade (see Appendix 1). As I set out in Appendix 1, the eleventh-grade textbooks have two more units than the twelfth-grade textbooks.

In general, the textbooks give little attention to provision of rationale of the topics except that for some of the units they include some text in their introduction. In section 7.4.3.1, I re-examine some of these topics. There are other topics of the textbook such as *rate*, which are also useful for students' stories reported in this category, but are dealt in the section 7.4.3.1. The textbook possibly influences the students' perceptions of relevance. The following subsections expose the diverse characterisations of perceptions of relevance about school-related experiences.

7.4.2.2 Mathematics is relevant because it is useful in everyday life

The data reported here are generated based on the interview question, whether mathematics is useful in everyday life. Some of the data are generated based on the same question, but specific to preparatory mathematics. The responses to these questions are diverse. I present some of the responses, which pertain to the perceptions of mathematics' use in everyday life and the associated constructs.

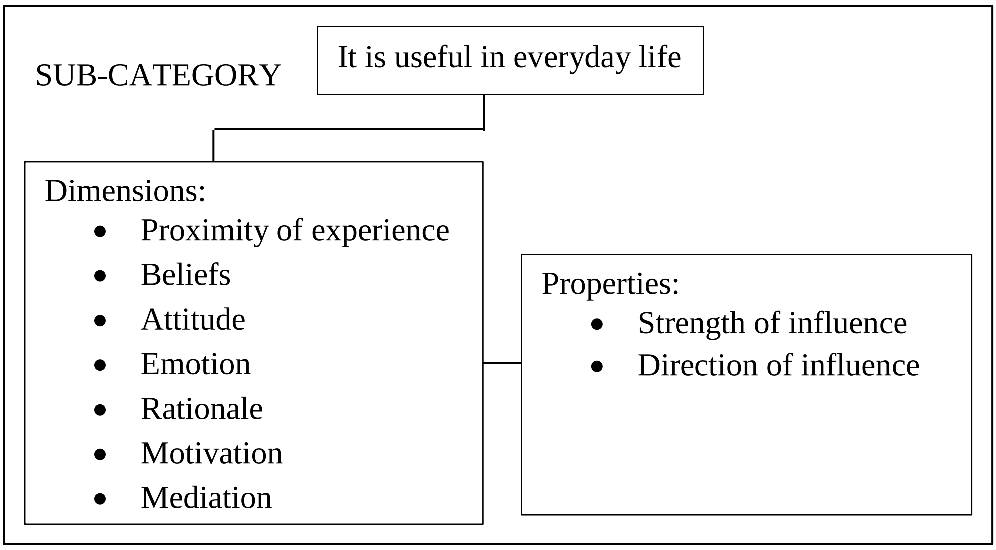


Figure 7.2: Dimensions and their properties for the sub-category about "it is useful in everyday life"

Figure 7.2 provides the dimensions and their properties. I set out the seven dimensions in this order. Then, I present their properties. I start with the proximity of experience. In the exposition of their perceptions of mathematics' relevance to everyday life students mention some examples, which they experienced by themselves, experienced in other subjects, experienced by reflecting on local culture, experienced by being told (by the teacher, textbook or media) and experienced by observing family members. I provide some examples to illustrate the proximity of experience. The students seem to experience mathematics' relevance by themselves (e.g. Ayana's and Hanan's [1] stories). Ayana says:

> I calculate the bill for electricity of our house ... {expressing mathematics' use in the activities in the society, family-life activity, expressing role}. When playing pool, we use numbers {expressing mathematics' use in leisure time activity, game activity}. [Ayana, FG H]

Hanan's story may be an example, among others, for experiencing mathematics by reflecting on local culture. It can also be an example where students can have direct access to the activities of Edir and Equb (see section 1.4). The students might also experience everyday life use of mathematics by being told by the teacher or the textbook (e.g. Robel's story). Robel says:

> In playing cards, though I do not play, there is the concept of probability {expressing preparatory mathematics' use in leisure time activity, game activity, expressing role}. We also learnt it in mathematics {expressing preparatory mathematics' use in leisure time activity, expressing artefact, the lesson}. [Robel, FG H]

Robel brings two activities to our attention: the game activity and the schooling activity. The mathematics lessons in the schooling activity provide the application of probability in the out-of-school activity of game (e.g. Robel's story). Students' access to the game activity may not be direct (e.g. Robel's story). Students' access to the game activity might be through other people, whom students might meet in another activity. It is also possible that they have other role such as an onlooker.

There might be occasions where students experience mathematics' relevance through the media (e.g. Hanan's story). Hanan did not mention her source about the experience of counting in elections. However, it was set out earlier in Chapter 1 that the data collection was held few months before the national and regional elections, and the communication media was busy with related news and advertisements. It is highly probable that the media is the source of information about counting votes in elections. Students can also experience mathematics' use in everyday life in other subjects (e.g. Haleluya's and Melkamu's [2] stories). Haleluya says:

> Other subjects are about everyday life: in geography, you learn about mountains, and all about what you can see. It is the same for economics and business, except languages. However, even languages, they are about culture; they describe history, and social issues {expressing other-subject's use in activities in the society}. You learn them with interest {expressing comparative inclination}. You would think, "Oh, is it like that in my language, the culture is like this? {expressing emotional reward in other school subjects} …, when the supply becomes low, the price goes up," and so on. However, there is no such thing in mathematics

{expressing lack of mathematics' use in the activities in the society, expressing proposition about what counts as mathematics}. [Haleluya, FG F]

This is an example, where students experience mathematics' use in everyday life through other school subjects; however, without being aware that this is the case. In this case, students perceive that, unlike the other school subjects, mathematics is not relevant to everyday life. Other students are aware that mathematics is available in the other school subjects and perceive that mathematics is useful in everyday life through other school subjects (e.g. Debesh's story in section 5.3.1.1).

The second dimension is beliefs. The students' beliefs about what counts as mathematics can have influence on this characterisation of students' perceptions of the relevance of mathematics (e.g. Haleluya's story). It seems that for some students relationships between quantities do not count as mathematics. Their beliefs about what counts as mathematics might have influence also on the level of mathematics concepts they consider in their examples, which are mostly from mathematics in lower grade levels. The preparatory mathematics' use, which they mentioned are limited to statistics and probability (e.g. Robel's and Eyasu's [3] stories). The third dimension is attitude. Students' perceptions of relevance relate to their attitudes (e.g. Fikadu's story). He says:

> You might think, this much is enough for local application, but you also think, "Let me see till the end" {expressing mathematics' use in activities in the society} though it is boring {expressing emotional disposition} …. I used to work hard before {expressing comparative inclination}. Now I ask myself why I need it {expressing the logic for learning mathematics}. [Fikadu, FG D]

The fourth dimension is emotion. In some cases, emotions could be read from their faces and voices (e.g. Haleluya). As Haleluya tells his story, the frustration that he experienced because of the absence of connection between mathematics and everyday life could be read from his face and the changing tone of his voice.

The fifth and sixth dimensions are rationale and motivation. The students perceive that they need some rationale for the learning of preparatory mathematics (e.g. Fikadu's, Eyasu's and Melkamu's stories). The absence or availability of everyday use of mathematics can have motivational influence in engaging in mathematics (e.g. Haleluya's story).

The seventh dimension is mediation. For example, in the two activities, Edir and Equb, there are rules and division of labour. According to the rules, members must contribute money. There are people assigned for collecting money. As I set out earlier in this section, the students might have direct or indirect access to the activities of Edir and Equb (e.g. Hanan's story). The students might participate by going with their parents or if their parents request them to go and do the monthly payments for them. Parents might interpret the actions undertaken in these activities to the students. The students' roles in direct involvement in these activities may mediate their perceptions of relevance through directing their attention to mathematics' connections to these activities. The students can also have indirect access through their parents. In their roles of enhancing the students' personal development, parents share to the child their experiences in those activities. The roles of parents and students in the family-life activity mediate perceptions of relevance.

In the schooling activity, the mathematics lessons might mediate the students' perceptions of relevance by providing (e.g. Robel's story) or depriving the everyday life use of mathematics or the lesson's rationale with respect to the everyday life use of mathematics (e.g. Melkamu's story). Besides, the lessons of the other school subjects mediate students' perceptions of relevance. These lessons do expose the mathematics they use (e.g. Akalu's [4] story) or do not explicitly expose it (e.g. Haleluya's and Melkamu's stories). The lessons of the other school subjects direct students' attention to this connection (or disconnection) by providing (or denying) the explicit exposition of the connections.

These dimensions have properties. One of these properties is strength of influence. For example, in the "proximity of experience" dimension, the influence of "experienced by themselves," and "experienced by being told," are strong. On the other hand, the influence of "experienced by reflecting on local culture" (e.g., Hanan's story) and "experienced in other school subject" (e.g., Haleluya's story) are not as strong as the other two. The reason is that the students did not mention specific mathematics concept used. Similarly, influence of the dimensions, rationale and motivation are not so strong since they are not substantiated by specific concepts and experiences. The dimension, beliefs is stronger (e.g., Haleluya's story) because it is a specific concept of economics. The mathematics concept is also specific, though Haleluya did not acknowledge the mathematics. For the mediation dimension, the strength of influence is weak in the sense that the students' examples are not specific enough about the situation to enable exposing the mediational processes (e.g., Hanan's story).

The direction of influence is another property of the dimensions, which can be prospective or retrospective. The direction of influence for the dimension proximity of experiences are retrospective in the sense that the experience they talk about are based on elementary mathematics. They are rarely based on preparatory mathematics and they are not about future use of preparatory mathematics (e.g. Hanan's story). On the other hand, the direction of influence of the dimensions, rationale and motivation are prospective (e.g., Melkamu's story) because students want to see relevance of the current learning, which could be about current activities or activities to which they might have access in the feature.

The students perceive that mathematics, in general, is relevant to everyday life. However, they perceive that preparatory mathematics' use in everyday life is limited. The characterisations of perceptions of relevance, which are set out in the next section pertains to preparatory mathematics.

7.4.2.3 Mathematics is relevant because it gives fresh perspective on life

The students participate in the school activity where learning mathematics is part of the object. They also participate in activities in their out-of-school lives. As part of their participation in the family-life activity, the students take actions towards enhancing their personal development. The data reported here are students' responses to the interview question, whether preparatory mathematics is useful in everyday life. This is a follow up question to the same question about mathematics in general. This section focuses on responses, which pertain to their perceptions of mathematics' relevance as providing a fresh perspective on life. Figure 7.3 provides the dimensions and their properties for this sub-category.

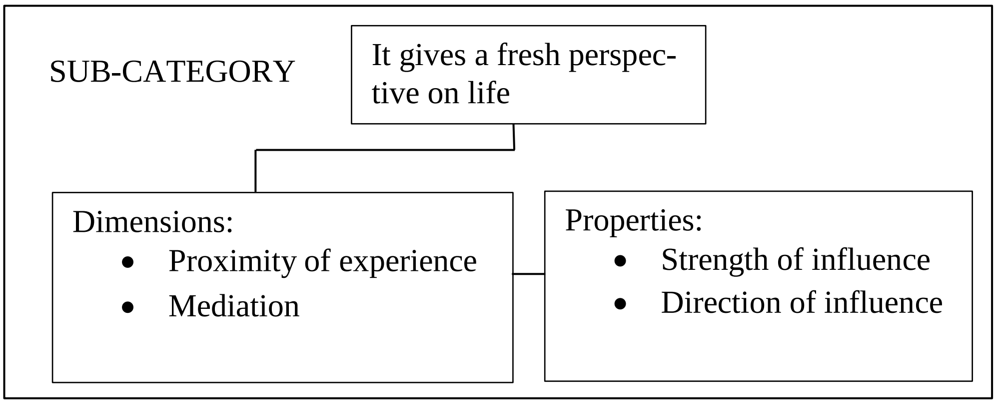


Figure 7.3: Dimensions and their properties for the sub-category about "It gives a fresh perspective on life."

Figure 7.3 displays the two dimensions of the sub-category. The dimensions are proximity of experience and the manner in which the relation is mediated. I start with the proximity of experience. The students provide examples, which expose their perceptions of mathematics' relevance that it gives a fresh perspective on life. This can be experienced by reflecting on personal observations (e.g. Eyasu's story). Eyasu says:

> The advantage of mathematics for me is since a mathematical problem could be solved in many ways, I learnt to see things not from one angle only but from different angles {expressing mathematics as providing a fresh perspective on life}... When I am solving some mathematical problem I make mistakes and people show me how I should do it in another way {expressing role}, and I learnt to see another direction. Thus, in life also I learnt to see and tackle things in many directions {expressing mathematics as providing a fresh perspective on life}. [Eyasu, FG D]

Students can also experience the relevance by reflecting on local culture (e.g. Hayal's and Makida's stories in section 5.3.1.2). I reproduce Hayal's story here:

> I brought the idea of limit {expressing the object of the schooling activity} to my life and interpreted it as, there is time when life ends; all the things that bother me together with my life in this world, come to an end, and begin the new life in heaven {expressing mathematics as providing a fresh perspective on life}… I have not seen any explicit application [of preparatory mathematics] yet {expressing lack of usefulness of mathematics in everyday life}. [Hayal, FG G_Pilot]

The other dimension is mediation. The students can obtain others' helps in both the schooling and the family-life activities. This is in accordance with the division of labour in those activities. As students undertake actions such as engaging in mathematics towards the goal of learning mathematics or solving mathematical problems, the division of labour mediates their perceptions of relevance through directing their attentions to seeking for alternative ways of approaching a problem (e.g Eyasu's story). Students participate in the schooling activity, where they attend to mathematics classes. The artefacts mediate their actions. These artefacts, which present limited applications of the mathematics concepts, also can direct their attentions to searching for other sources, from which they can find or impose relevance (e.g. Eyasu's, Hayal's and Makida's stories).

The students participate in the out-of-school activities. Particularly, as part of the rule in the family-life activity, parents encourage children to go to Church or Mosque. The artefacts in these activity systems such as the religious teachings mediate students' perceptions of relevance (e.g. Hayal's and Makida's stories). Hayal gives a spiritual meaning to the concept of limit, when she is looking at her life as function of time whose limit at a certain time gives a static life after death, which she believes in. Makida, a member of the same interview group, tells a similar story. The religious teachings mediate their perceptions of relevance through directing their attentions to alternative lines of thought and through availing a theory, which students can attempt to reflect their mathematical knowledge.

The strength of influence is one of the properties for the dimensions of the sub-category, "it gives a fresh perspective on life". There is variation in the properties within and across dimensions. For example, in the proximity of experience dimension, the strength of influence of "experienced by reflecting on personal observations" (e.g. Eyasu's, story) is less than that of "experienced by reflecting on local culture" (e.g. Hayal's and Makida's stories). This variation is because of the specificity of the mathematics topics, which students mentioned. For the same reason the strength of influence for mediation dimension is relatively weak. The direction of influence is another property. The direction of influence of the dimension, proximity of experiences, is prospective. The reason is that the students' statements are about the current, which possibly influences the future.

In this section, I presented perceptions of the relevance of mathematics, which is characterised by, "it gives a fresh perspective on life." The students tell stories in which they use the mathematics lessons they learn in the preparatory school to view their lives differently. The conflicting situation that students experience and the students' power /capability to act are important in this perception of mathematics' relevance. These issues are further considered in Chapter 8.

7.4.2.4 Mathematics is relevant because it gives a national identity

This section sets out the perception of mathematics' relevance, which is characterised by a national identity. The data are generated based on the question specific to preparatory mathematics, which is a follow up to the question, if mathematics is useful in everyday life. The students describe themselves as Ethiopians who are learning mathematics, which has hardly any use in their lives or in their society. Attitude and motivation are associated with this characterisation of perception of relevance.

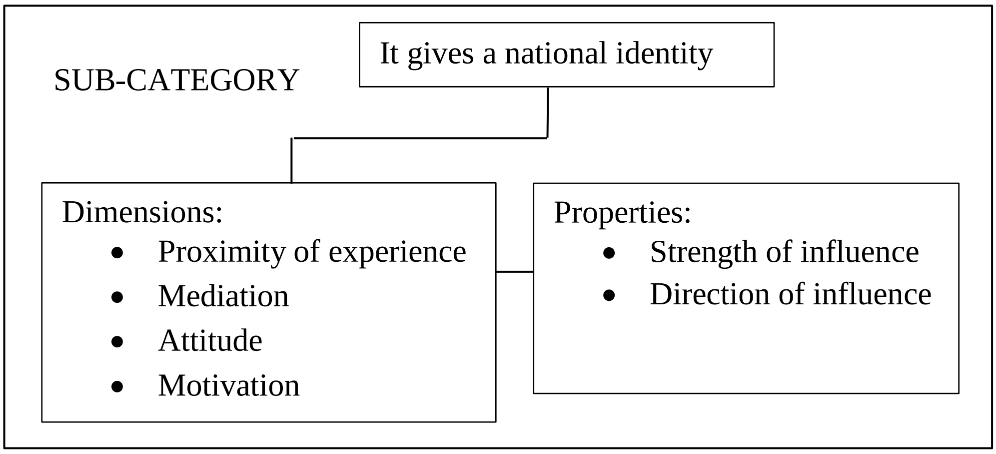


Figure 7.4: Dimensions and their properties for the sub-category about "It gives a national identity"

As set out in Figure 7.4, there are four dimensions in this sub-category. They are set out in the same order. I start with proximity of experience. The students may experience the relevance by themselves or experience by being told (by the teacher, textbook or media). Students seem to experience lack of usefulness of mathematics in their society by themselves (e.g. Ibrahim's story in Chapter 5). I reproduce Ibrahim's story here. The following excerpt is part of his response to my question about whether mathematics is useful in everyday life:

> The mathematics we learn {expressing the object of the schooling activity} is not used in the society {expressing lack of usefulness of mathematics in the activities in Ethiopian society} because the society is not a developed society {expressing mathematics as giving the basis for recognition of the Ethiopian society as such}. [Ibrahim, FG D_Pilot].

Some students compare mathematics learning in the Ethiopian society with others, and it is not clear from students' stories how they became aware of mathematics learning in other societies (e.g. Akalu's and Haleluya's [5] stories). The following is part of Akalu's response to the question if preparatory mathematics is useful in everyday life. He says:

> I think that is the difference between the others [other countries/ societies] and us. They are more practical {expressing mathematics as giving the basis for recognition of the Ethiopian society with respect to other societies as such}, but we grasp the theory {expressing object/ outcome of the schooling activity} and we get confused where to apply it. That is the problem {expressing the experience of a challenge/ conflict between the objects of the school and the activities of Ethiopian society}. [Akalu, FG D]

The second dimension is mediation. The mathematics lessons and mathematics textbooks mediate students' actions, which they undertake towards the goal of learning mathematics. The students belong to the community of Ethiopian preparatory students. The school rules enforce a nationally designed mathematics curriculum. The rules dictate that members of this community should attend some specific mathematics topics. According to the division of labour, the teacher has the responsibility of executing the curriculum and the students' role is usually following what the teacher tells them to do.

The mathematics lessons and textbooks; the school rules, and the division of labour mediate students' perceptions of relevance through directing their attentions to the connections and disconnections to their everyday lives (e.g. Akalu's and Haleluya's stories). The mathematics lessons and the textbooks direct students' attentions to the available gaps. These artefacts offer mathematics topics with limited applications. The school rules mediate students' perceptions of relevance by enforcing the mathematics curriculum, which have few possible applications in Ethiopian context. The division of labour, which give students the role of grasping the theory and does not allow students to have a clear idea of where to apply them, direct students' attention to develop this perception of relevance (e.g. Akalu's story).

The mathematics lessons and the mathematics textbook mediate students' perceptions of relevance by limiting everyday life usefulness of mathematics in the Ethiopian context. On the other hand, while the other school subjects do show the usefulness of their concepts in the Ethiopian context, they do not seem to explicitly show the mathematics concepts, which they involve. By limiting the explicitness of the mathematics used in them, the lessons of the other school subjects mediate students' perceptions of relevance (e.g. Haleluya's story).

Some students seem to be aware about another schooling activity whose community is supposed to be attending the mathematics topics with applications (e.g. Akalu's story) or the country's own practical situation (e.g. Haleluya's story). The student community with whom students are comparing themselves could be in other societies / countries. That is, those students who are participating in the activity of schooling and attending mathematics curriculum designed not based on the needs of them and their country. Another possibility is that the students, to whom the interviewees are referring, are those who study at foreign community schools. In those schools, the mathematics curriculum is adopted from their respective countries. Their access to such information can be through other students whom they meet in an out-of-school activity. Other possible sources of information are the mathematics lessons, which employ contexts of other countries or contexts foreign to them (e.g. Abebe's story in Chapter 5). I reproduce his story here. The following excerpt is part of Abebe's response to my question about whether mathematics is useful in everyday life:

> … word problems have to be related to our society, things that we know and experience in our lives. Not in some other society. The names when related to our situation {expressing mathematics as giving the basis for recognition of oneself as part of the Ethiopian society}, then we do it with interest {expressing inclination}. When it talks about some world, we do not know – names and places we do not feel that we have any concern about – then it is done in a way we did not understand {expressing incompatibility between the school object (learning mathematics) and object of the activities in the Ethiopian society (using mathematics in the society)}. [Abebe, FG D_Pilot].

Attitude is the third dimension in this sub-category. It is associated with the perception of relevance, which is characterised by, "mathematics gives a national identity." Students perceive that learning mathematics without its uses is boring (e.g Haleluya's story). This sub-category has a fourth dimension, motivation. The students incline to engage when mathematics has connection with the Ethiopian society than when it has connection with other society (e.g. Abebe's story).

The dimensions in this sub-category have properties. There is variation in the strength of influence of the experiences. Some of the experiences, which the students mentioned, are convincing but not to a higher degree because they lack specificity (e.g. Akalu's story). There are other experiences, which have stronger influence (e.g. Haleluya's story). The reason is that specific mathematics concept and experience are mentioned, though negative. The other property is the direction of influence of the experiences. The direction of influence of the experiences is prospective because the students told about their current experiences, which possibly have influence on the future.

The students recognize themselves as such in connection with their attending of a national mathematics curriculum, which has little usefulness in everyday life and their society. This perception of relevance emerges as they participate across the school and out-of-school activities. They appear to find themselves in a conflicting situation between learning mathematics and their out-of-school experiences. This is examined further in Chapter 8.

7.4.2.5 Coda to perceptions relating to out-of-school experiences

In this section, I have presented the students' perceptions of the relevance of mathematics in their out-of-school lives under three subcategories. The students perceive that mathematics in general is relevant to everyday life and their society. However, their perceptions of relevance about preparatory mathematics is different; the students perceive that preparatory mathematics has limited relevance. The preparatory mathematics topics, which the students mentioned, are from statistics and probability. On the other hand, some students inventively use the mathematics concepts or their experiences of learning mathematics to hold a perception that mathematics gives a fresh perspective on life. Some students form a perception that mathematics gives them an identity with respect to mathematics' use in their country, which is characterised by a national identity.

The artefacts, the division of labour and the rules in the schooling and out-of-school activities seem to mediate the students' perceptions of relevance. They sometimes offer opportunities and direct the students' attentions to the possible connections of mathematics concepts and everyday life. At other times, they deny opportunities and direct the students' attentions to the possible disconnections of mathematics concepts and everyday life. The students are attending to mathematics curriculum adopted from other countries. In Chapter 1, I set out the introduction of modern education in the country. I also mentioned that there is concern about whether the school transmits the cultural values of the society (see section 1.3). These form the context in which the students' national identity emerges. This is a collective identity (e.g. Roth & Lee, 2007).

It was set out in Chapter 5 that the students perceive that the relevance of mathematics can be presented in the mathematics classroom using word problems (see section 5.3.1.4). Some of the students expressed their attitudes towards word problems. The eleventh grade social science students were engaging in a number of tasks involving word problems during the classroom observation. The whole lesson of the day was solving these problems. These word problems are available in the textbook as well. Such data is not available in the main study. I provide suggestions for future investigations in Chapter 9 (see section 9.4.4).

The students' perceptions of relevance are understood as emerging from learning of mathematics in an Ethiopian sociocultural context that offers them its artefacts, rules and division of labour. On the other hand, there are individual difference among the students, which can be because of the student's capability to undertake action. This is dealt in Chapter 8.

7.4.3 Relevance relating to school experiences

The students are participating in the activity of schooling, where the motive is attending university. The students undertake actions towards the goals of learning mathematics and other subjects. They also participate in the activity of family-life, where the motive is sustaining the family. The family members undertake actions towards the goal of the students' personal developments. The students have perceptions of mathematics' relevance that are associated with these goals and motives. Four characterisations of perceptions of relevance are identified, which are presented in four sub-categories (see Figure 7.5). Each sub-category depicted in Figure 7.5 presents the characterisations and the associated constructs.

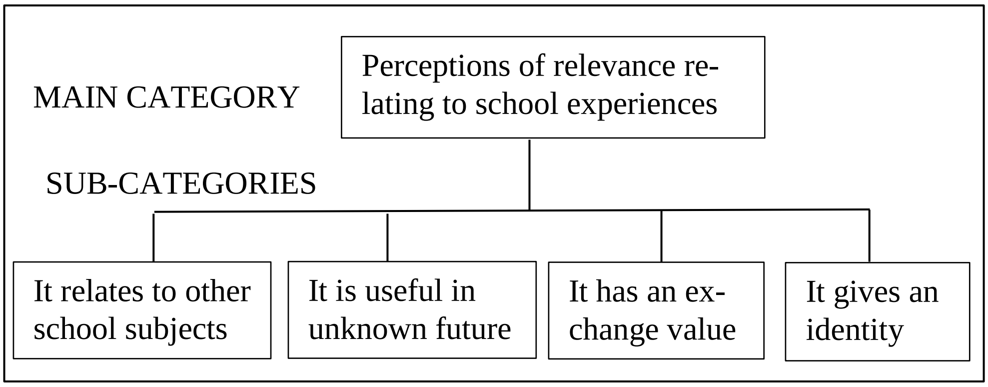


Figure 7.5: sub-categories of perceptions of relevance relating to school experiences.

Table 7.6 illustrates the contributions of each of the focus groups to the data, which establish the sub-categories. The table shows that all the interview groups contributed to the first three sub-categories. Few interview groups contributed to the fourth sub-category, which is about students' identities. However, the data reported under the other characterisations appear to exhibit the students' identities (e.g. Milkias's story in section 7.4.3.3). Further discussion about students' identities is available in sections 7.5 and 7.6.

Table 7.6: Data source for perceptions of relevance relating to school experiences

Sub-category	Source of evidence	Contribution to sub-category
It relates to other school subjects	Focus group A: Female, eleventh, social science	12.5 %
	Focus group B: Male, eleventh, social science	12.5 %
	Focus group C: Female, eleventh, natural science	12.5 %
	Focus group D: Male, eleventh, natural science	12.5 %
	Focus group E: Female, twelfth, social science	12.5 %
	Focus group F: Male, twelfth, social science	12.5 %
	Focus group G: Female, twelfth, natural science	12.5 %
	Focus group H: Male, twelfth, natural science	12.5 %
It is useful in an unknown future	Focus group A: Female, eleventh, social science	12.5 %
	Focus group B: Male, eleventh, social science	12.5 %
	Focus group C: Female, eleventh, natural science	12.5 %
	Focus group D: Male, eleventh, natural science	12.5 %
	Focus group E: Female, twelfth, social science	12.5 %
	Focus group F: Male, twelfth, social science	12.5 %
	Focus group G: Female, twelfth, natural science	12.5 %
	Focus group H: Male, twelfth, natural science	12.5 %
It has an exchange value	Focus group A: Female, eleventh, social science	12.5 %
	Focus group B: Male, eleventh, social science	12.5 %
	Focus group C: Female, eleventh, natural science	12.5 %
	Focus group D: Male, eleventh, natural science	12.5 %
	Focus group E: Female, twelfth, social science	12.5 %
	Focus group F: Male, twelfth, social science	12.5 %
	Focus group G: Female, twelfth, natural science	12.5 %
	Focus group H: Male, twelfth, natural science	12.5 %
It gives an identity	Focus group A: Female, eleventh, social science	50%
	Focus group C: Female, eleventh, natural science	50%

The students learn both mathematics and other school subjects. They explain that mathematics has relationships with other subjects. I categorized such explanations as, “mathematics is relevant because it relates to other subjects” or “it relates to other subjects,” in short hand form. These relationships include mathematics’ usefulness in other subjects. There are other relationships between mathematics and the other school subjects, which are described earlier in this chapter (see section 7.4.1.1).

The students describe what they think of mathematics’ usefulness (or lack of usefulness) in what they want to study in the future. I categorized such descriptions as, “mathematics is relevant because it is useful in an unknown future.” It is unknown because students are describing the relevance of mathematics to a field of study that they have not yet experienced. They also describe what they think about mathematics’ role in obtaining access to what they want to study in the future. The students explain that mathematics determines whether they could be admitted to university. I categorized such explanations as, “mathematics is relevant because it has exchange value.” In short hand form, these are referred to as “it is useful in an unknown future” and “it has exchange value.”

In their stories about mathematics’ relevance, students describe themselves in relation to mathematics in a way, which shows their recognition of themselves as such. Following Roth et al. (2004), recognition of themselves as such is categorized as, “mathematics is relevant because it gives an identity.” Others recognition of them as such is also included in this sub-category. These four characterisations are set out in this order. I start with a glimpse of the textbook.

7.4.3.1 A glimpse of the textbook pertaining to perceptions of relevance relating to school experiences

In this section, I provide a brief glimpse of some selected topics of the textbook that are pertinent to students' stories reported in this section. I attempt to expose if some of the topics are useful in other school subjects, future studies, etc. I provide a brief overview of three of the units of the twelfth-grade textbooks (both the old and the new textbooks). All of these units are about calculus (see Appendix 1), the topic raised by students during the interviews. The fact that the topic has a wider coverage in the textbook also adds to the interest in an overview of the units. I also present a brief overview of a unit in the eleventh-grade textbook. This unit is of interest mainly because students mentioned it in connection with future study. I start with the twelfth-grade textbook. Then I present the eleventh-grade textbook.

I start with the old one. The old twelfth-grade textbook does not have a general introduction, but each unit starts with an introduction (MoE, 2006b). Each of the three units in calculus provides objectives of the respective units and includes a rationale for studying them. For example, Unit 5 has a brief introduction, which provides reasons for learning mathematics in terms of other school subjects:

> It is a fundamental concept of calculus that permits you to consider instantaneous rates of changes as opposed to average rates of change in functional values. [Differential calculus] is generally used by any area of science that depends on methods of approximation as a tool to know the rate of change in a certain quantity relative to the change in another quantity (MoE, 2006b, p. 171).

Though this statement is general and does not refer to specific areas of science, students may be motivated by such statements. There are such statements in the other unit of the same textbook. The following is an excerpt from the introduction to Unit 6:

> The concepts that you are going to learn [pertaining to differential calculus] have applications not only to investigation of functions but also to solve problems in geometry and physics (MoE, 2006b, p. 225).

This unit is for both natural science and social science streams. The statement is relevant to the natural science school subject, but not to the social science school subjects.

There are exercises for each of the topics in these units of the old textbook, but they contain few applications. For example, the applications of differential calculus is the subject of Unit 6 (MoE, 2006b). However, the topic contains very little that shows applications of calculus to other school subjects. It does not connect to students' anticipated fields of study. Unit 7 introduces the student to integral calculus (MoE, 2006b). There is a section in Unit 7 about application of integral. There are several examples and exercises in this section. They are about area, volume, and applications in physics. In this section of Unit 7, it is mentioned that the integral has applications in physics and the particular physics concepts that apply integrals are mentioned. Apart from these, there are hardly any applications in the other school subjects nor in students' anticipated fields of study.

There are some differences in the new twelfth-grade textbook. Unlike the old textbook, the new textbook clearly articulates which units are for social science and which ones are for natural science streams. Units 6 and 7 are for the natural science stream, and 8 and 9 are for the social science stream. The remaining units are common for both. As in the old one, the new textbook has three units dedicated to calculus. Unit 4 deals with the topic “application of differential calculus” (FDREME, 2010c, p. 161). The introduction to the new twelfth-grade textbook begins by restating what was learned in the previous unit. Then it notes that:

> Derivatives can have different interpretations in each of the sciences (natural and social) (FDREME, 2010c, p. 162).

It explains that derivatives can be useful for chemists, biologists and manufacturers. Though it states that derivatives can be used in calculating marginal cost, the textbook does not associate it with the social science school subject or the discipline students would anticipate studying in university such as economics. The new twelfth-grade textbook hardly mentions the social science disciplines or school subjects. In one situation, social science is mentioned, in the following context:

> In fact, the computation of rates of change is important in all of the natural sciences, in engineering, and even in the social sciences (FDREME, 2010c, p. 162).

The use of the phrase “even in the social sciences” in this statement, adds to the imbalance in the weight that the textbook gives to the natural science and the social science streams. The third subtopic of unit 6 of this new twelfth-grade textbook is about “rate of change” (FDREME, 2010c, p. 197), which contains applications in everyday life and in other disciplines or school subjects. The introductory paragraph states:

> In this section, you will see that there are many real-life applications of rates of change. A few are velocity, acceleration, population growth rates, unemployment rates, production rates, and water flow rates (FDREME, 2010c, p. 197).

The book does not mention the social science school subjects, which involve these concepts. It will be set out in the data presentation and analysis that some social science students mentioned that they learn about population and unemployment rates in a school subject of social science stream. Other social science students do not seem to recognize that these concepts involve mathematics. During the data collection, the students did not yet learn about these concepts in mathematics.

I present a brief overview of one of the two units of eleventh-grade textbook, which are specifically for the social science stream. This unit has different names in the two textbooks. In the old textbook it is, "Simple interest, compound interest and depreciation" (MoE, 2006a). This is the last unit of the old eleventh-grade textbook. This unit of the old eleventh-grade textbook starts with a brief introduction. It then states the objectives of the unit. Neither the introduction nor the objectives state any of the school subjects or the anticipated future studies of the social science students. The unit has three main sections: simple interest, compound interest and depreciation. Each of these topics give a number of examples and exercises, with no mention of the school subjects or anticipated future studies of the social science students, which employ the mathematics concepts mentioned in those topics. The unit ends with summary and miscellaneous exercises, which share the same problems. Despite the limitations in mentioning the social science school subjects, there is a mention of profession or professionals as follows:

> For these reasons, many accountants and business managers believe that accelerated methods of writing of depreciation are preferable (MoE, 2006a, p. 431).

Such statements might give students idea about the connection that mathematics has with what they could anticipate to study in the future. During the interview a twelfth-grade student, who attended mathematics using this old textbook, mentioned the usefulness of this unit for their future study, and that they did not cover the unit due to shortage of time (see Melkamu's story in section 7.3.2).

In the new eleventh-grade textbook, the unit described above is called, "mathematical applications in business" (FDREME, 2010b, p. 425). This is one of the two units, which are specifically for the social science stream, and it is the last unit of the textbook. This eleventh unit starts with unit outcomes followed by a brief introduction, which contains an opening problem. The opening problem is about compound interest. Neither the introduction nor the unit outcomes refer to any of the school subjects or future studies of the social science students. One of the four sections of the unit is about compound interest. The unit ends with providing key terms, summary and review exercises.

As stated in Appendix 1, there are units, which are allotted for social science stream only. In a section of unit eleven (of the new eleventh-grade textbook), there is a subsection, “rate” (FDREME, 2010b, p. 429). Some of the examples in this subsection are problems, which involve the concepts of the social science school subjects such as price, audit, business, investment, etc. (ibid). Though the unit is for the social science stream, it does not mention these school subjects or social science disciplines, which students would study in the future. Moreover, one of the examples is a problem, which asks about the speed of a car; calculating speed from distance and time. Similarly, another subsection of this section, “proportion,” has an example, which solves a problem that asks about calculating power from electric current and resistance (FDREME, 2010b, p. 431).

The units, which are allotted for social science, relate to economic and business issues. They contain tasks, which relate to the same issues. There are hardly anything, which are related to disciplines such as law. As will be seen in the data presentation those students, who aspire studying fields such as economics and accounting, perceive that mathematics is relevant to their future studies, while those who aspire studying law perceive that mathematics is not relevant to their future studies or doubt its relevance.

In this section, I attempted to set out a brief overview of some topics of the textbook. I mainly focused on the units, which the students mentioned during the interviews. The titles of each of the units are listed in Appendix 1. This overview of the textbook supports the students’ stories, which pertain to the following four characterisations of perceptions of mathematics’ relevance.

7.4.3.2 Mathematics is relevant because it relates to other subjects

In their participation in the activity of schooling, the students undertake actions towards the goals of learning mathematics and other school subjects. The students attend school subjects as members of the social science or natural science streams (student communities). They attend mathematics topics, which are specific to their communities, as well as topics, which are shared for both communities. In this section, I present the data and the analysis, which exposes the students' perceptions of the relevance of mathematics to the other school subjects and the associated constructs such as motivation. The data are generated mainly from the interview question, about what connection mathematics has to the other school subjects. There are also data generated from other questions; namely, from the request to introduce themselves and tell their history in connection with learning mathematics. Figure 7.6a provides the four dimensions and their properties for the current sub-category.

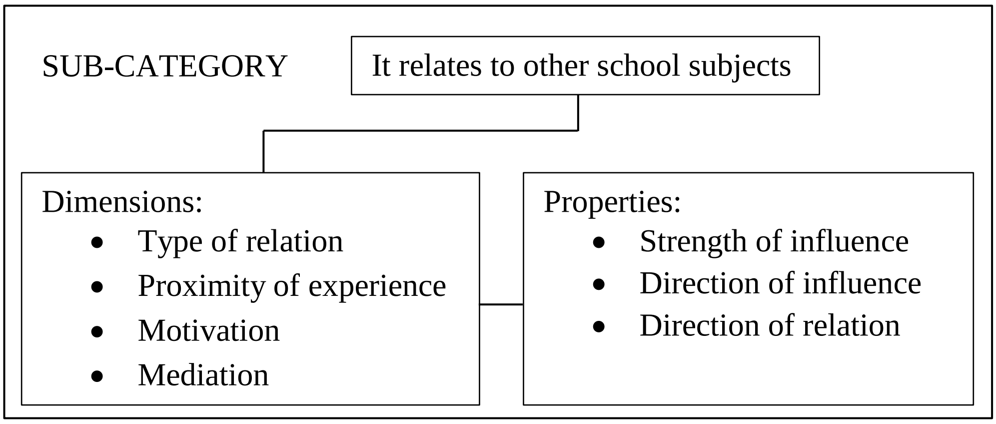


Figure 7.6a: Dimensions and properties for the sub-category about other subjects.

Students perceive that mathematics is relevant to other school subjects, which is exposed through the dimension, type of relation. The type of relation of mathematics to other school subjects is expressed in four different ways. Figure 7.6b presents these expressions of relation.

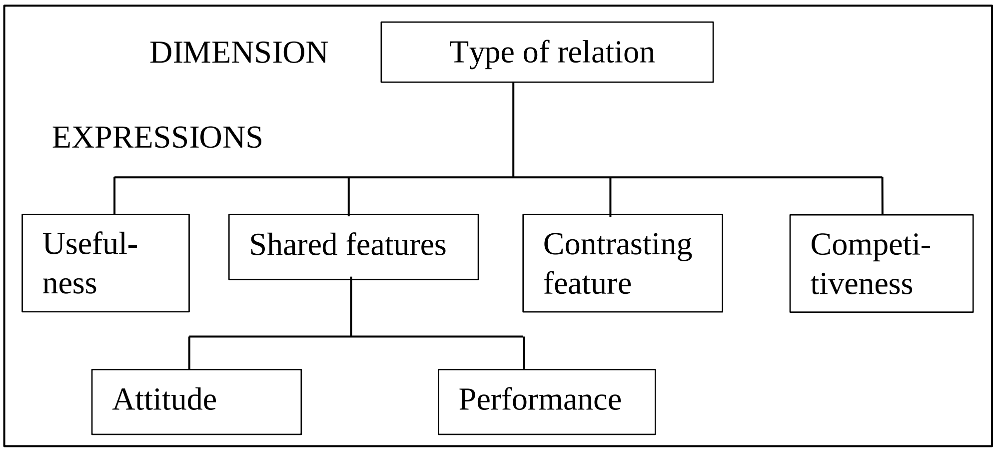


Figure 7.6b: The type of relation dimension and its different expressions

Students perceive that mathematics is useful to other school subjects (e.g. Beletu's story). The following excerpt is part of Beletu's story:

> In many of the subjects, there is mathematics. In business we have calculation; in economics {expressing mathematics' usefulness in social science school subjects}. When we learn the mathematical part of a subject, we hate the subject if we hate mathematics {expressing emotional disposition}. [Beletu, FG E]

The other type of relation of mathematics to other subjects can be shared features. This relation is expressed in different ways. First, attitude towards mathematics is shared with those subjects, which involve mathematics (e.g. Beletu's story). A second expression of shared feature is that mathematics has shared features with some of the other subjects such that performing in those subjects enhances possibility of performing in mathematics (e.g. Hana's story). Hana says:

> In seventh grade, I scored well in physics and poor in mathematics {expressing school rule}. The homeroom teacher, who also taught me mathematics, advised me {expressing role} that if I perform well in physics I could perform well in

> mathematics. In the second semester, I performed well in mathematics {expressing mathematics' relation with a natural science school subject}. [Hana, FG E]

This exposes students' beliefs about their abilities. On the contrary, other students perceive that the relationship is negative, where mathematics has a contrasting feature from other subjects. This perception of relation exposes students' beliefs about learning mathematics (e.g. Munaye's story). In her response to my request for her group to introduce themselves and tell their history in connection with mathematics learning, Munaye tells the connection. The following excerpt is part of her story:

> We cannot learn mathematics by heart, {expressing proposition about mathematics learning}.as we do for other subjects {expressing mathematics' relation with other subjects, exposing beliefs}. [Munaye, FG G]

A fourth type of relation of mathematics to other school subjects is that mathematics competes with the other school subjects for the students' attention and time, which students tell as part of their history of learning of mathematics (e.g. Melkamu's [8] story).

The second dimension is proximity of experience. The students experience the relevance of mathematics to the other school subjects by themselves (e.g. Beletu's story). The students do not usually mention other people. Instead, they use the pronoun, 'we' as in 'we have' and 'we use' to explain their experience of the relationship of mathematics to other school subjects. They also say 'we learnt,' which I understand as being informed by the teachers (e.g. Akalu's story). Akalu says:

> In nuclear reaction, for example, if we put excessive ingredients, it explodes and destroys the whole world {expressing mathematics' usefulness in a natural science school subject} ... I got [this information] from the media {expressing artefact}; we {expressing community} also learnt it in chemistry {expressing an artefact, lesson of another school subject}. [Akalu, FG D]

They can also experience it by being informed by the teacher (e.g. Hana's story). There can be occasions where students experience mathematics' relevance through the media (e.g. Akalu's story). On the other hand, there are occasions where exposing the proximity of experience is difficult. For example, students mention the use of mathematics to the other school subjects, which they no longer attend. These students do not mention any sources of information (see Beletu's story). These could be from their experiences in learning these school subjects in earlier grades. In this case, the experience is either first-hand or informed by other people. It could also be because of the mathematics textbook, which provides examples of natural science school subject even in topics, which are intended for social science stream (see section 7.4.3.1).

The third dimension is motivation. As I mentioned above, the students perceive mathematics and other school subjects as being competing with each other. The students' perceptions of mathematics' connection to other school subjects determine their inclination to engage in mathematics (e.g. Melkamu's story). Students' motivation is related with their emotion. There is emotion associated with this emergence of motivation. In particular, students' motivation emerges from emotional valence associated with engaging in mathematics. For example, their motivation can be because of their expectations of a feeling of being successful because of engaging in mathematics (e.g. Ayana's [6] story). If mathematics cannot guarantee such feeling, students shift their attention to the other school subjects, which can guarantee it (e.g. Ayana's story).

The fourth dimension is mediation. The mathematics lessons can mediate the students' perceptions of relevance by directing their attention to the possible connections between mathematics and the other subjects (e.g. Beliyu's story). Beliyu responds to the question about what connection mathematics has to the other school subjects as follows:

> We learnt log [logarithm] in mathematics {expressing artefact, mathematics lesson}. ... Then, we use it in chemistry to calculate pH {expressing mathematics' usefulness in a natural science school subject}. Both in social science and natural science {expressing community}, we have to learn mathematics {expressing comparative inclination}, since it is related. Mathematics is related to the other subjects in many ways, it is the base for the other subjects {expressing mathematics' relation with other school subject}. [Beliyu, FG C]

The lessons of the other subjects can also direct their attention to the possible connections (e.g. Beletu's story). They interact with the subjects as members of the social science or natural science communities. In accordance with the school rules, students should attend to some of the school subjects and some of the mathematics topics, which are specific to either social science or natural science communities. The school rules might mediate the students' perceptions of relevance through providing the various subjects, which students should attend as members of these communities (e.g. Zenebech's [7] story).

The division of labour directs the students' attentions to the relevance of mathematics. The mathematics teachers have roles of teaching mathematics concepts and the teachers of other school subjects show the mathematics concepts they use in their respective school subjects (e.g. Beliyu's story). The school rules mediate students' motivation. In particular, the choice of engaging in mathematics or other school subjects is determined by the success in examinations (e.g. Ayana's story). The school rules direct students' attention to whether they incline to one school subject instead of another. Members of the school community may also mediate the students' perceptions of relevance. It seems that the teacher interprets and amplifies the connection between mathematics and the other school subject for the students (e.g. Hana's story).

The dimensions have properties such as strength of influence. The strength varies depending on the level of specificity. For example, the experiences for the "usefulness" relation ranges from a general statement

that mathematics is useful for other school subjects (e.g. Zenebech's story) to a statement that a specific concept of mathematics is useful for specific concept of another school subject (see Beliyu's story).
Some of the experiences, which students mention for usefulness are convincing and positive (see Beliyu's story) and others are less convincing (e.g. Zenebech's story). "Competing" is also convincing, but negative (see Ayana's and Melkamu's stories).

Another property is direction of influence. The direction of influence of the experience can be prospective (e.g. Beletu's and Beliyu's stories). It can also be retrospective (e.g. Hana's story). Third property, the direction of relation of mathematics and the other school subjects, can be one- or two-directional. In most of the cases, it is one-directional and is from mathematics to the other school subjects. "Usefulness" is one-directional; in particular, from mathematics to the other subjects (see Beliyu's story). "Shared feature" is also one-directional. In some cases, the direction can be from other school subjects to mathematics (see Hana's story). "Competing" is two-directional (see Melkamu's story).

This section set out that the students do in fact perceive that mathematics is useful in many of the school subjects. However, the mathematics concepts the students considered are rarely from preparatory mathematics. Perception of relevance is not limited to the usefulness of mathematics in the other school subjects; it has various aspects. The relationship of attitudes and beliefs with students' perceptions of relevance are further dealt later (see sections 8.3 and 9.2).

7.4.3.3 Mathematics is relevant because it is useful in an unknown future

The students anticipate participating in the university activity in the future. There are characterisations of perceptions of relevance that students hold in this connection. This sub-category focuses on the perceptions of mathematics' use in future study and the associated constructs such as motivation and rationale. The data are generated by the question about what they want to study in the future; whether mathematics is useful for their future studies and how they come to know about its use. The question about whether preparatory mathematics topics have any use also generated some data. Figure 7.7a displays the four dimensions to the sub-category.

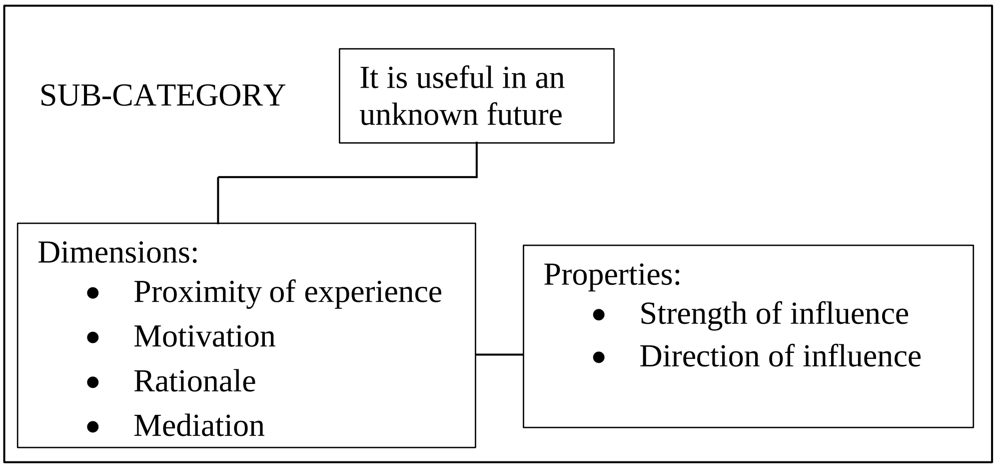


Figure 7.7a: Dimensions and their properties for the sub-category about an unknown future

These dimensions are addressed in this order. I start with proximity of experience. The students perceive that mathematics is useful in their anticipated future studies; however, they do not have a first-hand experience about this usefulness. The students can experience it "by being informed by other people," "through other school subjects" and "through reliance on the curriculum." The students get information from other people, mostly, from sources outside the school such as family members (see Hale's story). The following is Hale's response to my question about their future study, and mathematics' use:

> I want to study accounting or management {expressing a future study} ... Earlier I wanted to study medicine {expressing former future study before joining preparatory}. When I discussed with my family {expressing community} that I want to enrol in natural science stream {expressing a future study}, my uncle refused {expressing denial of capability to act, agency} because he thought it would be tough for me {expressing stereotype}. He suggested {expressing role} social science would be better for me {expressing denial of capability to act, agency} ... I also have other relatives working in the bank; one of them is a manager {expressing role in an out-of-school activity}. I used to hear from them that it is good to study accounting or management {expressing source of information about future study}. They advised me {expressing role} that I should work hard on mathematics, and that I should not ignore other subjects {expressing mathematics' usefulness in future study}. [Hale, FG A]

The students sometimes get information from school sources (see Milkias's story). In some cases, the students use their earlier or current experience in other school subjects to forecast about the future use of mathematics (see Zenebech's [9] story). Some students rely on the school curriculum that the mathematics they are attending provides the basis for their future study (see Fikadu's [10] story). On the contrary, other students appear to abandon their reliance that the curriculum would present any content that could have some use for them, which is a negative perception of mathematics' relevance (see Haleluya's [11] story).

The second dimension is about motivation. There is motivation associated with the perception of mathematics relevance to an unknown future (e.g. Haleluya's, Milkias's and Melkamu's [12] stories). This motivation can emerge in the schooling activity (e.g. Milkias's story). It can also emerge in an out-of-school activity (e.g. Melkamu's story). The students' perceptions of relevance influence their motivation to engage in mathematics, which can be positively (e.g. Melkamu's story) or negatively (e.g. Haleluya's story). Students' negative perceptions of relevance influence their inclination of engaging in mathematics negatively.

The third dimension is rationale. Students perceive that they miss some rationale in the mathematics lessons or the textbook in connection with the future use of mathematics topics (e.g. Haleluya's and Melkamu's stories). Students' motivation can be because of the rationale for the mathematics topics or tasks (e.g. Melkamu's story). The students' perceptions of mathematics' future use can serve as the rationale for their learning of mathematics.

The fourth dimension is about the manner in which perception of relevance is mediated. The artefacts such as the lessons, as signs might mediate perception of relevance by directing students' attention to the possible connections (e.g. Zenebech's story). They can mediate by providing or denying access to the possible connections (e.g. Melkamu's story). The textbook can mediate in a similar fashion (see section 7.4.3.1).

The school rules determine the school subjects for the social science and natural science students. They also determine the relationship of the mathematics topics with the other school subjects. The school rules may mediate students' perceptions of relevance by directing the students' attention to experiences, which enhance relying on the curriculum that it would present mathematics topics, which are relevant to their future studies (e.g. Fikadu's story). They can also direct the students' attention to experiences, which discourage relying on the curriculum that it would present relevant mathematics topics with respect to their future study (e.g. Haleluya's story). In accordance with the rules, there are specific fields of study at the university, which social science students can join and there are others, which the natural science students can join. The school rules mediate the students' perceptions of relevance through denying access to the possible connections of mathematics and the anticipated studies of members of the social science community (e.g. Melkamu's story).

The students interact with the object as members of the social science or natural science communities. The division of labour may direct the students' attentions to mathematics' relevance. For example, mathematics teachers have roles of informing the use of mathematics in the anticipated studies as members of these communities (e.g. Milkias's story).

Similarly, there is division of labour in the family-life activity system. Students get information and advice about future study from family members. The division of labour may direct the students' attention to mathematics' relevance to the students' anticipated studies (e.g. Hale's story). The rules dictate that students should follow the advice of elder siblings. Siblings can influence the students' choice of study (e.g. Hale's and Zenebech's stories). They have a role in determining the students' perceptions of relevance of mathematics to the students' future studies.

Students' motivation can emerge from the interaction between school community and the object. According to some students, some teachers assert that the community of social science students have lower motivation to engage in mathematics (e.g. Milkias's story). The following is part of Milkias' story about his future study, and mathematics' use:

> I want to study law {expressing future study}. I … do not think that it has mathematics {expressing lack of mathematics' usefulness in future study} ... Some teachers say {expressing teachers' role} to us, you [social science students] {expressing community} are not serious about mathematics {expressing lack of inclination} because you think you do not need it in the future {expressing lack of mathematics' usefulness in future study}. [Milkias, FG F]

The teacher's role as a source of information and the students' roles as listeners may direct students' attention to whether to engage in mathematics. Students' motivation can also emerge from the interaction between the community and object of the out-of-school activity (e.g. Melkamu's story). In the family-life, activity members of the family have roles. Siblings such as a cousin have the role of mentoring or informing students (e.g. Melkamu's story). For example, they provide information about university studies. Based on this information, students form their perceptions of mathematics' relevance, which can have influence on their motivation (e.g. Melkamu's story).

Members of the community to which the students belong also mediate the students' perceptions of relevance. Family members interpret to the students what it means to be enrolled in the natural science or social science streams with respect to future study (e.g. Hale's story). The people in the out-of-school activity also interpret to the students what mathematics and the mathematics topics mean to the students future study (e.g. Haleluya's and Melkamu's stories). The teacher interprets to the students what it means to learn mathematics as a member of the social science stream with respect to future study (e.g. Milkias' story). The teacher also selects one topic instead of the other, which also mediates the students' perceptions of the relevance of mathematics to future study (e.g. Melkamu's story in section 7.3.2).

The dimensions I mentioned above have properties. The properties include the strength of influence. The students provided examples to substantiate their perceptions of relevance. The experiences can be general, where students mention that mathematics is useful for future studies in general (e.g. Fikadu's story). The experiences can be about mathematics' usefulness to specific fields of future study (e.g. Hale's story). The experiences can be about use of specific mathematics topics to specific field of future study (e.g. Melkamu's and Akalu's stories). Following my question in connection with what they want to study, I asked Akalu's interview group if the topics in preparatory mathematics have any use. Akalu, who wants to study medicine or engineering, says:

> We do not yet know the use of preparatory mathematics {expressing the lack of rationale}; maybe when we enter the fields {expressing usefulness of mathematics in a future study}. However, as I heard from some students who are studying mechanical engineering {expressing role (information source) in out-of-school activities}, twelfth-grade mathematics, such as derivative, calculus are applicable to a high extent {expressing usefulness of mathematics in a future study}. [Akalu, FG D]

These experiences can be positive; for example, mathematics is useful for a specific field of study (see Hale's story). The experiences can be negative; for example, mathematics is not useful for a specific field of study (see Milkias's story). Another property of this sub-category is the direction of influence. The direction of influence of the experience is prospective (e.g. Zenebech's story).

In this subsection, I set out the students' perceptions of the relevance of mathematics to future study. The out-of-school activity is significant in the students' perceptions of relevance by providing information about the relevance of mathematics to the future studies.

7.4.3.4 Mathematics is relevant because it has exchange value

The students are in a preparatory school, readying themselves for university studies and for the national examination that determines whether they can join university. In this sub-category, I present the data and the analysis, which exposes the perception of mathematics' relevance as having exchange value in giving access to future study and the associated construct motivation. The data are generated from the question, why they learn and engage in mathematics.

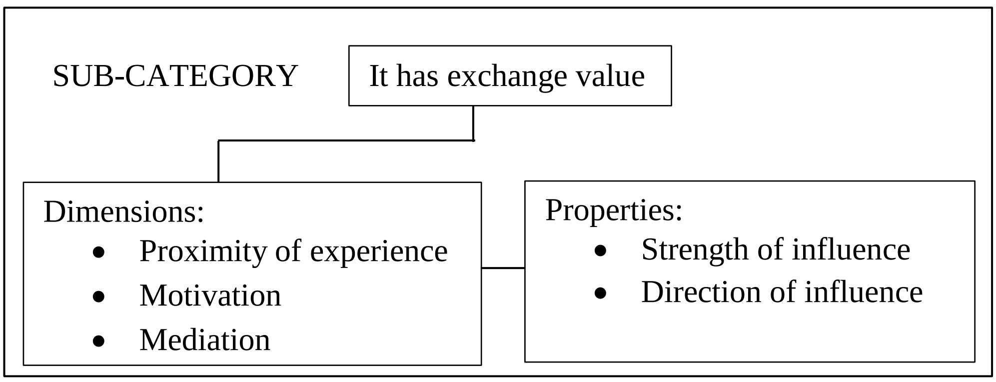


Figure 7.8: Dimensions and their properties for the sub-category about exchange value

As depicted in Figure 7.8, the dimensions for this sub-category are three. One of the dimensions is proximity of experience. Students perceive that mathematics is relevant in that it has exchange value in getting access to future studies. The students have been participating in the activity of schooling and have learnt that success in mathematics examinations is important (e.g. Fate's story). The following excerpt is part of Fate's story about why she learns and engages in mathematics:

> If we do a lot of exercise {expressing interaction with the object} we succeed in examinations if we do not work we do not succeed {expressing the school rule}. … Therefore, engaging in mathematics is useful. … It is useful in order to do well in examinations, to score well {expressing inclination}. … Scoring well is important to meet our goal {expressing mathematics' role in obtaining access to a future study, exchange value}. For example, in the assigning to fields of study {expressing the authorities' role}, our scores are taken into account; so it helps us to be assigned to fields of our choices … I want to be a doctor {expressing mathematics' role in obtaining access to a future study}. [Fate, FG G]

Students might be informed by reflecting on their school experiences (see Fate's story). For example, the students could join the preparatory school based on their scores in a national examination. Such experiences seem to inform them the importance of success in mathematics examinations, for getting access to the next level.

The students can also have a first-hand experience about mathematics' exchange value to get access to future studies. This can be on occasions where the students get the information when it is announced by the authorities as in advertisements of specific studies or training (see Hanan's story). Following my question to the group, why they learn and engage in mathematics, I asked them to think of the topics they learn this year, and why they learn and engage in these topics. Hanan says:

> When we complete eleventh and twelfth, we want to be enrolled in some institution {expressing motive of participating in the schooling activity}; we cannot do it without mathematics... It helps me to achieve my goal. I want to be a pilot. It requires mathematics and physics {expressing mathematics' role in obtaining access to a future study}... I read about it. I also heard from people I know, who are pilots; from the media as well {expressing source of information, out-of-school activities, artefact and community}. [Hanan, FG C]

A third option for experiencing exchange value is that other people can inform the students (see Hanan's story). The students obtain such information in their participation in the out-of-school activity from people who have direct access to the anticipated study or training.

The second dimension is motivation. The student's perception of the relevance of mathematics, which is characterised by "it has exchange value," appears to be a motivational factor for the students' engaging in mathematics. This is evident in the students' responses to the question why they learn and engage in mathematics. That is, the students' inclination for engaging in mathematics appears to be because of its exchange value, which sometimes is their sole reason for engaging (e.g. Fate’s and Hanan’s story).

The third dimension of this sub-category is mediation. The school rules enforce the school curriculum and that the students' knowledge is measured through examinations (e.g. Beliyu’s [13] and Fate’s stories). The school rule, which enforces that the score in examinations determines the students’ access to the anticipated future field of study, seem to direct their attention to the exchange value of mathematics (e.g. Beliyu’s and Fate’s stories). The rules, which mediated the students’ perceptions of relevance through directing their attention to the connections, also influence their inclination to engage in mathematics.

The artefacts mediate the students’ perceptions of relevance. Students interact with the object of schooling activity. The object contains the motive of the schooling activity. The motive is to enable students join the university and be capable of solving problems of everyday life. In the family-life activity system, students undertake actions related to their school tasks (e.g. Atnafu’s [14] story). They use the school artefacts when they undertake action such as doing homework, towards the goals of their personal developments. In their participation in the out-of-school activity such as the family-life activity, the artefacts such as the communication media can mediate their perceptions of relevance (e.g. Hanan’s story). The communication media presents announcements such as those made by the airline to recruit university students for its Pilot Training School. The communication media directs students’ attentions to mathematics’ connection with Pilot Training in allowing or denying access to the institution.

The division of labour also can mediate the students’ perceptions of relevance. In their engagement with others, the division of labour in the school activity system directs students’ attention to the possible connection that mathematics has to getting access to the anticipated future study. In order to realize the motive of joining the university, the student and the teacher take roles (e.g. Atnafu’s story). The teacher shows to the students how to solve a certain mathematical problem. The students see what the teacher did and attempt to do the same using a different task. This is what I observed during the classroom observation, for example, when their teachers give them classwork. The roles of authorities who set the examinations and use student’s score in their decisions of assigning the student to a field of study also seem to mediate the students’ perceptions about the exchange value of mathematics (e.g. Fate’s story). The roles of authorities and the students’ responsibility to prepare for the examination direct the students’ attention to and emphasize mathematics’ exchange value.

In their participation in an out-of-school activity, students know other people who have direct access to the anticipated future study. These people have a role in providing information, which students might need (e.g. Hanan's story). The division of labour in the schooling and out-of-school activities, which seem to mediate the students' perceptions of relevance through directing their attention to the connections, can also mediate students' inclination of engaging in mathematics.

The dimensions have properties, which include the strength of influence of the experiences. These experiences are usually convincing, but with various strengths. The strength of influence of the proximity of experience dimension ranges from a general statement that mathematics has exchange value for getting access to the university (e.g. Beliyu's story) to a statement that mathematics has exchange value for getting access to a specific field of study (e.g. Hanan's stories). For the mediation dimension, the strength of influence is weak in the sense that the experiences are not specific enough to expose the mediational processes (e.g., Hanan's story). For the motivation dimension, the strength of influence is weak in the sense that the experiences are not specific situation or topic (e.g., Beliyu's story). The other property is the direction of influence of the experience. For proximity of experience, mediation as well as motivation, the direction of influence of the experiences are prospective because they are about the current and the future.

In this section, I set out that the students perceive that mathematics has exchange value to join university. Some students perceive that mathematics has exchange value to get access to a particular field of study. Others perceive that mathematics has exchange value beyond joining university; particularly, using the university as a springboard to get access to another activity. The school rule and the division of labour in the school and in the family appear to mediate this perception of relevance. This perception of relevance is a motivational factor in engaging.

7.4.3.5 Mathematics is relevant because it gives an identity

In this section, the focus is on students' personal identities. During the interviews, I asked students to tell me why they learn and engage in mathematics. I interpreted some of the students' responses to this question and the follow up question about preparatory mathematics as exposing perception of relevance, which is characterised by "mathematics gives an identity." The excerpts from students' responses, together with my interpretations are reported. The associated constructs such as beliefs, emotion and motivation are also exposed.

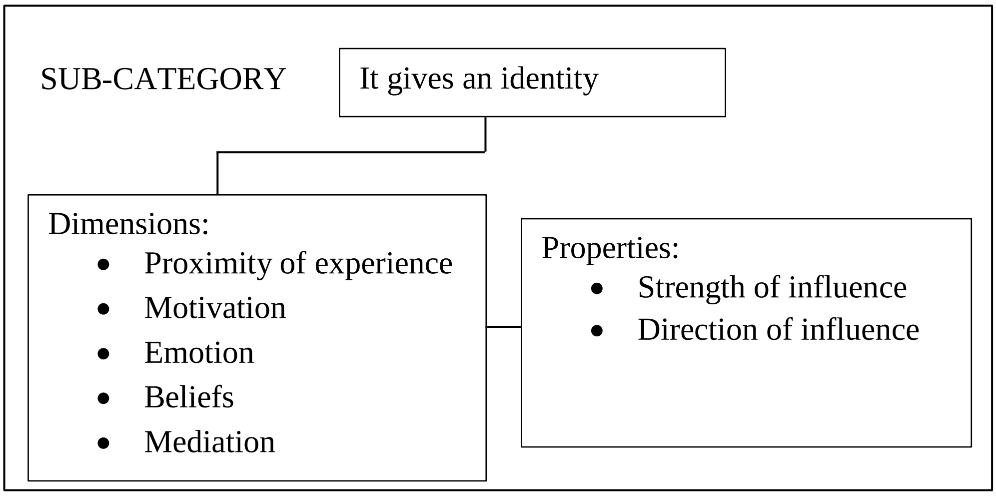


Figure 7.9: Dimensions and their properties for the sub-category about identity

Figure 7.9 provides the dimensions and their properties for the sub-category. The five dimensions of this sub-category are set out in the same order. I start with the proximity of experience. This dimension includes “experienced by themselves,” and “experienced by observing family member.” The students perceive that mathematics is relevant in that it gives an identity. Some students experience the relevance by themselves (e.g. Beliyu’s story). In her story about her reason for engaging in mathematics, Beliyu says the following:

> Primarily, to get a higher rank in the class {expressing mathematics as giving basis for recognition of oneself as such with respect to the members of the community one belongs}. I derive pleasure from it [getting a higher rank] {expressing emotional reward or expectations of it} ... Some people say mathematics cannot be studied but I think it needs to be studied {expressing proposition about learning of mathematics}. We need to understand the theorem before we go to the calculation. Therefore, mathematics needs to be studied it is not only calculation {expressing proposition about learning of mathematics}. [Beliyu, FG C]

Students may form their perceptions of relevance by observing experiences of other family member (e.g. Sofia’s story). The following excerpt is part of her story where she told her reason for engaging in mathematics. She says:

> It is joyful answering about something you know {expressing the emotional reward, which engaging in mathematics promises} ... It tells who you are {expressing mathematics as giving the basis for recognition of oneself as such with respect to others}. Let us say I graduated [from the university] and someone asked for help, how could I explain to him, if I do not know about it? {Expressing mathematics as building the capability to act, agency}. However, if I know it, I can explain it without feeling ashamed. Therefore, I enjoy knowing it, even though I do not benefit from it {expressing the emotional reward, which engaging in mathematics promises}. [Sofia, FG A]

When I asked her if she had such experience of helping others in mathematics, Sofia replied:

> I have little brothers and sisters {expressing community of the family-life activity} and I help them {expressing own role as a mentor in the family-life activity}

> ... My brother used to help me and advise me using his own experiences {expressing role as mentor in the family-life activity}. Now, he is studying at the university {expressing the university activity}. [Sofia, FG A]

There are other dimensions in this sub-category – motivation and emotion. There is motivation associated with the perception of the relevance of mathematics, which is characterised by identity. The students incline to engage in mathematics in order to maintain their identities (e.g. Sofia's and Beliyu's stories). That is, students' desires to maintain their identities are a motivational factor to engage in mathematics. There is also emotion associated with this characterisation of perception of the relevance of mathematics. The students derive pleasure from attaining identity and this can be one reason for their engaging in mathematics (e.g. Beliyu's story). The motivation to engage in mathematics is a consequence of the emotional valence, which engaging in mathematics promises (e.g. Sofia's and Beliyu's stories).

There is a fourth dimension in this sub-category. This dimension is about students' beliefs about the learning of mathematics. The students' perception of the relevance of mathematics, which is characterised by, "it gives an identity," has an aspect, which relates with the students' beliefs about the learning of mathematics (e.g. Beliyu's story). Beliyu compares herself with others with respect to her beliefs about mathematics learning. Students' beliefs are associated with the characterisation of perception of relevance, "it gives an identity."

Mediation is the fifth dimension. The characterisation of perception of relevance, "it gives an identity," seems to emerge as students participate in the school and out-of-school activities (e.g. Sofia's story). It appears to emerge in the interactions between the students, the community and the object. The artefacts, the rules, and the division of labour mediate this perception of relevance. The school rules enforce that students should master certain topics at a certain grade level, which is measured by students' scores in examinations. The rules, which enforce also that attaining higher scores and better rank in the class is significant, directs students' attentions to recognize themselves as such in connection with mathematics (see Beliyu's story).

In the family-life activity, there is interaction between the community and the object, in which members of the family have roles in the student's personal development (e.g. Sofia's story). The rules in the family-life activity enforce that students should follow what their elders tell them to do and that the elders should care for the younger ones. Members of the family recognize each other as such. Some students recognize their siblings and themselves as mentors (e.g. Sofia's story). The rules and the division of labour in this activity direct students' attentions to recognize themselves as such in connection with mathematics.

These dimensions have properties. The properties include the strength of influence. As in the earlier categories, the more specific the students' examples are, the more convincing the experience is. For the proximity of experience, which are "experienced by themselves," and "experienced by observing family member", the strengths of influence are moderate (e.g., Sofia's story). For the mediation dimension, the strength of influence is weak in the sense that the experiences are not specific enough to expose the mediational processes (e.g., Beliyu's story). The direction of influence is another property of the dimensions. For the proximity of experience as well as mediation, the direction of influence is prospective (e.g. Sofia's stories).

This section exposed the students' recognition of themselves as such in their interaction, as subject, with the community and the object. These interactions also expose the recognition of students by others who participate with them in the school and out-of-school activities. This is further dealt in the next section. These students' identities are also exposed in their stories about other issues, and is often associated with other characterisations of perceptions of relevance.

7.4.3.6 Coda to perceptions of relevance relating to school experiences

In this second section of the data presentation and analysis, I focused on students' perceptions of the relevance of mathematics relating to school experiences. The students perceive that preparatory mathematics is relevant to the other school subjects. They also hold perceptions of relevance that are characterised by "it gives an identity" and "it has exchange value." They form perceptions in connection with their future studies, which are characterised by "it is useful in an unknown future."

The characterisations of perceptions of relevance, which are presented above, are related to each other. Students' perceptions that mathematics is relevant to other subjects can influence their perceptions of relevance of mathematics to their anticipated future studies. For example, students perceive that mathematics is useful for future study based on their experience of the current usefulness in other school subjects (e.g. Meseret's story in Chapter 5 and Zenebech's story in section 7.4.3.3).

The students recognize themselves as future students of the field they anticipate to study. Then, they describe the relevance of mathematics to their anticipated future studies (e.g. Melkamu's and Milkias's stories in section 7.4.3.3, and Fate's and Hanan's stories in section 7.4.3.4). It appears that students' perceptions of mathematics' relevance characterised by identity could influence their perceptions of mathematics' relevance to their anticipated future studies.

The students' perceptions of mathematics' relevance to other school subjects may influence their perceptions of mathematics' relevance characterised by identity (e.g. Hana's story in section 7.4.3.2). In particular, I set out that the teacher's recognition of the student as a well-performing in a mathematics-related school subject and the encouragement to do the same in mathematics enhanced the student’s performance in mathematics. This could change the student’s identity. Now, her teacher recognizes Hana as a medium-achieving student in mathematics.

One of the characterisations of students’ perceptions of relevance reported in this category is, “mathematics gives an identity” (see section 7.4.3.5). Section 7.4.3.5 focused on personal identity. However, as set out in Chapter 2, in addition to a recognition of oneself as such, other members of the community such as the mathematics teacher, recognizes the individual student as such (see section 2.4.3). For example, Hana’s teacher recognition of her as a medium-achieving student mentioned above and Beliyu’s teacher recognition of her as a high-achieving student (see section 7.4.3.5) could be their social identities (e.g. Roth et al., 2004). There can also be recognition of the student as such by other students, which also shows the student’s social identity (e.g. Ayana’s story in section 7.3.2). In section 7.3.2, I reported the stories of two students about tackling the difficulties in mathematics, where one helps the other. Ayana’s and Robel’s stories have a sense of recognition of Robel as someone who never gives up regarding solving mathematics tasks.

There is also collective identity (e.g. Roth & Lee, 2007). The participants are either natural science or social science students (see Chapter 1). In section 1.5, I set out that there are school subjects, which strictly belong to one of the natural or social science streams. I also mentioned that there is a distinction between the fields of study, which students of these streams can attend in the university. The students also recognize themselves as members of these streams in their stories about their future studies (e.g. Fikadu’s and Milkias’s stories in section 7.4.3.3).

The students themselves or others recognize them as such because of the membership, particularly, in connection with mathematics. I set out about the teacher's recognition of social science students in connection with perceptions of mathematics' use in future studies (e.g. Milkias’s story in section 7.4.3.3). This also demonstrates the relationship between the characterisations of perceptions of relevance in this category of perceptions of relevance. There are some relationships between some of the characterisations across categories of perceptions of relevance. Such issues and some issues of differences are set out in the next section.

7.5 Discussion

The diverse characterisations of students' perceptions of relevance are presented as sub-categories. These characterisations, which I presented earlier under two categories, have relationships. These are set out in the following paragraphs. Some issues of differences among students also received attention in this section.

The analysis sections made it clear that there are seven characterisations of students' perceptions of relevance, which are set out under two categories. These categories are not strictly distinct from each other. They are rather related; in particular, there are some relationships between some of the characterisations across these categories. For example, the perceptions of relevance, which are characterised by "Mathematics relates to other school subjects," and "Mathematics is useful in everyday life," which are reported under separate categories, are related. Their relationship is that students perceive that the other school subjects, which utilise mathematics, are useful in everyday life. The other thing, which shows the relationships across these categories, is the perception of relevance characterised by identity. In both categories, there are perceptions of relevance characterised by aspects of identities.

There are eight dimensions and three properties, which emerged in the analysis. The dimensions such as mediation and proximity of experience are evident across the sub-categories. All characterisations of perceptions of relevance result from mediational processes. There are dimensions, which are evident in one or few of the sub-categories. For example, the dimension 'rationale' is available in just one sub-category of both categories. Students perceive that they miss some rationale in the mathematics lessons or the textbook in connection with everyday life as well as the future use of mathematics topics (see sections 7.4.2.2 and 7.4.3.3).

As set out in section 7.4.1.1, proximity of experience refers to whether the experience is a first-hand or informed by other sources. The sources include the teacher, family members, textbook, lessons, other school subjects and the media (see sections 7.4.2 and 7.4.3). This can depend on the particular characterisation of perception of relevance. For example, the students experience the use of mathematics in other school subjects in the lessons; usually in the lessons of other subjects (see section 7.4.3.2). They get information about the relevance of mathematics to their anticipated future study and to everyday life mainly from out-of-school sources such as family members (see sections 7.4.2.2 and 7.4.3.3). Some students have experience of workplace mathematics through observing other members of the family (see Beza's story in Chapter 5) or members of the workplace (see Eyasu's story in section 7.4.2.2). These experiences have influences on perceptions of relevance. However, students did not use the concepts for themselves, which could have a stronger influence (e.g. Miettinen, 1999).

The dimension "type of relation" is also limited to few sub-categories such as "it relates to other school subjects." The type of relation between mathematics and the other school subjects can be its usefulness in those subjects. The 'usefulness' type of relation also emerges in other characterisations, namely, "mathematics is useful in everyday life" and "mathematics is useful in unknown future." An important property of the type of relation is the direction of relation; that is, whether the relation is one-directional or two-directional. Mathematics' usefulness is one-directional because mathematics is useful in other subjects, in everyday life and in future study, but not vice versa.

The mediational role of the division of labour could play a role in making a difference between the perceptions of relevance among the social science and natural science students. I set out earlier the teacher's role in a mathematics class of social science students in terms of offering the appropriate information in connection with mathematics' use in future studies (e.g. Milkias's story in section 7.4.3.3). The teacher also has a role in making the decisions with respect to topics of future use for social science students. For example, in situations where there is time limitation, the teacher might need to make his own judgement of the topics the students require most with respect to their stream and future study (e.g. Melkamu's story in section 7.3.2). The backgrounds of the teacher and those who prepare the textbook might also have a role in the provision of mathematics' use to the social science students' current and future studies (see section 7.4.3.1).

There could be difference between the social science and natural science streams in terms of how the artefacts mediate students' perceptions of relevance. The lessons or textbooks of the school subjects mediate the perceptions of relevance through availing or limiting the application of mathematics concepts in the other school subjects. For example, they include the use of logarithm in chemistry (e.g. Beliyu's story in section 7.4.3.2). I observed the inclusion of logarithm's application in calculating pH (a chemistry concept) being taught for social science students. The textbook gives examples of natural science school subjects in topics, which are allotted for the social science stream (see section 7.4.3.1).

On the other hand, some social science students mention the use of rate in economics without being aware that rate is a mathematics concept (see Haleluya's story in section 7.4.2). I did not have the chance to observe the inclusion of the application of rate in mathematics class. However, the mathematics textbook mentions such usefulness, namely, unemployment rate, without mentioning any school subject or field of study such as economics (see section 7.4.3.1). The lessons and textbooks can mediate the students' perceptions of the connections through including or omitting the names of the other school subjects or fields of study, to which the mathematics concepts relate. The school rules, which enforce the school curriculum, mediate students' perceptions of relevance.

This section focussed on discussions of relationships between the characterisations of perceptions of relevance. Possible differences across the streams are also examined. These are further examined in Chapter 8 (see section 8.3). Differences based on gender are set out in section 8.5. The motivational influence is also outlined (see section 8.6). Perceptions of relevance and the associated constructs such as motivation emerge in the interactions between the subjects the community and the object, which are mediated by the rules, division of labour and the artefacts. This is consistent with Roth (2007).

7.6 Reflection on the data generated

The main data in this chapter is interview data. The classroom observation, textbook and conversation with the teachers are the other data sources. However, their contributions to the data corpus vary greatly. The classroom observations and textbook have much lower contribution to the data corpus than the interviews. Conversations with the teachers make a very limited contribution. There is also variation in the data across the characterisations of students' perceptions. In this section, I reflect on the data generated from the various sources and across each of the characterisations of students' perceptions of relevance.

I did not weigh the evidence obtained with respect to the corresponding categories of students as I was undertaking the data collection of the pilot study. During the interview of the main study, I attempted to find out evidence in the various parts of student-categories. However, there are still variations in the richness of the data across the various categories of students. There are even cases where some data, which are available in a specific student-category, are absent in others.

The data obtained from classroom observations and my conversations with the teachers are not strong by their own, but they are supportive in strengthening the data generated from students' interviews. Even then, there are many occasions in the analysis where I thought that it could have been very useful if I had generated more data through the classroom observations. The data from the textbook is limited to what students mentioned, and I used the data extracted from textbook to examine some of the students' claims.

In addition to supporting part of the interview data. The data from the classroom observations exposes a glimpse of the classroom culture. However, it does not support the interview data as required. For example, usually the lessons I observed are continuations of previous lessons. It is difficult to obtain accurate data about what information students have in connection with a particular topic with respect to my research questions. The extent to which I expose mathematics classroom practices is limited to my observations of particular lessons. It does not represent the whole practices of mathematics teaching at the preparatory school nor does the practices at a particular grade level. It provides a limited view of students' exposure in the classroom.

The data generated reveals that students obtain information about mathematics' relevance from both their school and out-of-school experiences. The supportive data is provided pertaining to those data, which reveal students' school experiences. For example, when the interview data involves specific mathematics topics, I attempted to support it by my overview of the textbook. On the other hand, the data have limitation in the exposition of some of the out-of-school activities. These activities are examined to the extent the available data allows.

The data, which established the diverse characterisations, have various levels of strength. The category of perceptions of relevance relating to out-of-school activities consists of three characterisations of perceptions of relevance (see section 7.4.2). The characterisation about everyday life is relatively strong in terms of the diversity of the informants' backgrounds. The data are also supplemented with some data from the textbook. The data for the other characterisations are not as strong as the first. Only two students of the same interview group from the pilot study and one student from the main study contributed to the characterisation, "it gives a fresh perspective on life." Only two students of the same interview group from the pilot study and two students from the main study contributed to the characterisation, "it gives a national identity."

However, what is common for these three characterisations is that the interview data pertaining preparatory mathematics are not strong. The data of the characterisation, "it is useful in everyday life" are about mathematics in general. Many of the examples, which students provided, are not from preparatory mathematics. As I mentioned earlier, the data for these characterisations are generated based on the interview question, whether mathematics is useful in everyday life, and based on the same question specific to preparatory mathematics.

The second category (i.e., the school-related) consists of four characterisations. The data generated, which established the characterisations of students' perceptions of relevance in this category are relatively strong. The following characterisations are based on relatively strong data: "it relates to other school subjects"; "it is useful in unknown future" and "it has exchange value." These characterisations are strong in terms of the diversity of informants' backgrounds, and the richness of what students told with respect to the analytic model I adopted. The other characterisation, namely, "it gives an identity" is less strong.

The data that established the characterisation of perception of mathematics' relevance to other school subjects is strong in many ways. In addition to the issues of diversity mentioned above, the interview data is supported to some extent by the classroom observation and by a brief overview of some of the units of the textbooks. The data generated reveals that many of the other characterisations of perceptions of relevance within the category of the school-related perceptions of relevance as well as those outside of this category relate with this characterisation.

Similarly, the data that established the characterisation of perception of mathematics' relevance to unknown future is obtained from students of diverse backgrounds. It is also supported by the classroom observation, negatively though, because I did not hear any of the teachers mentioning if what the students are learning will be useful for their university studies. The extent to which the textbooks address the future use of specific mathematics topics, which students mentioned are also exposed.

The data that established the perception of relevance characterised by exchange value of mathematics is not obtained in response to a question, which directly addresses it. While there are questions about mathematics' relevance to the other subjects and to their future studies, there are no questions about mathematics' role in getting access to the university. However, students of all backgrounds contributed to the characterisation about the exchange value of mathematics. The classroom observation and overview of the textbook do not seem to provide direct evidence for supporting the data generated from students' interviews. However, exemplars of the daily routines in the mathematics lessons are provided in section 7.3.3, and the school rules are exposed in Chapter 1.

The data that established the perception of mathematics' relevance characterised by "it gives an identity" is not as strong as those data, which established the other three characterisations of school-related perceptions of relevance, in terms of diversity of informants, which are limited. A possible reason can be the interview questions do not target students' identities. That is, unlike for most of the data for the other characterisations, these data are obtained through the students' own initiatives, not through a question that refers to the notion. The interview data pertaining to the characterisation "it gives an identity," are not supported by the data from the textbook and classroom observation directly. However, the characterisation is useful for the findings of this study, because the data that established this characterisation of perception of relevance relates with the others. Particularly, the data reported under the other characterisations often exhibit the students' identities (see section 7.4.3.6).

The characterisations under this category are strong in the sense that they are mostly about preparatory mathematics. For example, nearly the entire data in the characterisations, "it is useful in unknown future," "it has exchange value," and "it gives an identity" are about preparatory mathematics. There are some differences if we compare them with each other. Though the characterisation "it relates to other school subjects" contains data, which is strong in many other ways, when it comes to preparatory mathematics, the data is not as strong as the data for “it is useful in unknown future” and “it has exchange value.” Particularly, the usefulness aspect is not so strong in that the examples, which the students gave, are mostly from mathematics prior to preparatory.

Though the interview questions were intended to explore perceptions of relevance, there was only one question, which is about students’ motivation. This question is about why they learn and engage in mathematics, and it generated the data, which established the characterisations, “it has exchange value” and “it gives an identity” (see section 7.4.3). I did not examine the students' actual engaging in mathematics, other than their words. I did not examine the students' motivation using other methods. For example, I did not examine their engaging in mathematics using classroom observations to see if their perceptions of relevance of specific topics motivates them to learn and engage in those topics.

The data, which established the characterisations about the two aspects of identity, are different from each other in that one is about out-of-school use of mathematics and the other is with respect to school-related experiences. In both categories, the number and diversity of students who contributed to these two characterisations are smaller. This could be because of differences in the interview questions. The data, which established the perceptions of relevance characterised by “mathematics gives an identity,” are obtained based on question about why they learn and engage in mathematics. The data, which established the perceptions of relevance characterised by “mathematics gives a national identity,” are obtained based on question if mathematics is useful for everyday life.

There is also variation in the strength of the data across the dimensions. There are also occasions where accurate exposition of the dimensions and properties was not possible. For example, in the dimension proximity of experience, data about students’ information sources were often lacking. This is partly because of absence of follow-up interviews after the analysis started.

Unlike the pilot study, the report of the main study does not contain the third category, which is about prior experience. It was my intention also to follow up the pilot study by exploring perceptions of relevance of prior experience. To this end, I included interview questions such as ‘is mathematics, which you learnt before relevant to preparatory mathematics?’ I asked them to think of the mathematics topics they are learning and if the concepts are related to the topics prior to preparatory. The questions did elicit responses from students, however, on critical reflection, because of the nature of the question and the lack of clarity in students' responses, I decided that the data lacked the authenticity and trustworthiness to sustain the arguments that I hoped to present. For a similar reason, I left out the sub-category, “mathematics is relevant because it empowers one to make informal decisions.”

In this section, I provided a reflection on the data. A repeated or follow up interview was rarely undertaken to make more accurate interpretations of participants’ words. However, there is variation in the strengths of the results. I assessed the strength of the data generated based on the data generated from the diverse data sources and the contributions of students of diverse backgrounds. This has influence on which characterisations stand out as significant part of the study’s findings. Further reflections and suggestion for future studies are provided in Chapter 9. The data and the analysis presented in this chapter are qualitative. The results are supplemented by the data analysis from the questionnaire. A discussion and synthesis of these results obtained in the current and preceding chapter is a subject of the next chapter.

8 Discussion and synthesis

8.1 Introduction

In this chapter, I present a synthesis of the results from the qualitative and quantitative analyses. I attempt to supplement the results from the students' stories reported in Chapter 7 by the proportions of positive responses to the questionnaire items, which I presented in Chapter 6. I present these results together with the results from previous studies.

Many of the studies in belief research draw on cognitive and social cognitive theories. There are studies, which draw on sociocultural theory, and are not situated in belief research. In this chapter, I leave aside the theoretical perspectives and methods they adopt and focus on the results, except when differences between results from these studies and the current study could be due to methods and theoretical perspectives.

I present further interpretations of results by using additional features of activity theory. I handle these issues in the section, "further interpretations of results." In the same section, I also employ the tactics of verifying meanings, which I set out in Chapter 4. I re-examine the students' perceptions of mathematics' relevance to the school and out-of-school lives. I present these issues under a section, "perceptions of the relevance of mathematics." I present the characterisations about identity, and motivation under separate sections.

The structure of this chapter is as follows: further interpretations of results, perceptions of the relevance of mathematics, mathematics' relevance and identity, gender issues and motivation. Finally, I set out generalizability and transferability of the results before I provide a concluding remark.

8.2 Further interpretations of results

This section presents a discussion of the results using additional constructs of activity theory, particularly, tension/ contradiction, agency and structure. Additional perspectives into the emergence of the students' perceptions of relevance are included.

Students seem to find themselves in a conflicting situation when they think of the use of preparatory mathematics in everyday life. For example, students learn mathematics at school with limited knowledge of possible uses in everyday life. It was set out earlier that apart from few concepts such as statistics and probability, it appears that students do not experience the relevance of preparatory mathematics to everyday life (see sections 7.4.2). Sections 7.4.2 also exposes that the schooling activity provides knowledge of the mathematics concepts with hardly any rationale with respect to its use in everyday life.

This limitation of schooling activity is in conflict with the students' perceptions that the motive of the schooling activity is to enable them join the university and become capable of solving problems of everyday life. This experiencing of conflict between the school and out-of-school settings make students find themselves in a situation where they experience tension/ contradiction between the objects of the school and out-of-school activities. The possible development from tensions/ contradictions that students experience between the objects is set out later (see sections 8.3.4 and 8.4). The students could also experience tensions/ contradictions within the object of the schooling activity (Roth et al., 2004). This is dealt in section 8.6. Another possible tension/ contradiction, which students can experience is between the division of labour in the school and family-life activities (see section 8.5).

Another construct, which can have influence on the students' perceptions of the relevance of mathematics, is agency. As I set out in Chapter 2, agency is the individual's power/ capability to act (Roth et al., 2004). There are individual differences in using agency (ibid). For example, some students can be inventive in applying their experience in mathematics or mathematics concepts to their situations outside the mathematics classroom while other students may not (e.g. Eyasu's story in section 7.4.2.3 and Hayal's story in sections 5.3.1.2 and 7.4.2.3).

Students can exhibit limitations in exercising agency with respect to mathematics. The limitation to use their own agency can shape students' perceptions of the relevance of mathematics. For example, a student fails to recognize the mathematics available in students' own examples about the usefulness of a school subject in everyday life (e.g. Haleluya's story in section 7.4.2.2). On the other hand, students use their agency to form a perception about use of mathematics in future study. Students use current experience of mathematics' use in other school subjects, which relate with their anticipated field of study, to forecast its use for this field of study (e.g. Zenebech's story in section 7.4.2.3).

The student's agency cannot be viewed in isolation (e.g. Roth et al., 2004). The structure is also significant in forming a constraining and empowering situation in which the students can or cannot exercise their agency (ibid). For example, the teacher, as a member of the school community, has a significant role in changing students' perceptions of mathematics' relation with other school subjects (Hana's story in section 7.4.3.2). The structure can also create a favourable situation for some students and a constraining situation for others. For example, the school rule, which enforces the school subjects, can enable students to make connection by offering a subject, which provides the ground for their future study such as economics (e.g. Zenebech's story in section 7.4.3.3).

On the other hand, the components of the activity systems sometimes deny students the favourable situation to make connections of mathematics with future study. For example, the school rules do not offer a school subject that provides the ground for the anticipated future study, law. The mathematics textbooks (probably also the lessons) either hardly contain topics relevant to law or they hardly specify the topics which are relevant to this field of study (see section 7.4.3.1). Besides, the teacher, who has a role as a source of information, suggested that some fields of study are not likely to involve mathematics (e.g Milkias' story in section 7.4.3.3). These differences can shape students' perceptions of the relevance of mathematics to their future studies differently. I set out earlier that students who anticipate studying law perceive that mathematics is not relevant, or are sceptical about its relevance, to their future study while students who anticipate studying fields of study such as accounting, economics, engineering, management and medicine perceive that mathematics is relevant (see sections 7.4.3.3).

The interaction between student's agency and structure can contribute to the emergence of the characterisation of perception of relevance such as "it gives fresh perspective on life" (e.g. Hayal's and Makida's stories in sections 7.4.2.3 and 5.3.1.2). For example, the school artefacts such as the textbook make available the mathematics topics. However, the school artefacts hardly make available the use of some topics of mathematics in everyday life nor the rationale for the topics. This seems to leave the students to speculate about possible uses of mathematics. On the other hand, the activities outside the school provide the students with the means so that they can make their own decisions about possible uses of the mathematics topics. That is, the students use their agency to invent uses of the mathematics topics to the out-of-school life.

In Chapter 4, the attempt to examine outliers and find out their meanings were set out (e.g. Miles & Huberman, 1994). The cases of some particular students' assertions based on their backgrounds, which distinguishes them from the rest of the participants were examined. For example, the story of a high achiever natural science student who is described by his teacher as extraordinary and he is critical of the Ethiopian preparatory mathematics in respect of the limitations in showing its utility in everyday life (see Akalu's story in section 7.4.2.4). Another high achiever natural science student, who cannot imagine natural science without mathematics, uses preparatory mathematics inventively by reflecting on local culture (see Hayal's story in sections 5.3.1.2 and 7.4.2.3).

These students' assertions contributed to the data that established some of the characterisations of perceptions of relevance, namely, "it gives fresh perspective on life" and "it gives a national identity." Their perceptions of relevance are "at the end of the distribution" of the students' perceptions of the relevance of preparatory mathematics to out-of-school life (Miles & Huberman, 1994, p. 269). That is, while the majority of the students perceive that they do not see the relevance of preparatory mathematics to out-of-school life, few students have a different perception of relevance. These few students have a perception of relevance, which is either based on an inventive use of preparatory mathematics (by reflecting on local culture), or recognition that the preparatory mathematics give a national identity. These are outliers (Miles & Huberman, 1994). These outliers support the conjecture that the perceptions of relevance of mathematics to out-of-school life is due to the limitations that the structure imposes.

It can be argued that inventive uses of preparatory mathematics by reflecting on local culture (see Hayal's story in sections 5.3.1.2 and 7.4.2.3) verifies the significance of student's agency on perception of the relevance of mathematics to out-of-school life. Even then, the structure is significant in enabling the student's agency as the out-of-school activity offers the artefacts (in this case the religious teachings), which the students use to apply their mathematical knowledge (see section 7.4.2.3).

Students can experience tension/ contradiction between the structure and agency (e.g. Hale's and Zenebech's stories in section 7.4.3.3). I set out in section 7.4.3.3 that the students obtain information from family members about mathematics' relevance to their anticipated future studies. The provision of information is favourable, as the schooling activity hardly provides such information. On the contrary, the influence, which is against their own choice, is unfavourable because it denies their agency to make choices of their own (see section 8.5).

This section focused on re-examining some of the results of Chapter 7 to interpret further. The possible role of the constructs agency and structure in the emergence of students' perceptions of relevance were set out. The possible role of tensions/ contradictions in the emergence of the characterisations of perceptions of relevance and motivation are outlined. The possible roles of these constructs and the characterisations of perceptions of relevance and the associated motivation are further examined in the next sections.

8.3 Perceptions of the relevance of mathematics

There are diverse characterisations of students' perceptions of relevance. The students held these characterisations with varying popularity. This is evident in the students' narratives as well as from the proportions of positive responses of students to the questionnaire items. In this section, I present the characterisations of students' perceptions of relevance based on both the qualitative and the quantitative results. I compare results from my study with some of the results in the available literature.

This section has four subsections, which are about students' perceptions of the relevance of mathematics. In the current presentation, the characterisations, "it is useful in an unknown future" and "it has exchange value" are merged into "relevance of mathematics to students' goals," because both characterisations are about students' goals. The presentation has the following order: relevance of mathematics to other school subjects; relevance of mathematics to students' goals; relevance of mathematics to everyday life, and cultural heritage and inventive use of mathematics.

8.3.1 Relevance of mathematics to other school subjects

This section sets out a synthesis of the results pertaining the characterisation of perception of relevance, "Mathematics is relevant because it relates to the other school subjects." I present the diverse connections between mathematics and the other school subjects. I also relate with some of the results in the available literature. I also set out what might be new in my study.

In general, the students perceive that mathematics is a useful tool in the other school subjects. This is evident in the high proportions of the students who held that they see as well as use mathematics in general, and preparatory mathematics in particular, in the other subjects (see section 6.3.2). There is difference in this perception of relevance across steams. A much higher proportion of natural science students than social science students hold this perception of relevance (see section 6.3.3). On the other hand, the results in Chapter 7 show that there are situations, which could determine this difference (see section 7.5). Section 7.5 set out that there are differences between social science and natural science students in what they get from their mathematics teacher, the lessons and the textbook regarding mathematics' use in the other school subjects.

The interview data shows that, the perception about the relevance of mathematics to other school subjects is not limited to usefulness of mathematics in the subjects. It has three additional aspects. One aspect is that the students perceive that mathematics is relevant to the other school subjects in the sense that they bear shared features such that if one performs well in those school subjects, one possibly performs well in mathematics. There are students, who perceive that mathematics has a contrasting feature from other school subjects, which exposes the students' beliefs about learning mathematics. Another connection between mathematics and the other school subjects is if one has a negative attitude towards mathematics, one also has a negative attitude towards those subjects, which use mathematics, particularly, towards the relevant topics. On the other hand, they perceive that the relation between mathematics and other school subjects is such that they compete with each other for the students' attention and time. These diverse relations are exposed in section 7.4.3.2 (see also section 7.5).

As mentioned in Chapter 3, there is literature about mathematics' relevance to the other school subjects, which focuses on the usefulness aspect (Flegg et al., 2012; Rojano, 2002). The results in my study about the usefulness of mathematics in other school subjects are consistent with the available literature (e.g. Rojano, 2002). Rojano examined the relationships between mathematics and other school subjects but did not pay attention to students' perceptions of these relationships. Rojano's difference from mine is because of the fact that her review is not situated in belief research. Rojano's work is not about students' perceptions of relevance. Consistent with Flegg et al. (2012), my study shows that the lack of connection in the artefacts such as the mathematics lessons influence the students' perceptions of the usefulness of mathematics in the other subjects. Flegg et al. (2012) is not about upper secondary students.

The results in my study, which show that some students perceive that mathematics has shared features with some of the other school subjects such that performing in those school subjects can be transferred to performance in mathematics is consistent with Michelsen and Sriraman's (2009) result about transfer of students' interest. However, in my case it is the students' perceptions of performance in one school subject and not necessarily students' interest in one school subject that is transferred to the other school subject. This difference in the results could be because of the differences in the research questions – I investigate students' perceptions of relevance while theirs is about students' interests.

The perception that mathematics and the other school subjects are competing for the students' attention and time is also consistent with the available literature (e.g. Eccles et al., 1998; Wigfield et al., 2008). There is literature in belief research, which is concerned with choice and decision. This can include students' choice of engaging in mathematics and the other school subjects (ibid). The competitive aspect in my study is consistent with these studies. These studies expose students' choices and decisions among various alternatives, which are competing for the students' attention and time as students make their choices. Eccles and colleagues as well as Michelsen and Sriraman (2009) used questionnaires to collect data.

Diverse aspects of the relation between mathematics and other school subjects are exposed in my study. This is because of the interview method, which unlike questionnaires, provided opportunity to hear from participants, who view the connections in diverse ways. The theoretical framework also provides an opportunity to view learning mathematics and other school subjects as parts of the object of the same activity.

In this section, I pointed out the diverse ways of connections that students make between mathematics and the other school subjects. In addition to its diverse aspects, this characterisation of perception has a relationship with the other characterisations of perceptions of mathematics' relevance. Moreover, the usefulness of mathematics in general and preparatory mathematics in particular in other subjects is highly popular among the students. These issues are among the reasons for my claim that this characterisation is one of the most important results of this study (see Chapter 9).

8.3.2 Relevance of mathematics to students' goals

In this section, I present the students' perceptions of the relevance of mathematics that pertain to the students' future goals. The two characterisations of perceptions of relevance, which I present here, are "mathematics is relevant because it is useful in an unknown future" and "mathematics is relevant because it has exchange value."

The students perceive that mathematics is relevant to their future goals. This is evident in the interviews as well as in their responses to the relevant items of the questionnaire. A high proportion of students responded positively to those relevant items. In particular, the majority of the students perceive that mathematics has exchange value for getting access to their future study. The interview results show that the students perceive that mathematics has exchange value for getting access to the university and others perceive that it has exchange value to get access to a particular field of study of one's own choice. There are students who perceive that mathematics has exchange value beyond joining university such as training institutions, which require some university courses.

The majority of the students perceive that mathematics is useful in their anticipated future studies (see section 6.3.2). There is difference in this perception of relevance across steams. A much higher proportion of natural science students than social science students hold this perception of relevance (see section 6.3.3). On the other hand, the results in Chapter 7 show that there are situations, which could determine this difference between social science students and natural science students (see section 7.5). In section 7.5, it was set out that there are differences between social science and natural science students in what they get from their mathematics teacher and the textbook regarding mathematics' use in their anticipated future studies. It is set out in section 8.3.1 that similar sociocultural situations prevail with respect to the other school subjects.

On the other hand, the results from the interviews show that the students' perceptions of the usefulness of mathematics to their future studies depends on the field of study they aspire to study in the future. Since there is clear distinction between the fields of study, which the social science students and natural science students would go upon joining university, the qualitative and quantitative results are consistent. Although I did not explore the popularity of perceptions of relevance with respect to the specific fields of study, the results from the interview data provides some evidence about the variation within social science students. As outlined earlier in section 8.2, those students who aspire studying law perceive that mathematics is not relevant or doubt its relevance, and those who aspire studying accounting, economics, engineering, management or medicine perceive that mathematics is relevant. Thus, I conjecture that the students' anticipated future study than the streams they belong determines their perceptions of relevance.

The new conjecture that the perception of mathematics' relevance to anticipated future study depends mainly on what students want to study than the stream to which they currently belong is a consequence of an attempt to challenge an earlier tentative conjecture. My expectation, and what I obtained from the preliminary results of the pilot study, was that in general the social science students doubt the usefulness of preparatory mathematics for their future studies.

Consistent with Miles and Huberman (1994) in an attempt to challenge my conjecture, I followed up some social science students' use of their current experience of usefulness of mathematics in the social science subjects to hold a perception that mathematics would be useful in future studies (see Meseret's story in section 5.3.2.2). Meseret's story challenged my conjecture that the social science students' perceptions of relevance of mathematics to their future studies depend on, their stream. Following Miles and Huberman (1994), I attempted to reflect, revise my conjecture and find supportive evidence for the revised conjecture. In my attempt to follow such surprises in the main study, I obtained data, which supports it (see Zenebech's story in section 7.4.3.3). These students' stories also show that students use their agency to attach meaning to the connection between mathematics and future study.

The interview results also show that the students perceive that mathematics is relevant based on reliance on the curriculum and the teacher. The majority of the students held that mathematics would not have been taught if it were not relevant. However, this questionnaire item is general, and is not specifically about students' anticipated future studies. The interview results show that the reliance that the participants expressed are partly consequences of the lack of appropriate information about the rationale for learning mathematics with respect to the future studies. The overview of the textbook supports this result.

There is a difference in the students' responses to the interview question and their response to the questionnaire items requesting for their information sources about mathematics' use in future studies. The results from interview data show that their sources are the out-of-school activities. On the other hand, according to the results from the questionnaire, for the majority of the students their teacher is the source of information. The difference appears to be due to the framing of the questions. In the questionnaire, following the item about the relevance of mathematics to future study, those who responded positively were asked to give their information sources. This is followed by alternatives of sources from which the majority of the students chose ‘the teacher.’

In the interviews, the students were asked about what they want to study and whether mathematics is relevant to it. The students mostly specify what they want to study and mathematics’ relevance. Then, when they were asked about their sources, they mentioned mostly out-of-school source. It appears that their mathematics teacher could say that mathematics is useful for their studies at the university. However, the information, which the teacher provides, may not be specific to the individual student’s anticipated field of study. The information, which is specific to the individual’s anticipated field of study, is obtained in their participation in out-of-school activities such as, the family-life activity.

I examined extreme cases. In particular, I examined cases, which support the argument that the limitation of rationale in the mathematics they learn at school determines the students’ perceptions of relevance. For example, the story of a high achiever natural science student who is described by his teacher as extraordinary, whom I mentioned earlier in this section (see Akalu’s story in sections 8.2 and 7.4.3.3). He asserts that he only hopes that preparatory mathematics will have use in his future study. While he gave an exemplar topic, which he asserts to be useful for future study, his source of information is outside of the school. Akalu’s case can be seen as an extreme case, which can be used to expose the influence of a limitation of rationale for learning of preparatory mathematics topics with respect to the students' future study on their perceptions of relevance. The overview of the textbook in connection with the topics mentioned by students also supports this claim.

The results in my study are consistent with the available literature in affect and belief areas of research (e.g. Brophy, 1999; Wigfield & Eccles, 2000). The results in my study are consistent with Eccles and Wigfield (2002) in that they also point out that the value that students attach to mathematics tasks includes the usefulness to the students’ goals. However, Wigfield and Eccles (2000) did not make distinctions between the exchange value and use value. Brophy includes both values. The results in my study are consistent with the available literature about the relevance of mathematics to future study (e.g. Michelsen & Sriraman, 2009; Sealy & Noyes, 2010; Black et al., 2010). The results in my study differ from Michelsen and Sriraman, in that they do not examine the diverse sources of perceptions of mathematics’ relevance to future study.

The results in my study are consistent with Black et al. (2010). “Use value” of mathematics, which is reported in Black et al. (2010) is the same as “mathematics is useful in an unknown future,” which is a characterisation of perceptions of the relevance of mathematics. The results in my study also show that mathematics has exchange value for the students, which is also consistent with Black et al. (2010). The results in my study are also consistent with Sealy and Noyes (2010) except that the characterisation “It is useful in an unknown future,” in my study, is reported as part of exchange value in Sealy and Noyes (2010). As mentioned in Chapter 3, Sealy and Noyes viewed that whether it is used in getting access to a field of study, or it is used in courses, which are offered in those fields of study, the students’ perceptions are the same. According to Sealy and Noyes (2010), in both cases, the ultimate use of mathematics for the students is obtaining an academic degree in those fields. This difference between Sealy and Noyes and my result is because of focuses of our studies. As set out in Chapter 7, the focus of the current study is on students’ perceptions in connection with joining the university and not beyond. Thus, whether students’ motive is obtaining an academic degree is not investigated in my study.

This section presented the results that pertain to students’ goals. Some of the results of my study differ from earlier ones, which could be due to the theoretical perspective. These studies usually draw on cognitive or social cognitive theories.

8.3.3 Relevance of mathematics to everyday life

The characterisation of perception of relevance, which is examined here, is “mathematics is relevant because it is useful in everyday life.” This result from students’ interviews is examined together with proportions of students’ positive responses to those items, which are about the relevance of “mathematics” and “preparatory mathematics” in the students’ participation in activities in the society. There are items about the leisure time activities; however, the results from these items are not included because students have problems in understanding the items (see section 6.4).

The students perceive that mathematics is relevant to everyday life. This is evident in the interview results. These activities include games, transaction, subsistence businesses, and other workplaces. This also includes activities, which are peculiar to the Ethiopian culture such as Edir and Equb. This perception of relevance is also evident in the high proportion of students who held that they see and use mathematics in the activities in the society. However, the results obtained from the interview data show that the mathematics concepts the students mention are rarely from the preparatory school. This difference is evident in the survey results as well. The majority of the students responded negatively to the items of "preparatory mathematics" (see Figure 6.1).

The results in my study are in agreement with the available literature (e.g. Bishop, 1988a; Masingila, 2002; Miettinen, 1999; Presmeg, 2002; Wedege 2004). The examples the students mention to explain their perceptions of the use of mathematics fall in one or the other of the six categories that were identified in Bishop (1988a). They are also consistent with Masingila (2002). However, Masingila (2002) and Bishop (1988a) are not about upper secondary school students.

The results in my study are consistent with Miettinen (1999) in that the relevance to everyday life is important for learning, and that it can be formed through the students' participation in activities beyond schooling. However, Miettinen's work is not about the students' perceptions of relevance. It is about learning in general through establishing relevance. Consistent with Mellin-Olsen (1987), the perception of mathematics' relevance to everyday life serves for students as rationale for their learning of mathematics (see sections 7.4.2.2).

I mentioned earlier in this section that the results in my study show that students' perceptions of the usefulness of mathematics in everyday life can be through other school subjects. This is consistent with the result of earlier studies (e.g. Michelsen & Sriraman, 2009). However, such results are rare even in studies, which investigated the everyday-life use of mathematics and other school subjects (e.g. Darby, 2008).

Consistent with Wedege (2004) the results in my study show that the challenge for the students in making connections between mathematics and their out-of-school experiences can be because of the limitations of the school and out-of-school artefacts, which might not make the connections readily available to the students' attention. Wedege's study is not about upper secondary students' perceptions of connections between the school and out-of-school experiences. Consistent with Presmeg (2002) the current study show that beliefs about the nature mathematics has influence on the students' perceptions of the relevance of mathematics to everyday life.

The results presented above are the synthesis of the results pertaining to everyday life. The results in my study add to the available literature about perception of mathematics' relevance in everyday life, in a new context. The literature in belief research gives little attention to students' perceptions of relevance of mathematics to everyday life at upper secondary.

8.3.4 Cultural heritage and inventive use of mathematics

This section focuses on perception of mathematics' relevance characterised by fresh perspective on life. It is different from the rest of the characterisations in the out-of-school category. In particular, it is not a direct use of mathematics, which students experience in out-of-school life. The students hold this perception of relevance based on inventive use of mathematics.

The students experience tension/ contradiction between the objects of the schooling and the out-of-school activities because they find themselves in a situation where mathematics and the sociocultural context it presents are not compatible with the out-of-school life (see section 8.2). Some students use their agency to respond to this tension/ contradiction by being inventive, and they use their own situation for ascribing relevance of mathematics. There are other students, who use their sociocultural heritage including the religious teachings inventively to make mathematics relevant to their own situations. The heritage provide them with the means to deal with the tensions/ contradictions.

The results in my study are consistent with the available literature in that the tensions/ contradictions, which students experience, may lead to some developments (Roth et al., 2004; Black et al., 2010). In my case, the development is being inventive and formation of a particular perception of mathematics' relevance, which is characterised by "mathematics is relevant because it gives a fresh perspective of life" (see section 7.4.2.3). This result in my study is different. This difference in the results of my study can be due to the research question, which focuses on mathematics' relevance to the school and out-of-school activities and the theoretical perspective, which views activities as vital to cognition. The focus on the diverse activities, in which the students participate, opens up opportunities to expose such perception of relevance. This result can also be due to the research method, namely the group interviews, which allowed hearing from the students about their participation in activities and their experience of mathematics in those activities.

8.4 Mathematics' relevance and identity

In this section, I set out a synthesis of the results pertaining to identity, which I presented in different parts of this dissertation. I discuss these issues here mainly based on the interview results. I also use the results from the questionnaire. Then, I compare the results in my study with the literature and set out what might be new in my study.

There two characterisations of perceptions of the relevance of mathematics, which relate to identity. These characterisations are, "mathematics gives an identity" and "mathematics gives a national identity." These characterisations are not based on strong data in terms of the diversity of students' backgrounds, possibly because of absence of interview questions targeting these characterisations.

Only two students contributed to the characterisation, "mathematics gives an identity" (see section 7.4.3.5). These students are eleventh grade, female, and one student from each stream. On the other hand, as shown in Chapter 6, a considerable proportion of students held that mathematics gives identity, and the backgrounds of students, who responded positively to this item, are more diverse. Particularly, both eleventh and twelfth grade as well as female and male students from both streams responded positively. Students from each of these categories wrote responses to the open question, which indicates that they perceive that mathematics gives them an identity (see section 6.3.2).

The interview data also contains evidence about the relationship between the perception of relevance characterised by identity and motivation. As outlined in Chapter 7, the characterisation, "mathematics gives an identity" resulted from data generated based on the interview question, "why do you learn and engage in mathematics," and the follow-up question about preparatory mathematics (see section 7.4.3.5). This question and the data generated expose the relationship between the two. In particular, the perception of mathematics' relevance characterised by identity is a motivational factor for students' engaging.

As it is evident above, the current study did not investigate identity as such. However, the results of the current study about the perception of mathematics' relevance characterised by identity are consistent with earlier results about identity. Consistent with Roth et al. (2004), the results in the current study confirm the significance of the structure in enabling and limiting the student's agency, which together shape the student's perception of relevance characterised by identity. My results are consistent with Roth (2007) as well. In particular, the results in my study expose that the perception of relevance characterised by identity can be consequences of the emotional valence that engaging in mathematics have (see section 7.4.3.5). However, Roth's studies are not about identities relating to learning mathematics.

The students also have collective identities (ibid). They have identities as social science or natural science students (see section 7.4.3.6). However, Roth did not investigate collective identity pertaining to categories of students, who attend different school subjects based on their categories. Such studies are in general scarce. Studies, which examined identities of students who aspire to study at the university, rather focused on the students' personal identities (e.g. Black et al., 2010). Black et al. (2010) did not examine collective identity with respect to groups such as social and natural science streams.

They examined students' personal identities, and to some extent the social aspect. The focus of Black et al. (2010) is on what the students aspire to study and what these students want to become in the future. Unlike for the students in my study, the school subjects for the students in Black and colleagues' study are elective. In their study, there are no such groups as social and natural science streams. This could be the reason for not examining collective identity (see section 2.4.3).

The results in my study are also consistent with Michelsen and Sriraman (2009). As I set out earlier, Michelsen and Sriraman examined interest in mathematics and natural science school subjects, where the students' identity is one of the dimensions (see sections 3.3.2). According to Michelsen and Sriraman, students' identities influence perceptions of mathematics' relevance to their anticipated future studies. Michelsen and Sriraman (2009) focused on students' personal identities. They hardly noted students' social identities. Though participants are upper secondary students who were attending natural science school subjects, they did not examine students'collective identities.

The students hold perception of the relevance of mathematics characterised by national identity. National identity is a collective identity, and the focus is on the structure, in which students are operating (cf. Roth & Lee, 2007). Roth and Lee (2007) assert that collective identity is associated with the structure. The students' national identity in my study is new in the sense that in other studies the description of identity in relation to students' cultural background focuses on minority groups (e.g. Nasir, 2002; Nasir & Saxe, 2003). National identity is different from ethnic identity of minority groups.

National identity is associated with the peculiar features of Ethiopian sociocultural and historical context. The historical context of the introduction of education in Ethiopia is set out in Chapter 1. The students operate in preparatory school, which is part of an Ethiopian school system and enforces education policy of Ethiopia. They operate in an Ethiopian sociocultural milieu (see Chapters 1 and 7). They are attending a national mathematics curriculum, which is adopted from other countries and some perceive that it does not embrace their sociocultural features. They learn in a foreign language, which some perceive it to be a source of difficulty in understanding mathematics. These national features of the structure form the context in which students' national identity emerges.

Moreover, in this study students did not identify themselves in terms of their ethnic backgrounds. The students belong to a society, which uses artefacts and has a cultural heritage that are Ethiopian, though diverse. Studies about mathematical identity in relation to nationality (a national domain); particularly, where the participants live in a specific cultural-historical setting and share a national curriculum, are scarce if any.

It was noted above that in the current study identity is used in some of the characterisations of perceptions of relevance. There could be an alternative explanation of the relationship between identity and perception of relevance in terms of dialectical relation. The students' expositions of perceptions of relevance carry a sense of identity. They recognize themselves as preparatory students, and therefore have a future goal. Then, they perceive that preparatory mathematics has an exchange value in giving access to this goal (e.g. Hanan's story in section 7.4.3.4), and they rely on the teacher and the school curriculum to provide them with what is useful for their future studies (e.g. Fikadu's story in section 7.4.3.3). Expositions of perceptions of the relevance of mathematics to other school subjects appears to presuppose who the students are with respect to others as well (e.g. Hana's story). Thus, a discussion of students' perceptions of relevance presupposes their identities.

On the other hand, students' identities presuppose their perceptions of relevance. The students' expositions of their identities presupposes their perceptions of the relevance of mathematics as having exchange value in giving access to university study (e.g. Sofia's story in section 7.4.3.5). The students' expositions of their identities also appears to presuppose their perceptions of the relevance of mathematics as having exchange value, where one uses a mathematics score in being placed at a better rank than others (e.g. Beliyu's story in section 7.4.3.5).

Similarly, students' exposition of their perceptions of the relevance of mathematics to everyday life appears to presuppose who they are as Ethiopians and learners of mathematics in an Ethiopian situation (e.g. Fikadu's story in section 7.4.2.2). On the other hand, students' expositions of their national identities also appears to presuppose their perceptions of the relevance of mathematics to everyday life in an Ethiopian situation (e.g. Haleluya's story in section 7.4.2.4). These dialectical relationships could be an alternative explanation for the relationship between identity and perception of relevance.

In this section, I presented the results pertaining to aspects of identity. The result I presented here is important in that it can be used for further exploration of national identity. The motivational influence of national identity, which is barely examined in this study, can be explored in future studies.

8.5 Gender issues

In this section, I focus on the gender difference in the students' perceptions of the relevance of mathematics. This includes the guidance that the students receive about their anticipated future study, the affirmative action in place, and gender roles. I also compare results from my study with the available literature.

I set out in Chapter 1 that there is affirmative action that is in place to favour female students' participation in preparatory education. There is a positive development in that the trend during the data collection shows that female students are outnumbering the males in this school. However, the participation of female students in the natural science stream is still worrisome because a smaller proportion of female students pursue natural science in both grade levels: 74% female to 77% male in eleventh, and 64% female to 76% male in twelfth-grade (See section 1.5.2). This background information obtained from the school gives a better meaning when we look at the disparity in perceptions of relevance. 66 % of the female students and 70 % of the male students held that preparatory mathematics is useful for their future studies (see section 6.3.3). This gives hint to the possible gender disparity in the participation of students in what they perceive are mathematics-related fields.

Moreover, analysis of the interview data suggest that there is gender disparity in guidance that the students receive about their future studies from the out-of-school sources. In particular, family members or siblings have influences on female students' choices of future study, and deny their agency (see Hale's and Zenebech's stories in section 7.4.3.3). This is particularly significant with respect to mathematics, because these female students are advised not to choose a stream or fields of study, which are perceived to be related to mathematics. I set out in section 8.3.2 that the out-of-school activities such as family-life are the major sources of information about mathematics' relevance to future study.

I set out in Chapter 7 that female students of rural background told stories, which expose a conflicting situation in their school and out-of-school lives (see section 7.3). They experience tension/ contradiction between their roles in the school and family-life activity systems (e.g. Beletu's and Zenebech's stories in section 7.3). The community and the division of labour in the schooling activity sometimes ease this tension/ contradiction, as the teachers attempt to help (e.g. Zenebech's stories in section 7.3).

Besides, though the situation for female students' education is improving there are still situations, such as heavy demands on them to share in work at home, which may not favour female students' learning. This is exposed in the stories of students of rural backgrounds (see section 7.3.1). This is significant for mathematics, as students perceive that mathematics takes more time than the other school subjects do. This can contribute to gender disparity in motivation to engage in mathematics.

Some of the results in my study are consistent with the available literature (e.g. Grevholm, 1996). The results in my study suggest that there could be gender disparity in participation in mathematics and related fields beyond the school. The results in my study are different from the available study in terms of participation at the school level (e.g. Leder et al., 2006; Vale, 2008). It is different in that my study shows that the female students are outnumbering their male peers in the preparatory school. That is, there is higher participation of female students at least at the school level, which means a higher participation in mathematics, because preparatory mathematics is obligatory. However, due to the influence of others in connection with choice mathematics-related fields of study and the lower proportion of female students' perceptions of relevance to future study suggest that their participation would be lower at higher level. Consistent with previous studies, results in my study show the influence of others' attitudes on the students' perceptions of relevance (e.g. Fennema & Sherman, 1977, 1978).

In this section, I presented the gender difference in the students' perceptions of the relevance of mathematics and issues related to these gender differences. There are issues such as the affirmative action in place, and limitations of guidance and counselling about future choice, which need to be further examined (see section 9.4.4).

8.6 Motivation

Although perception of relevance was the main agenda of the study, there was one interview question, which addresses motivation. This section presents the relationship of motivation with the characterisations of perceptions of mathematics' relevance. It also sets out other sources of motivation such as emotion. These results are compared with the results from earlier studies.

Students' perceptions of relevance influence their motivation to engage in mathematics (see sections 7.4.2 and 7.4.3). This is consistent with previous studies, which are situated in belief research (e.g. Eccles and colleagues; Kloosterman, 2002). However, these studies draw on cognitive theory. They are often criticised for seeing motivation as being external to the activity or the students' actions (e.g. Roth, 2007). Consistent with Roth (2007), based on the results in my study I conjecture that motivation is integral to the activity.

The perception of mathematics' relevance characterised by, "it has exchange value," is a motivational factor for students' engaging in mathematics (see sections 7.4.3.4). This characterisation is an example where perception of relevance can be used as a rationale (cf. Mellin-Olsen, 1987). According to Mellin-Olsen, this is an instrumental rationale and is a motivational factor for engaging in mathematics. The results pertaining to exchange value of mathematics and its motivational influence are also consistent with Black et al. (2010).

The present study provides evidence that the students perceive that their motivation to engage in mathematics relates to their engaging in other school subjects and their choice of future studies (see sections 7.4.3.2, and 7.4.3.3 and 8.2). The students experience tension/ contradiction within the object of the schooling activity. This is between their goal of learning mathematics and the other parts of the object, namely, their goal of learning the other school subjects and their anticipated future studies. The reason is that the goals can support each other in that one is useful for the other as well as compete with each other for the students' time and attention (e.g. Melkamu's story in sections 7.4.3.2 and 7.4.3.3). The students perceive that mathematics consumes much time with lesser guarantee of success compared to the other school subjects (e.g. Ayana's story in sections 7.4.3.2). This tension/ contradiction appears to contribute to the students' motivation in that their inclination of undertaking one action instead of the other comes as a development from the tension/ contradiction.

The literature about mathematics' relevance gives little attention to the motivational impact of students' perceptions of mathematics' connection with the other school subjects at upper secondary. Michelsen and Sriraman's (2009) results show that the relevance of mathematics has influence on students' motivation. However, their focus is on the usefulness aspect. They do not pay attention to the motivational influence of other aspects of mathematics' relation with other school subjects.

Although motivation is not the main issue in Flegg et al. (2012), they also acknowledged the motivational influence of perception of relevance of mathematics to other disciplines. This study is not about upper secondary. It is about university students. On the other hand, as mentioned above, the motivational influence of mathematics' connection with the other subjects can be due to their competition for students' attention and time. Examining this aspect of mathematics' connection with the other subjects together with the other aspects received little attention in studies about relevance and in belief research at upper secondary. The results in my study may encourage more attention on this issue.

There is relationship between motivation and perceptions of mathematics' connection with everyday life (e.g. Haleluya's story in section 7.4.2.2). This result is consistent with the available literature (e.g. Miettinen, 1999), though Miettinen is not about mathematics. The motivational influence of mathematics' relevance to everyday life is given little attention in studies about mathematics' relevance as well as in belief research, particularly at upper secondary. This is pronounced in countries with struggling economy such as Ethiopia.

The students' attempts to maintain positive perceptions of the relevance of mathematics characterised by identity are a motivational factor for engaging in mathematics (e.g. Sofia's and Beliyu's stories in section 7.4.3.5). The result pertaining to this relationship is consistent with the results in the available literature (e.g. Nasir, 2002; Roth, 2007; Roth & Lee, 2007; Roth et al., 2004). There are few if any studies in belief research, which examine the relationships. In those studies, which examine the relationships between motivation and identity in upper secondary schools, mathematics is elective and the motivation is about choosing mathematics. In my case, mathematics is already obligatory, and the motivation is about giving more time or less time for mathematics.

I conjecture that students' inclination to engage can be because of the emotional reward, which they expect to attain because of maintaining a perception of mathematics' relevance characterised by identity (e.g. Beliyu's story in section 7.4.3.5). In section 7.4.3, I explained that students perceive that their inclination to engage in mathematics depends on whether engaging promises or fails to promise a positive emotional reward. This is consistent with Roth (2007). My results differ in that Roth (2007) is not about students.

Students' motivation are examined in affect and belief areas of research mainly drawing on cognitive and social cognitive theories. I miss in those studies the role of emotion and tension/ contradiction in the students' motivation (e.g. Hannula, 2006). According to Hannula, the influence is from motivation onto emotion. Those studies, which draw on expectancy-value theory, hardly examine the tensions/ contradictions, which the students experience between their different goals (e.g. Wigfield & Eccles, 2000). Moreover, the studies hardly consider the diversity of characterisations of perceptions of relevance, which can have influences on students' motivation.

In this section, I presented the motivation associated with the diverse characterisations of perceptions of the relevance of mathematics. I conjecture that students' motivation can have diverse sources including the characterisations of perceptions of relevance, emotional valence as well as the tension/ contradiction they experience.

8.7 Generalizability and transferability of results

This section is about generalizability of the results obtained in this study to the school population and transferability of the results to other contexts. The claim about transferability of the results to other settings in Ethiopia beyond Memiru School is mainly based on the descriptions of the context, which I provided in Chapter 1 and section 7.3. I set out in Chapter 4 that the results would be transferable to other settings in Ethiopia because the relevant contextual issues are similar. I make distinctions between the various results of the study.

I obtained the same characterisations of perceptions of relevance repeating the same method after a year in the same school but with different students (see Chapters 5 and 7). It is likely that the same characterisations are obtained across schools in Ethiopia. However, there could be variations in the students' experiences, which establish these characterisations as well as in the proportions of students who hold these characterisations across schools.

I set out a methodological justification for generalizability of the results of this study to the school population (see section 4.4). I also set out the limitations (see section 4.5). There are variations in generalizability of the various results of this study. Those results pertaining to other school subjects, usefulness in future study and the exchange value of mathematics as well as those results pertaining to everyday use of mathematics are generalizable because the data obtained are from all sections of the student population in the school. The result pertaining to identity is generalizable to the school population. Though the diversity of students' backgrounds is limited in the interview data, the responses to the open questions are from the various sections of the student population in the school (see sections 6.3 and 8.4). On the contrary, it is not certain whether those results pertaining to national identity as well as fresh perspective of life can be generalizable to the school population. The reason is that there are no items pertaining to them.

Those results pertaining to other school subjects and the exchange value of mathematics can be transferable to other settings. The students in rural and urban settings alike would perceive that mathematics has exchange value for joining university and mathematics is relevant to the other school subjects. The reason is that these characterisations of perceptions of relevance almost exclusively emerge in the schooling activity. The relevant contextual issues of the public preparatory school are nearly the same (see Chapter 4). Similarly, the results pertaining to identity are transferable.

The results pertaining to usefulness of mathematics in future studies can be transferable to urban Ethiopia. Those results need further investigation regarding their transferability to rural Ethiopia. As I set out earlier in this chapter, the main information sources about mathematics' usefulness in future studies are the out-of-school activities such as family-life. There can be variation in the out-of-school activities of rural and urban settings in providing such information. In rural settings, there may be a lesser chance of having someone who has knowledge of university studies. It is unlikely that there would be difference in rural and urban settings concerning the other sources of information about future use of mathematics, which are the other school subjects. On the other hand, it is likely that there would be difference concerning the students' reliance on the curriculum and the teacher that they offer them mathematics, which would be useful for future study, which may dominate in rural settings. It is likely that a lesser proportion of the students in rural settings perceive that mathematics is useful in future studies.

Those results pertaining to national identity are also transferable in the sense that there will be students who would question their learning of mathematics with respect to their own situations as Ethiopians. The school rules, which enforces the nationally designed mathematics curriculum, are the same in every school in every part of the country. The students recognize themselves as such with respect to mathematics curriculum and its relation with them as Ethiopians.

The everyday use of mathematics can be transferred to other contexts because the examples, which the students used to explain their perceptions of relevance relate to the activities in most rural and urban Ethiopia. Those results, which pertain to their cultural heritage such as Edir and Equb need investigation to explore whether the same or similar activities are available in the various contexts of Ethiopia. On the other hand, the results, which are related to workplaces, could be even more limited in rural areas. The characterisation about fresh perspective on life is likely to prevail among some students in public preparatory schools of any region of the country both urban and rural areas. There could be variations in the students' experiences, which establish this characterisation, as there are variations in the cultural and religious composition of the different regions of the country.

One can also expect slightly different results with respect to influences of others on female students' choice of future study. This needs investigation in rural parts of the country to explore possible differences, as there is a lesser chance of having a family member or a sibling who has knowledge of university studies. This issue and other issues of concern about female students in rural areas need further investigation (see section 8.5).

8.8 Concluding remarks

This chapter presented the results of the qualitative and quantitative analyses that aim to give a coherent picture of the whole study, and enable the articulation of implications and suggestions for future investigations. The importance of perceptions of relevance as motivational factors for students' engaging in mathematics is suggested, in addition to the suggestions obtained from the literature. I compared the results in my study with those results in some of the literature, and set out what is new my study. The available literature situated in belief research have interesting results, but pay little attention to the sociocultural situation, which creates the constructs. Focusing on the school and out-of-school activities, the current study exposed perceptions of relevance in the sociocultural context.

Chapters 1 and 7 provided contextual issues to enable the reader decide whether results of this study are transferable to their own situation. As set out in the previous section, most of the results of this study could be transferable to other urban public schools in Ethiopia. There are some issues, which need further investigation regarding rural settings. Even then, most of the results of this study could be transferable to public schools of rural Ethiopia. Problems related to the methods and instruments, and issues for future investigations are set out in section 9.4.

The exposition of the contradictions/ tensions was not always possible. For example, it is expected that there could be contradictions/ tensions that the students who moved to Memiru from a different cultural tradition and language could experience within the schooling activity and in the out-of-school activities. As set out in section 7.3, students of rural backgrounds told stories about their experiences before enrolling Memiru. However, the stories did not help to expose any contradictions/ tensions, which the students experience in Memiru in relation to their backgrounds. Probably because it was not the agenda of the data collection.

These results I reported her are mainly from the qualitative data. I attempted to supplement these results by the results' popularity among the students. However, this was not always successful mainly because the questionnaire lacked the relevant items. The study has implications. The methods and theoretical framework raise issues to be considered in retrospect. There are issues, which require further investigations. These issues are the subject of the next and final chapter.

9 Conclusions implications and reflections

9.1 Introduction

This chapter is the final chapter of this dissertation. The chapter is structured as follows: conclusions of the study, implications of the study, and reflections and suggestions. Then, I set out the section on becoming a mathematics education researcher. Finally, I give a concluding remark. In this study, I did not investigate students' actual engaging. I did not have the opportunity to expose the mediational processes and tensions/ contradictions through extensive interviews and by following students' actions and the classroom practices. Consequently, the results pertaining to the mediational processes and tensions/ contradictions as well as students' motivations are presented as conjectures. Due to the methodological limitations set out in Chapter 4, the conclusion itself is in general a strong conjecture. Even then, they give insight for future investigations.

9.2 Conclusions of the study

In this research project, I set out to explore the Ethiopian preparatory students' perceptions of the relevance of mathematics using interviews and drawing on cultural historical activity theory. This section presents the conclusions of the study by answering the research questions that I posed in Chapter 1. The students perceive that mathematics is relevant to their future goals, to everyday life and to the other school subjects. The perceptions of relevance are related to each other, and the perceptions of mathematics' relevance to other school subjects is central in the relationships. Preparatory mathematics has limited use in out-of-school activities. On the other hand, the out-of-school activities are very important sources of perceptions of relevance of preparatory mathematics.

The other school subjects have mediational role in the students' perceptions of the relevance of mathematics in two ways. They mediate the perceptions that mathematics is relevant to future goals and that mathematics is relevant to everyday life. Similarly, the out-of-school activities have mediational role (e.g Miettinen, 1999). The students' perceptions of relevance is not necessarily based on their direct experiences. It is also based on other people's experiences in activities, in which the students do not take part. That is, in their mutual engagement with other people who have access to other activities, the students obtain information about those activities.

The students perceive that the mathematics at lower grades is relevant to everyday life. The out-of-school activities utilise mathematics. The students see that their society uses the mathematics in the activities such as Edir and Equb. The society also values the students' mathematical knowledge, which is revealed through parents' requests to solve problems of everyday life using mathematics. That is, mathematics enables them to have some role in the family-life activity.

The local artefacts as well as the local community appear to be readily available for assistance and for mediating the students' perceptions of relevance. The students' perceptions of the relevance of mathematics, which they learnt at lower grades, are largely positive. The students perceive that preparatory mathematics is rarely relevant to everyday life. In the rare occasions they find it relevant to everyday life, it is based on their access to workplace mathematics or is based on inventive use of mathematics. Through limiting the exposition of the usefulness of preparatory mathematics, the artefacts such as the lessons and the textbook mediate the students' perceptions of relevance. This limitation appears to lead to the perceptions of relevance, which are based on inventive use of mathematics, as well as to the formation of a national identity.

It appears that as students are going up in grade levels, mathematics' connection with everyday life including their cultural heritage becomes weaker. The students' future goals become available to the students' attention. The students' perceptions of the relevance of preparatory mathematics is dominated by the relevance of mathematics to their future goals. This transition of relevance from usefulness in everyday life to relevance to future goals does not seem to be smooth for the students. Because these are not the same type of relevance. They differ in two ways. First, the students do not have direct access to the information about future usefulness of mathematics. The students only get information through other sources. Second, the relevance to future goals is not just usefulness. It is partly the exchange value of mathematics, which is not about its usefulness. The other subjects are important to them to predict mathematics' usefulness in future study (see section 7.4.3.3).

I set out in Chapter 2 that the motive of the schooling activity is producing students who are capable of joining the university and become capable of solving problems of everyday life. The motive of the family-life activity is survival of the family. The family-life activity embraces the school's motive. This is revealed through one of the goals of the family-life activity, namely, personal development of the students. For example, as part of the actions towards the goal of personal development, family members undertake actions, which includes supporting the students' engaging in school tasks and preparing for future studies. The students adopt/ share the motives of the two activities. These adopted motives shape students' perceptions of the relevance of mathematics. The embracing of the school's motive by the family-life activity is also revealed through parents' requests to solve problems of everyday life. The students' perceptions of the relevance of mathematics seem to derive from the motives of the activities, in which they participate, particularly, the school and family-life activities (cf. Roth, 2007). According to Roth (2007), motivation and identity derive from both emotions and motives.

For the students, undertaking actions towards the goal of learning mathematics appears to be the same as undertaking actions towards the goal of acquiring knowledge, which can make them successful in examinations. This success in examinations would help them to gain access to further education, namely university. Their aspiration to join university is consistent with the motives of the school and family-life activities. It is important for the students to make choices and decisions about which school subject to focus on such that they can achieve the required score for joining university or an anticipated future study. However, students also want to have knowledge of mathematics, which they can utilise in the future studies if they know that it would be useful.

As I mentioned earlier in this section, the other subjects are among the information sources about mathematics’ usefulness in the students’ future studies. The second and most important information sources about mathematics’ usefulness in students’ future studies are the out-of-school activities, particularly, the family-life activity. In the division of labour in the family-life activity, some members have a role of mentoring the student towards their personal development. Unlike the schooling activity, the out-of-school activities such as the family-life activity provide specific information about the usefulness of mathematics in students’ anticipated future studies. This provision of information often involves guidance. The guidance that the students receive from family members can involve gender bias. Some female students reported that they are advised not to choose natural science fields or streams.

The third source of information about relevance for future study is the mathematics lesson and teacher. In their role as sources of information, the mathematics teachers can give general information about mathematics' usefulness for future studies. The results show that there is a disadvantage for the students who aspire to study social science fields of study. The mathematics teachers have a natural science background, and they use a textbook written by people who have a natural science background. This can influence students’ perceptions of the relevance of mathematics for future studies (see sections 7.4.3.3, 7.5 and 8.3.2).

The schooling activity is a source of information about mathematics' relevance for anticipated future study in another way also. Some students just rely on the curriculum and the teacher. They rely that the mathematics they are learning would be useful for their future studies.

Students perceive that mathematics is useful in other school subjects. As I mentioned earlier in this section, this perception of mathematics’ usefulness is one aspect of the perceptions of mathematics’ relevance. The main sources of the perception of mathematics’ usefulness in other school subjects is the schooling activity, in particular, lessons of other school subjects. The mathematics lessons are other sources. In rare occasions, the out-of-school activities are the sources of this perception of relevance. For example, artefacts such as the media provides information about mathematics' usefulness in another school subject.

A very high proportion of students perceive that mathematics is relevant to the other subjects and to their future studies. There are differences in the proportions of the female and male students who hold the perceptions of mathematics' relevance to their future studies as well as in the sociocultural situations, which could shape the perception of relevance (see section 8.5). Similarly, there are differences in the proportions of the natural science and social science students who hold that mathematics is relevant to the other school subjects and to their future studies as well as in the sociocultural situations which could shape them (see section 8.3). On the other hand, within the social science stream itself, the perceptions of the relevance of mathematics to their future studies vary depending on the fields of studies. The sociocultural situations, which could shape the perceptions of relevance, are also different (see section 8.3). These have implications (see section 9.3).

In general, the out-of-school activities have a significant role on students' perceptions of the relevance of mathematics in everyday life. The students' perceptions of the relevance of mathematics to everyday life is based on their sociocultural situation outside the school including their sociocultural heritage such as Edir and Equb. The students' sociocultural heritage also appears to be important in enabling students to handle the tensions/ contradictions they experience between everyday life and learning mathematics. For example, the religious teachings appear to enable a few students to handle the tensions/ contradictions they experience between their learning of the mathematical concepts and their everyday life. The out-of-school activities contribute to the students' perceptions that mathematics gives them a national identity. This perception of relevance appear to result from the tensions/ contradictions students experience between their learning of preparatory mathematics and the objects of the out-of-school activities (everyday experiences, culture, and the goal of student's personal development).

The perception of mathematics' usefulness is one aspect of the perceptions of mathematics' relevance. In general, the artefacts such as lessons and textbook of mathematics have little positive contribution to the perceptions of the usefulness of mathematics. The students obtain information about the usefulness of mathematics to their future studies, to everyday life and to the other school subjects mostly from sources outside the school and from the other school subjects (see section 7.4).

The constructs in affect and belief areas of research such as attitudes and beliefs have relationships with perceptions of relevance. For example, section 7.4.2.2 set out that, students' beliefs about what counts as mathematics has influence on the characterisation of perception of relevance, "mathematics is useful in everyday life," which is consistent with Presmeg (2002). It was also set out in section 7.4.3.5 that the characterisation, "mathematics gives an identity," relates with beliefs about the learning of mathematics. However, the exact relation is not clear. Students' beliefs about mathematics are exposed when they compare mathematics with other school subjects. Similarly, perception of relevance relates with attitudes in that it contributes to the development of attitudes towards mathematics (see section 7.4.2.2 and 7.4.2.4). Such attitudes, in turn, can influence attitudes towards the other subjects, which use mathematics (see section 7.4.3.2). These results are consistent with Fennema and Sherman (1976) and Michelsen and Sriraman (2009), respectively.

Students' perceptions of relevance can be a motivational factor for the students' engaging in mathematics. As I set out earlier in this section, exchange value is the main motivational factor. Another important motivational factor is the perception of relevance characterised by "mathematics gives an identity." Motivation is set out in section 8.6.

In this section, I attempted to articulate the answers to the research questions. I undertook the study in a particular sociocultural context, where the schooling activity is situated in the Ethiopian sociocultural context, and mathematics the students learn is adopted from technologically advanced cultures. Some of the findings are peculiar to this context. The out-of-school activities have a mediational role of the students' perceptions of the relevance of mathematics by closing the gap, which the schooling activity leaves. Consistent with Kuutti (1996), the school and out-of-school activities form the sociocultural context. Particularly, the context in which the students' perceptions of the relevance of mathematics are shaped. The context includes the learning of the other subjects.

9.3 Implications of the study

This study is about students' perceptions of the relevance of mathematics and hence the implications of the study I present here are largely about improving and utilising the students' perceptions of the relevance of mathematics. The focus of the implications is mainly on the sociocultural context. This involves the activities to which the students have direct or indirect access. The study has implications for mathematics teaching and learning, for the mathematics education community, and for the Ethiopian curriculum. These implications are set out in this order.

9.3.1 Implications for mathematics teaching and learning

The implications for the teaching and learning of mathematics are about collaboration of the school with out-of-school activities**,** which utilise mathematics such as workplaces. The need for collaboration also includes experts of the disciplines, which utilise mathematics as well as teachers of other school subjects, which utilise mathematics. These implications including the need for consideration of the students' beliefs as well as consideration of students' reflections are presented here.

Section 9.2 set out that students use mathematics' usefulness in the other school subjects to predict that preparatory mathematics would be useful in their anticipated future studies. Consistent with Flegg et al. (2012), the implication is that there should be collaboration with teachers and experts of other school subjects and disciplines, which utilise mathematics. The intention is to enhance students' perceptions of the usefulness of mathematics over its competitiveness with the other school subjects. The collaboration is important to convince students that mathematics is useful for the other school subjects and that engaging in mathematics is useful for the learning of the other school subjects. Improving students' shared attitudes towards mathematics and towards those school subjects, which utilise mathematics, necessitates the collaboration. The influence of the natural science background of mathematics teachers was set out in section 9.2. This strengthens the need for collaboration of mathematics teachers with teachers of the social science school subjects, which utilise mathematics.

In section 9.2, I set out that the most important information source about mathematics' usefulness in the future studies are the out-of-school activities. The implication is that there should be collaboration with out-of-school activities, in particular, with experts of various disciplines. These disciplines are students' anticipated future studies in the university. In such way students get information (and opportunity to ask) about disciplines and the disciplines' relations with mathematics (cf. Michelsen & Sriraman, 2009). Michelsen and Sriraman note the necessity of exposing students to the transition to their anticipated future studies and future careers in order to enhance their perceptions of mathematics' relevance.

As set out in sections 7.4 and 7.5, whether the experience is a first-hand has influence on the students' perceptions of relevance. The implication for the teaching of mathematics is that the collaborations with the out-of-school activities should involve the students so that they experience them directly and the experiences could have a stronger influence on learning (e.g. Miettinen, 1999) as well as on the students' perceptions of relevance. The out-of-school activities should be those, which utilise mathematics or those, which utilise mathematics through other disciplines or school subjects. The intention is to show the usefulness of mathematics. As I set out in section 9.2, the other subjects can serve as a way of seeing connections between mathematics and everyday life.

I set out earlier in section 9.2 that what counts as mathematics affects the students' ability to relate what mathematical concepts are involved in everyday life, the other school subjects, in the artefacts they experience, and in students' inventiveness (cf. Presmeg, 2002; Wedege, 2004). Consistent with Presmeg (2002) I suggest that enhancing students' perceptions of relevance needs to consider enhancing students' beliefs of what counts as mathematics. Consistent with Wedege (2004), I suggest that it is necessary to make the uses of mathematics, which are hidden in the artefacts, available for the students' attention. This includes the mathematics, which is hidden in the other school subjects. The collaboration within the schooling activity and with the out-of-school activities might help to make students be aware of the roots of the mathematics concepts used in other school subjects as well as in out-of-school activities, thus enhance students' perceptions of the relevance of mathematics. These collaborations can involve students' reflections of what relevance of mathematics they attach to their experiences with the activities.

This section presented the implications for mathematics teaching and learning. Given that I collected the data from an Ethiopian school, these implications mainly apply for Ethiopia and similar contexts. The implication focused on enhancing perceptions of relevance through improving the context. This context includes the learning of the other school subjects and their experiences with the out-of-school activities.

9.3.2 Implications for mathematics education community

My study has implications for the research community of mathematics education. These implications are mostly pertinent to the need for focusing on the sociocultural context. I set out issues, which acquired only limited attention in affect and belief areas of research.

Consistent with Kuutti (1996), the current study shows that the focus on activities gives opportunity to see the peculiar features of the sociocultural context. The studies situated in affect and belief areas of research should pay attention to the sociocultural context, in particular to the activities, to which the students have direct or indirect access.

Students' perceptions of the use of mathematics in life outside the school including in workplace are under-investigated in affect and belief areas of research, particularly in context of countries with less use of advanced technology such as Ethiopia. Similarly, investigations into students' perceptions of mathematics' relevance to future goals and to other school subjects are rare at the pre-university levels, particularly in the context of developing countries such as Ethiopia. The results of this study adds to the knowledge base of research about students' perceptions of relevance of mathematics in a different cultural context.

Section 7.5 set out the importance of specificity of topics, experiences, and the activities, which students mention to substantiate their perceptions of relevance in determining the strength of influence on their perceptions of relevance. The implication is that the research about the relevance of mathematics should focus on specific mathematics topics to specific activities to which students have direct or indirect access.

There are other issues, which acquired little attention in belief research. In the investigations of students' perceptions of the relevance of mathematics, we need to take into account issues of compatibility of the mathematics curriculum with the sociocultural context. Such research should also incorporate students' reflections on their mathematical experiences with respect to the diverse activities to which they have access, where students can inventively use mathematics. We should also consider the language in nations where the instruction is in a second language. The students' national identity and other issues such as reliance on the teacher and the curriculum also require investigation in belief research.

I set out in Chapter 3 that the Op't Eynde group addressed the social aspect of beliefs in mathematics education, particularly, the social context. The cultural context within which the mathematics classroom and students are situated does not seem to receive sufficient attention. I suggest that *Beliefs about the social context* in Op't Eynde et al. (2002) be changed into *Beliefs about the sociocultural context*. It can create an opportunity to include beliefs related to the mathematics curriculum and its coherence with students' sociocultural situation, learning mathematics, which is adopted from foreign culture, and learning mathematics in a second language. This can include beliefs related to inventive use of mathematics, national identity, and other issues connected with peculiar features of various national contexts. This can embrace the out-of-school activities, and the artefacts students experience in the school and outside of the school in various national contexts.

The implications presented are mainly for belief research. I set out the importance of paying attention to the sociocultural context, in which students' perceptions of relevance might emerge. It is possible to expose this context through focusing on the activities (Kuutti, 1996). I provide further reflection on this issue in section 9.4.1.

9.3.3 Implications for mathematics curriculum in Ethiopia

In this section, I set out the implications of the study pertaining to the mathematics curriculum in Ethiopia. I focus on curricular materials, particularly the mathematics textbook, and the lessons, which the teacher prepares by using the nationally produced textbook and teacher's guide. I set out implications, especially relating to the other school subjects and students' anticipated future studies as well as to everyday life and to the society.

I set out earlier that the main source of information about mathematics' relevance to future study are the out-of-school activities (see section 9.2). The fact that the school is not the main source of such information is a serious concern because these students are preparing for university studies. The implication I set out in section 9.3.1 about collaboration is relevant here as well. On the other hand, there is gender issue associated with this provision of information by the out-of-school sources (see section 8.5). This has implication for the affirmative action for enhancing female students' participation, which should also focus on choices of studies (see section 9.4.4).

The other school subjects are the other sources of information about future use of mathematics (see section 9.2). Moreover, the units of the textbook, which are pertinent to the interview data, have little about other school subjects and students' anticipated future studies (see section 7.4.3.1). In section 7.4.3.1, I also set out that these units of mathematics textbook do not serve the social science and the natural science students equally in providing information about other school subjects and students' future studies. The imbalance in the provision of information prevails in some mathematics lessons as well. I set out earlier the possible influence of natural science background of the people behind the mathematics textbook and the mathematics teachers (see section 9.2).

There should be collaboration between experts who prepare the mathematics textbook and experts of the other school subjects. This is to ensure that the students get appropriate information about mathematics' relevance to the other school subjects. The collaboration with experts of the other school subjects or disciplines is important with respect to mathematics' use in future studies as well (cf. Flegg et al., 2012). Flegg and colleagues suggest that there should be collaboration between the departments of engineering and mathematics towards designing the mathematics curriculum for engineering students (ibid).

There is variation among students of the social science stream itself in their perceptions of mathematics' relevance to their future studies (see section 8.3). For example, the perceptions of students who anticipate studying economics is almost opposite to those who anticipate studying law. The decision about whether the students who anticipate studying economics and those who anticipate studying law should attend to the same mathematics needs further investigation. That is, the mathematics content and depth with respect to the students' anticipated future study needs investigation. This also necessitates the collaboration with experts of the respective disciplines.

I set out in section 9.2 that the students' perceptions of the relevance of preparatory mathematics to everyday life is mostly negative. In the overview of some of the units of the textbook as well as in the observed lessons the everyday use of preparatory mathematics is scarce (see section 7.4.2). The implication is that there needs to be a broader investigation of the curricular materials such as the textbook about their inclusion of everyday use of mathematics including its use at workplaces.

The inclusion of students' reflections and inventiveness with respect to their sociocultural context in the mathematics curricular materials needs investigation. The textbook should reflect the peculiar features of Ethiopian sociocultural and historical context. The mathematics tasks should address these situations. The students learn in a foreign language, which some perceive it to be a source of difficulty in understanding mathematics. The curricular materials should address these issues, which can shape students' national identity.

There are external partners in the education sector in Ethiopia, including in the teaching and learning of mathematics. For example, there were supports in the publication of the new textbook from a number of countries and projects, which are acknowledged in the textbook. I suggest that such supports may also target the collaborations, which I mentioned above. On the other hand, Norwegian organizations such as Norad are supporting partners in the education sector in Ethiopia (Norad, 2015). Support from such organizations may also target investigating possible collaborations between school and out-of-school activities as well as interdisciplinary collaborations towards improving the teaching materials of mathematics, and teaching and learning of mathematics, in general.

Relating the mathematics curriculum to the broader situation of the society would also be important for enhancing the perception of relevance of the local community. Particularly, the students' families seem to value the students' learning when they see that mathematics is related to the society's situation. This in turn influences the students' perceptions of relevance. This use may also be significant in strengthening the link between school and society; it can encourage embracing of school by the local community. Society's culture and the formal education system have existed separately for a century. There is an opportunity to bring them together, and to integrate them by using students as the bridge between school practice and the local culture. However, language may form a barrier. Such issues, which require further investigations, are set out in section 9.4.4.

9.4 Reflections and suggestions

In this section, I reflect on the theoretical and the methodological issues. Then I provide suggestions for future use of the questionnaire and suggestions for future investigations. I present these issues in this order.

9.4.1 Theoretical reflection

This section presents a reflection on my use of Engeström's model. In the following paragraphs, I explain how the model suited my purpose. I also set out some drawbacks in my use of the model.

The model that I used to explore students' perceptions of mathematics' relevance is suitable to see learning mathematics as one of the students' multiple goals in their participation in the activity of schooling to realize the motive of attending university. It enables viewing the perceptions of mathematics' relevance in the sociocultural context. The model does not favour isolating mathematics learning from its context (which includes learning other school subjects). The reason is that the focus is on the schooling activity, where learning mathematics is only one of the goals towards which students take actions in order to realize the activity.

Engeström's model fits well into the need to understand students' perceptions of relevance and the associated motivation in the sociocultural and historical context in which the students are situated. Because it provides a possibility for focusing on the peculiar features of the sociocultural context and see its details (including the artefacts, the community, the rules, and division of labour) in which the individual finds her/himself (e.g. Kuutti, 1996), and enables to expose perception of relevance as a sociocultural product. The results of this study are partly consequences of such focus. The model could expose the diverse sources of motivation (see section 8.6).

Roth's work influenced my study in that I followed his use of Engeström's model. I also followed him in my attempt to expose some constructs such as identity. Roth (2007) showed that emotion, identity and motivation are integral to an activity. The results in my study suggest that students' perceptions of relevance and motivation are integral to an activity. However, there are limitations in my use of the model efficiently. Contrary to Roth, my relation with my informants was limited; I was not part of the schooling activity. I attempted to understand the perceptions of relevance as narrated by the students. The data I obtained were limited and I used the model to the extent I needed to analyse the available data (see Chapter 4).

My study is situated in belief research in mathematics education. Belief research is often criticized for objectification (Skott, 2010). I objectified the notion of perception of relevance in order to communicate effectively the students' perceptions of relevance and enhance the knowledge base of the rarely explored Ethiopian context. However, I was careful about the detaching of the notion from the context by using descriptive phrases instead of single words in characterising them, which are followed by the students' own words. These characterisations of perceptions of relevance do not restrict us from having a more open mind to see new things, as these are open to further scrutiny. Moreover, such results from the specific context are important as a starting point in order to follow students’ patterns of participation (cf. Skott, 2010). As I mentioned in Chapter 3, Skott’s new direction to belief research is based on the overview of the rich Western literature about teachers’ beliefs.

9.4.2 Methodological reflection

In this section, I reflect on the methodological issues, focusing on why I believe that the methods are appropriate to my study. I examine how efficient the methods are in enabling me to explore and expose students' perceptions of relevance, with particular focus on their strengths and weaknesses. I also provide some insight into future use of the methods.

In Chapter 4, I explained that students with similar classroom experiences were interviewed together. The situation helped students to feel free to tell their stories. It also helped them remind each other. A student’s exposition of a certain issue reminded the others to tell their stories (which could be different or similar stories). This situation appears to contribute to obtaining diverse characterisations of perceptions of relevance. On the other hand, it appears to contribute to the variation in data obtained from the various interview groups, which represented the various categories of the student population. There are some issues, which were extensively dealt in one group and are not dealt at all in another. The difference in the results may not necessarily reflect that there is variation in the students’ perceptions across various categories of students.

There were occasions where this imbalance of data across the categories of students did not allow comparison of perceptions of relevance across the categories of students used for sampling. This can be an example, which shows the need for repeated interviews to exhaust the possibilities of emergence of similar perceptions of relevance in the various categories of students. I presume that the students might come with some examples of everyday use of mathematics, even some inventive uses of mathematics if I met them a second or third time while they continued to participate in the diverse activities, use the artefacts and interact with others. On the other hand, as I was undertaking the analysis, there were situations where I wished to meet the participants again to ask further questions. For example, to clarify their sources of perceptions of relevance and in cases where meanings were not clear. These also show the need for repeated interviews while the data analysis was underway.

The interview data were collected during the same period of consecutive years. The examples cited by the students are usually from the topics covered during the interview period. For example, during the interview period, the topic in twelfth-grade was “limits of functions.” Some twelfth-grade students talked about absence of application of limits, and other twelfth-grade students used this concept inventively in out-of-school life and in another school subject. On the other hand, few students mentioned preparatory mathematics topics, which were taught beyond the interview period. For example, a single twelfth-grade student mentioned of the use of probability in games, and an eleventh-grade student told about statistics. An eleventh-grade and other twelfth-grade students told about the use of calculus in future study based on out-of-school sources even before they begin to attend it in school. If the interviews were in a period when students were learning these topics, students might have told diverse stories, which probably influence the results.

I encouraged the students to use examples from their recent lessons. Both the interview situation and the fact that the mathematical experiences were fresh in their memory might have helped the students to reflect on specific topics. If the students are interviewed at various points in time, their experiences including the example they consider could vary. Such situations might give a possibility of obtaining data, which are missing in some sections of the population while they are available in the others. For example, the characterisations such as "mathematics gives fresh perspective on life" and "mathematics gives a national identity" are based on data generated from fewer sections of the population. The situations I mentioned above might give an opportunity of obtaining similar data for the remaining sections of the population.

On the other hand, there were some situations, which might have caused differences in the data generated across interview groups. The follow up questions are based on what students mentioned during the interviews. Thus, they varied across interview groups. There were cases where an issue raised by one student became a focus of the other members, even attracted my focus, hence I invited other members to add.

Given that the purpose of this study is serving as a springboard for launching a further study, I saw the variation across interview groups as an opportunity to obtain data that allows a wider description of students' perceptions of relevance. In particular, the variation opened the possibility for obtaining diverse characterisations of students' perceptions of the relevance of mathematics. However, due to these differences, there is an imbalance in the data generated across gender, grade levels, and streams. This imbalance in the data generated is set out in Chapter 7.

I presented the preliminary results of the pilot study to the teachers and obtained some feedback (see Chapters 4 and 7). It would have been useful to invite teachers to reflect after presenting the result of the main study. This could have been used, among others, for further checking hard facts (Miles & Huberman, 1994). The classroom observation could also have been used for the same purpose.

The classroom observation was not the main instrument for the data collection, but it was helpful in enriching the data, as it was used to probe the students. The students and I shared similar experiences of mathematics in their classes. In occasions of silence, these shared experiences were helpful in order to make the discussion lively. However, there was variation in the students' participation in the interviews. Some students reflected well on particular issues and others did not. The probing did not help in some cases and the interview time was short. I presume that every student has a story to tell. A repeated classroom observation followed by interviews about the particular observations of their actions might have been helpful to elicit information from students.

The lack of a considerable engagement in classroom observations in between the extended interviews has negative consequence in my claims about motivation, tensions/ contradictions and mediational processes. There were some limitations in exposing the activities, in which the students participate. The students were not interviewed over extended period. The few classroom observations were held before the interviews. I attempted to identify the activities, actions and operations from the students' words. I also attempted to identify the mediational process and the students' experiencing of tensions/ contradictions in the same way.

As set out in Chapter 7, the interviews of students with rural background had an advantage. The gender role in the society was identified in the students' who came from the rural areas. These data emerged because of the attention given to the students' background. Moreover, the interview group gave them a comfortable situation to tell their stories and remind their experiences to each other because female students of rural background were in the same interview group.

The main purpose of adopting the mixed approach is to explore the characterisations of students' perceptions of relevance and to explore the popularity of these characterisations. However, this approach is useful to this study in another aspect, too. For example, the data generated using the questionnaire shows that the major source of information about future use of mathematics is the teacher. However, the analysis of the interview data indicated that students' out-of-school sources are significant in the students' perceptions of the relevance of mathematics to their anticipated future studies. Such seemingly inconsistent results could be obtained when a mixed approach is employed. As pointed out in Chapter 8, the advantage is in its potential to allow a deeper analysis (e.g. Pring, 2004).

9.4.3 Future use of the questionnaire

This section focuses on suggestions for future use of the questionnaire. I set out pitfalls and ways to improve the items, and suggest additional items. The suggestions are mostly based on the reports in Chapters 6 and 8.

There are items about the use of mathematics in the students' out-of-school experiences such as "leisure time activity" and "activities in the society," which are rather general questions. Replacing them by other items about specific out-of-school activities, which students listed in the interviews such as specific games, would be a good idea. Alternatively, it is possible to ask the students to list the out-of-school activities, to which they have access and then ask them if they see or use mathematics in these activities. Similarly, there should be items, which enable to examine the popularity of the perception of preparatory mathematics' usefulness in workplace.

As I set out in Chapter 6, the items about other school subjects focus only on the usefulness of mathematics in these subjects. The open questions, which follow these items, ask students to list the other school subjects, which use mathematics. I suggest that there should be open questions, which ask about the mathematics concepts used, in addition to asking them to list the other school subjects.

There are other issues about other school subjects, which the questionnaire should include. It is particularly important to measure the popularity of the perception that mathematics' usefulness in everyday life is through other subjects. We also need an item, which examines the popularity of the perception of mathematics' usefulness in future study based on its usefulness in the other school subjects. We also need items for the diverse aspects of perceptions of mathematics' relevance to the other school subjects. In particular, for the aspect that mathematics has features that are shared/contrasting with other school subjects. We also need items for the aspect, which is about shared attitude towards mathematics and those subjects, which use mathematics. The third aspect is that the other school subjects compete with mathematics for the students' attention and time. We need an item for this aspect as well.

I set out in Chapter 8 that the results obtained from the interview and the questionnaire about the future use of mathematics are different because of the difference in the questions (see section 8.3.2). I suggest modifying the questionnaire item about the use of mathematics for future study. The existing item is general (see Chapter 6). I suggest that the item should be about the use of mathematics for the individual's specific anticipated future study. I also suggest modifying the existing follow-up question. It is better to ask them about their sources of information regarding the use of mathematics in the individual's specific future study.

The questionnaire items are usually the characterisations of perceptions of relevance I obtained from the interviews. However, in some occasions I attempted to make the items closer to the original ideas from students' stories so that it is easier for the students to understand. For example, some students inventively used mathematics in their spiritual life, which I categorized as "it gives a fresh perspective on life." Instead of this categorization, the questionnaire contained items about spiritual life such as, "I use mathematics in spiritual life." On the other hand, these two are not the same and one cannot replace the other. For example, in the main study, the interview data from which the characterisation, "mathematics gives a fresh perspective on life" was established are not about spiritual life. However, in both the pilot study and main study, this characterisation is based on inventive use of mathematics.

On the other hand, the items about spiritual life as well as fresh perspective on life could be difficult for students to understand. Instead, it is better to include items, which ask if the student has thoughts about possible uses of mathematics other than the ones stated in the lessons or textbook. For example, ask them if they inventively use or experience mathematics in other school subjects, everyday life or spiritual life. Then ask them for explanations about spiritual life and in what ways mathematics is used inventively.

Similarly, the terms such as curriculum might be rather esoteric and students might not understand it well. It is better to use simpler vocabulary, use descriptions, which students used in the interviews or descriptions used for coding in the interview data. It is also important to provide examples. On the other hand, the Amharic equivalent of the term identity is not difficult for the students to understand.

I did not examine the popularity of the characterisation of perception of the relevance of mathematics, "it gives a national identity" among students. We need a questionnaire item about this issue. I suggest that there should also be items, which can specifically expose the popularity of the perception of mathematics' relevance to anticipated future studies based on reliance on the curriculum and the teacher. The current item about reliance on the curriculum and the teacher is general. It is not specific to students' anticipated future studies (see sections 6.3.2 and 8.3.2). Furthermore, we need items to examine the popularity of the motivational effect of perceptions of relevance. We also need items about relationships of perceptions of relevance with attitudes, beliefs and emotions.

As outlined in Chapter 6, the fact that students rarely responded or did not respond with clear handwriting to the open questions, had repercussions on the results obtained. The possible reason for a low rate of response could be the period of completion of the questionnaire and the amount of time that students were willing to spend on it. The students completed the questionnaire in the period between the midterm and final examinations of the first semester. This period is about one month, and they are very busy in this period. Future use of the questionnaire needs to strike a balance between the choice of period of completion of the questionnaire; the number of items and the need for the open questions. Since the open questions are important in both generating data and checking whether students understood the items, it is better to administer the questionnaire at the beginnings of the semesters when students are not busy. The second semester could be a better choice as participants will have the experience of the current grade level.

9.4.4 Suggestions for future investigations

In this section, I set out suggestions for future investigation. My suggestions are based on the results of this study. There are also suggestions, which are based on the feedback I received from the teachers following my presentation of the preliminary results. I also use my overview of the textbook and issues, which are excluded because of the limited scope of the current study.

Section 9.3, presented the study's implications. In particular, the need for collaborations within the schooling activity as well as with the activities outside the school. There could be challenges on the part of the teacher in relation to the implementation; for example, exposing mathematics' usefulness is not an easy task (Gainsburg, 2008). Gainsburg assert that the school rules could also create a problem (see section 3.3.3). The implementation of these collaborations requires investigation.

Reliance on the curriculum and the teacher emerge as a characterisation in Chapter 5 and as a part of another characterisation in Chapter 7. Future studies can examine through extended interviews if reliance on the curriculum and the teacher could emerge in specific characterisations or diverse characterisations of perceptions of relevance. On the other hand, whether this reliance is inclined to dependence in contrast to independent exploration of relevance or evidence, also require investigations.

I set out the importance of holding extended interviews accompanied by classroom observations, including a wider coverage of topics, in an attempt to guarantee a richer data (see section 9.4.2). In particular, this may give a better opportunity to look for data obtained in one section of the population and absent in the others. I also mentioned that the interview questions targeted some of characterisations, and did not target the others such as "mathematics gives an identity," "mathematics gives a national identity," and "mathematics gives a fresh perspective of life" (see sections 7.6). Future investigation should include interview questions targeting these characterisations.

The current study was undertaken in an urban setting in Ethiopia. The study is a single case. Future investigations could also attempt to replicate the findings using multiple cases including rural settings and attempt to expose differences, if any, across various settings.

I had a glimpse of the textbook and classroom observation, which are about a few topics (see sections 7.3, 7.4.2.1 and 7.4.3.1). This provided some evidence, which supports the interview data, in exposing the mediational role of these artefacts. They appear to have a mediational role in the students' perceptions of the relevance of mathematics to other school subjects, to the anticipated future studies as well as to everyday life. Since their mediational role is examined based on few topics, it requires further investigation. The overview of the textbook came after the data collection was over. Future investigations of perceptions of the relevance of mathematics need to consider a prior and parallel overview of the textbook in order to generate more data to expose the mediational role of this artefact.

I set out in section 7.6 that the examples, which the students gave about the usefulness of preparatory mathematics in other school subjects, are mostly from mathematics prior to preparatory. Some also doubt the usefulness of preparatory mathematics in the other school subjects. On the other hand, the relevant items in the questionnaire show that this perception of relevance is held widely among the students (see sections 6.3.2 and 8.3.1). Following Pring (2004), I suggest further exploring this inconsistency using extended interviews and observations to obtain a more meaningful interpretation.

Another issue, which could have been addressed by extended interviews, is word problem. Some students mentioned about it in the pilot study, but such data was not available in the main study. Consistent with Greer et al. (2002), the students perceive that the relevance of mathematics can be presented in the mathematics classroom using word problems (see section 5.3.1.4). The issue of learning mathematics using word problems, in a second language is an important subject of future investigation. These students find themselves in a historical situation where a mathematics curriculum that is not in their own language has been adopted. The use of language with respect to the students' capability of coping with the English language also needs further investigation.

Motivation is not the main agenda of the data collection. However, there was one interview question, which addresses it and the data contains some evidence of relationship between students' perceptions of the relevance of mathematics and motivation. There are also other sources of motivation including emotion and tensions/ contradictions. I suggest that the relationships of motivation with perceptions of the relevance of mathematics as well as the other possible sources of motivation should be a topic for future investigation. It is also important for the researcher to be part of the activity (Roth, 2007). Moreover, understanding if their engaging is consistent with their perceptions of relevance requires additional methods; for example, holding interviews on multiple occasions with intervening classroom observations. This could allow a decision about the impact of perceptions of relevance.

The perceptions about the relevance of prior experiences to preparatory mathematics is one of the research questions in this study. However, both the interview and the survey data generated for this research question lacked the authenticity and trustworthiness to sustain the arguments that I hoped to present. I suggest a separate investigation of this issue.

In this study, I reported students' stories about the video method of teaching. I set out that since the students were learning by the video method of teaching earlier, it forms part of the context in which students perceptions of relevance took shape (see sections 1.5 and 7.3). On the other hand, there is evidence that there was variation in the way the teachers handle their classes in the little time available for them. If the video method of teaching continues to be in use, it needs further investigations about some mechanism by which teachers share their positive practices. Another issue of concern, which the students and the mathematics teachers expressed, and needs future investigation is the vastness of the textbook and its rate of change.

I set out earlier that gender is an issue in Ethiopian education (see sections 1.4, 1.5 and 8.5). Though it is evident in the qualitative data that female students are more likely to experience influences from siblings about their choice of future study, I did not explore the prevalence using quantitative methods. It is important that future studies examine the sources of influences for students' choices of future study. On the other hand, more proportion of male than female students perceive that mathematics is useful in future studies. Such gender disparities need further investigation. The already available affirmative action program for female students and its effectiveness with respect to mathematics also needs investigation. For example, since the higher participation is due to the affirmative action, which allowed many female students to enter the preparatory school with a lower score than their male peers, their success in the preparatory school, needs further investigation. Future investigations should also address issues of appropriate guidance and counselling with respect to female students' choices of study.

Historically, education has been viewed as a means of improving the individual's life, and the introduction of modern education was met with scepticism and concern in society lest it not allow transferring cultural values (see Chapter 1). Some parents may remain sceptical on that score, which might affect parents' commitment to children's education in the rural areas. In Chapter 7, some parents or guardians were described as being hesitant about the females' learning, in rural Ethiopia. Ethiopian mathematics education needs to address the concerns of the society associated with the females learning. In the Ethiopian culture, the female has a primary responsibility of mentoring and transferring cultural values to children. Whether the society's hesitation relates to their concerns about preserving their cultural values needs investigation. This might add weight to the need for embracing the cultural heritages so that the society develops confidence in education that it preserves the society's values.

The students' inventive use of mathematics was set out in this study. The students might exhibit misconceptions in connection with their inventive use of mathematics. I did not investigate such possibility of misconceptions in my study. Moreover, how to exploit this inventive use of mathematics in the mathematics classroom can have its own challenges. These could be issues for future investigation.

9.5 Becoming a mathematics education researcher

In this section, I present my experience in the process of becoming a mathematics education researcher. I present my reflection on the various components of the PhD program that contributed to my development as a mathematics education researcher. I also set out other relevant experiences, which contributed to this development.

As I mentioned in Chapter 1, my experience in teaching mathematics inspired my interest in students' perceptions of the relevance of mathematics and about gender differences in mathematics. Motivated by this and related experiences, I studied curriculum and instruction for a second master's degree. My intention was primarily to develop my capacity in undertaking classroom research. My first research is on perceptions of gender differences in mathematics achievements. After studying curriculum and instruction, I began to offer a course in teacher education program, which exposed me for a further reading. This exposure, my classroom experience and my academic background motivated me to engage in investigating issues of beliefs and primarily for local consumptions.

The PhD education at the University of Agder further shaped my competence in doing research in mathematics education in several ways. The PhD education consists of courses, seminars, and conferences in addition to undertaking a PhD research project. I received a great deal of mentorship from the different components of the PhD program, including supervision, courses, seminars, and conferences. These diverse experiences enabled me to acquire more knowledge in theories and methods of research in mathematics education through encouraging more reading.

The courses, in which I participated at the University of Agder included writing essays based on the lessons and experiences obtained in the courses. The course leaders assessed the essays. The courses were organized in such a way that there were doctoral weeks every four weeks and in between we (the PhD students) had to work on our research projects by relating the course themes to the research projects. The essays were geared towards enabling us to build on our project in terms of theory and methodology. In particular, in the theory of learning course, we argued for a theory that suits our research projects and in the methodology course, we argued for the methods that we use in the projects.

The feedback I received from course leaders was an important part of the mentoring process. This process significantly developed my competence in theories and methods of mathematics education research. It contributed to my position about the choice of theories and methods for undertaking a particular research. I am now convinced that the appropriateness of a given method and theory is a matter of what I want to investigate. I do not judge certain theories and methods as superior to others.

The summer and autumn courses, in which I participated such as the Rdid School and the Nordic Summer School, were also important in obtaining mentorship. I benefited from the conversations and discussions I had with expert professors both in private and groups in the summer schools. My participation in the summer schools also contributed to enhancing my competence in theories of mathematics education and in critical and selective reading. They enhanced readiness for further learning. I benefited from responding to the critical issues that the group leaders raised. The Nordic Summer School, in particular, enabled me to reflect further on the model I am using to analyse my data. I also received external supervision and mentorship from professors who visited the University of Agder for workshops and seminars. The community of mathematics education at the University in general and my supervisor in particular created a favourable condition for such external supervisions.

As part of the PhD fellowship, I participated in international conferences, such as Psychology of Mathematics Education (PME), Congress for European Mathematics Education (CERME), and Mathematical Views (MAVI). The process of writing conference papers and the feedback I received from reviewers was significant. It contributed to enriching my competence in academic writing. My presentation in the conferences and the audience's feedback invited further reflection. The community of mathematics education in the international organizations gave me the opportunity to discuss and reflect on my work.

The critical feedback I received from the examination committee was extremely helpful in many ways. It encouraged me to engage in critical reading and helped to clarify my thoughts further. Moreover, it helped me to write the theoretical perspective in more detail and rewrite more explicitly the methods I used to analyse the interview data. I revisited the different parts of the thesis and restructured it in a much better way. This whole process further enhanced my capacity of academic writing.

I acknowledge that there are problems in the qualitative data, especially the amount. There are problems in the items of the questionnaire, and the data generated. However, some of the results are still useful. The results expose situations, which need attention regarding mathematics teaching and the curriculum in Ethiopia. There are other results, which are useful in giving insight to future investigations. For example, national identity and fresh perspective on life can be used as a starting point. Moreover, I consider writing this dissertation as a learning process. I attempted to outline a description of perception, which can be used for future investigation, but needs further scrutiny. This attempt of outlining a description of perception itself is an opportunity in the learning process.

After passing through all the challenges in this learning process, I now feel that I belong to the community of mathematics education. I am capable of undertaking research and contributing to mathematics education. I know much more now about doing research, especially doctoral-quality research. I developed skills of academic writing through writing a monograph and writing conference articles. I believe that I have become an independent researcher with a capability of engaging in learning from critical reading, observation, and investigation.

9.6 Concluding remarks

This chapter presented the conclusion of the research project and its implications. I set out my reflections on the theoretical and methodology issues. I provided suggestions for future investigations and for future use of the questionnaire. This study has a limited scope; it focuses on students’ perceptions of the relevance of mathematics.

In my view, the development of mathematics education in Ethiopia must consider the sociocultural situation. The situations that separated parents from students, in the introduction of modern education, still appears to prevail in the students’ learning of mathematics. The students feel detached from their society with respect to the usefulness of mathematics in the society, and they formed an identity, which I referred to as national identity. Mathematics education in Ethiopia should develop in harmony with the sociocultural context of the country. The mathematics that the students learn should embrace the sociocultural situation of the country. Further investigations need to be undertaken in this direction.

In this PhD research project, I attempted to provide a descriptive and analytic account of the Ethiopian preparatory students’ perceptions of the relevance of mathematics. Using a mixed approach and cultural historical activity theory, I identified a wide range of characterisations of perceptions of relevance. It is my belief that the results of the project will be useful for future investigation of mathematics classrooms in Ethiopia and beliefs in mathematics education using an activity theoretic approach.

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11 Appendices

Appendix 1

Table 11.1: The units of the old and new eleventh-grade textbooks

Unit	Title in new textbook	Titles in old textbook
1	Further on relation and functions	Polynomials and polynomial functions
2	Rational expressions and rational functions	Rational functions
3	Coordinate geometry	Further on exponential and logarithmic functions
4	Mathematical reasoning	Further on geometry
5	Statistics and probability	Coordinate geometry
6	Matrices and determinants	Further on trigonometric functions
7	The set of complex numbers	Vectors and transformation of the plane
8	Vectors and transformation of the plane	Matrices and determinants
9	Further on trigonometric functions	Simple interest, compound interest and depreciation
10	Introduction to linear programing	
11	Mathematical applications in business	

Table 11.2. The units of the old and new twelfth-grade textbooks

Unit	Title in new textbook	Title in old textbook
1	Sequence and series	Complex numbers
2	Introduction to limits and continuity	Sequence and series
3	Introduction to differential calculus	Mathematical proofs
4	Application of differential calculus	Introduction to limits and continuity
5	Introduction to integral calculus	Introduction to differential calculus
6	Three dimensional geometry and vectors in space	Application of differential calculus
7	Mathematical proofs	Introduction to integral calculus
8	Further on statistics	
9	Mathematical applications for business and consumers	

Appendix 2

Table 11.3: List of 29 items of the questionnaire

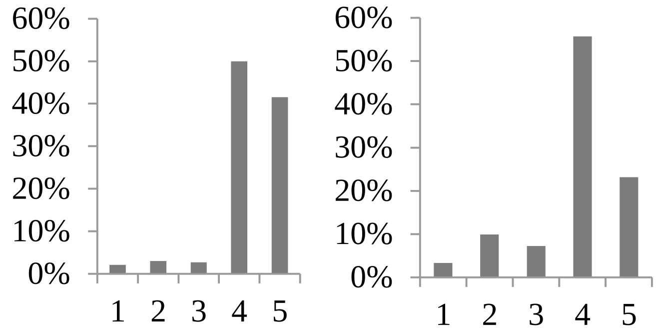
S.N	items
1	I see mathematics in the activities in the society
2	I use mathematics in the activities in the society
3	I see preparatory mathematics in the activities in the society
4	I use preparatory mathematics in the activities in the society
5	I see mathematics in my leisure time activities
6	I use mathematics in my leisure time activities
7	I see preparatory mathematics in my leisure time activities
8	I use preparatory mathematics in my leisure time activities
9	I see mathematics in spiritual life
10	I use mathematics in spiritual life
11	I see preparatory mathematics in spiritual life
12	I use preparatory mathematics in spiritual life
13	I see mathematics in other school subjects
14	I use mathematics in other school subjects
15	I see preparatory mathematics in other school subjects
16	I use preparatory mathematics in other school subjects
17	Preparatory mathematics is useful in my future study
If your answer to question 17 is ‘I disagree,’ ‘I strongly disagree’ or ‘I don’t have any view’, go to question 19.	
18	Your source of information about future use of mathematics is a. teacher b. mother/father c. brother/sister d. others, please specify _______
19	Preparatory mathematics is important to gain access to future study
20	Preparatory mathematics is relevant because it gives me an identity
21	Preparatory mathematics is relevant because it helps me make decisions
22	Preparatory mathematics is relevant because it would not have been taught if it were not
23	Prior mathematics is relevant to preparatory because the teacher tells me so
24	Prior mathematics is relevant to preparatory mathematics because the textbook tells me so
25	Prior mathematics is relevant to preparatory mathematics because the curriculum tells me so
26	Prior mathematics is relevant to preparatory mathematics because preparatory has become broader
27	Prior mathematics is relevant to preparatory mathematics because it has become more difficult
28	Prior mathematics is relevant to preparatory mathematics because it has vital concepts
29	Prior mathematics is relevant to preparatory mathematics because it tells me of a change in my identity

Table 11.4: List of open questions following the 28 items[3] of the questionnaire

S.N	items
1	What are these activities in the society[4]
2	What are these activities in the society
3	What are these activities in the society
4	What are these activities in the society
5	What are these leisure time activities
6	What are these leisure time activities
7	What are these leisure time activities
8	What are these leisure time activities
9	Can you give examples
10	Can you give examples
11	Can you give examples
12	Can you give examples
13	What are these school subjects
14	What are these school subjects
15	What are these school subjects
16	What are these school subjects
17	In what ways is it useful in your future study
19	How does it help you to get access to future study
20	How does it give you identity? Can you give examples?
21	Can you give examples
22	Can you give examples
23	Can you give examples of what the teacher tells you
24	Can you give examples of what the textbook tells you
25	Can you give examples of what the curriculum tells you
26	Can you give examples to illustrate what you mean by it has become broader
27	Can you give examples to illustrate what you mean by it has become more difficult
28	Can you give examples of these vital concepts
29	How does it tell you the change in your identity? Can you give examples

[3] The open questions following the questionnaire items are 28 because item 18 does not have open question (see Table 11.3).
[4] The open questions 1-4 are the same but students responses could be different based on the corresponding items. Similarly, there are the same open questions for other groups of items, to which students' responses could be different.

Appendix 3

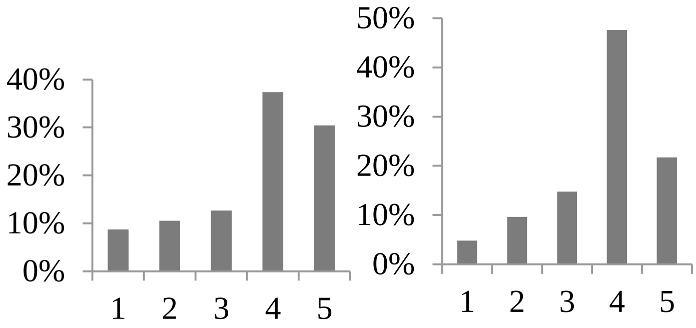


I see mathematics in other subjects

I use preparatory mathematics in other subjects

1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree

Figure 11.1 Proportions of students' responses to the items about other subjects.



Preparatory mathematics is important to gain access to my future study

Preparatory mathematics is relevant because it would not have been taught if it were not

1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree

Figure 11.2 Sample bar graphs for proportions of students' responses to the items about preparatory mathematics.

Appendix 4: Protocol for semi-structured interview[5]

1. Please would you introduce yourself? Would you tell your history in connection with mathematics learning? [Probes: your family life and life in school; just what you want to tell us.]

2. Is mathematics useful in everyday life? [Probes: Is mathematics useful in the society or in your own lives. Is preparatory mathematics useful for society or in your own lives? Think of the activities in which you participate or you know. Can you mention them, please? Is there mathematics in them?]

3. What connection does mathematics have to the other school subjects? [Probes: Think of the mathematics topics you have learnt this year, or the current mathematics topics. Do they have connection to the other school subjects?]

4. What do you want to study in the future? Is mathematics useful for what you want to study? How do you come to know about its use?

5. Do the topics in preparatory mathematics have any use? [Probes: Think of what you learnt in mathematics this year. Do the exercises or examples show mathematics' usefulness? Does the mathematics textbook reveal the usefulness of mathematics? Are there other mathematics books, which show uses of mathematics?]

6. Why do you learn and engage in mathematics? [Probe: Do you often engage in mathematics at school or at home? Why?]

7. Is mathematics, which you learnt before, relevant to preparatory mathematics? [Probes: Do what you were learning earlier help you in what you are learning now? How? Think of the mathematics you have been learning recently; do they have connection to the prior?]

[5] In each of the interview questions 2, 3, 4 and 7, I remind the students about the topics of the lessons I observed in their classes. Then, I ask them if they find those topics to be relevant?

Appendix 5 Excerpts of students' interviews

[1] We cannot do anything without mathematics. A merchant has to use mathematics {expressing mathematics' use in activities in the society, trading activity} ... In social life, as well we need it. To construct a house we need mathematics: we have to measure {expressing mathematics' use in activities in the society, construction activity} ... Our fathers and mothers who are not educated, they collect money in Edir and Equb{expressing mathematics' use in activities in the society, expressing mathematics' knowledge obtained outside of the schooling activity, activity peculiar to Ethiopian culture}. In elections there is counting {expressing mathematics' use in activities in the society, workplace activity}. [Hanan, FG C]

[2] In economics, it is about our use of resource, our demands, about surplus, etc. Since we see it in our daily life, we cannot forget it {expressing school-subjects' use in activities in the society, in contrast to mathematics}. I think [in mathematics] there should be few lines stating: as a result of learning this, may be for something planned for the future,.... or something like these innovations are results of this {expressing the logic for learning mathematics}. [Melkamu, FG F]

[3] We think about our expenditure; and we would say, "Why we don't keep a record of it?" {Expressing mathematics' use in activities in the society, family-life activity}... I once went to an office and heard people talking about mean and standard deviation {expressing mathematics' use in activities in the society, workplace}, I was surprised to see that they use it in offices {expressing feeling about mathematics' use, feeling of surprise}... In lower grades, I used to say mathematics is useful for buying and receiving the change ... {expressing mathematics' use in activities in the society, trading activity}. Though I understand it, I say "Why?" I also ask, "Where do I use it?" {Expressing the logic for learning mathematics} [Eyasu, FG D]

[4] For example, in order to make something in the factory we need to apply calculations. To make something of some size, we need to know the length, the width, or diameter; otherwise, we cannot do it ... {expressing mathematics' usefulness in activities in the society, workplace}. It is difficult to tell specific uses of the concepts we learn in preparatory, because our focus is on the theory and on the concepts, we are not able to go deep into it, practically {expressing the logic for learning mathematics}. [Akalu, FG D]

[5] We learn to change our situation in a scientific way. Therefore, what we learn has to be related to our everyday life {expressing the motive of schooling} ... After consuming two or three pages, you get one or two numbers. This makes mathematics boring {expressing emotional disposition}. … Finally, what is its importance in my life? …. Or something related to problems you see in the society {expressing the logic for learning mathematics}. Our country might not have a need for mathematics {expressing mathematics as giving the basis for recognition of the Ethiopian society as such}. However, in economics, many people want to know …, and about business, about alleviating unemployment ... How we can use our resources {expressing usefulness of other subjects in everyday life}. [Haleluya, FG F]

[6] I want to score above average in mathematics examinations {expressing the school rule} so that I would feel successful {expressing emotional reward}. When I could not solve the tasks in examination, I question myself, 'did not I prepare sufficiently; after spending a lot of time? {expressing the school rule and time cost} and how useful is this subject for me?' … then, I consider shifting to subjects {expressing competition between school subjects for students' attention} which I can perform better and work relaxed such as biology {comparative inclination based on the school rule}. [Ayana, FG H]

[7] Mathematics and English are basic because, all subjects are in English. Second mathematics is in every subject: physics, economics, business, geography, in doing research and data, they involve mathematics {expressing mathematics' usefulness in other school subjects}. In geography we do research, like population; we need mathematics. If we cannot do mathematics, we cannot calculate the population growth, etc. In business also we talk about trade, profit and tax, we calculate; in economics as well, about cost, we use mathematics to do this {expressing mathematics' usefulness in social science subjects}. Therefore, everybody has to do mathematics {expressing the logic for learning mathematics}. [Zenebech, FG E]

The following is an excerpt from Melkamu's response to my request to his group to tell their history:

[8] If I score low on the midterm examination out of 25% {expressing rule}, then I hesitate to spend my time in mathematics for the final {expressing comparative inclination}, because I want to score high in other subjects. Usually, I score 90% or above in other subjects {expressing competition between school subjects for students' attention}. [Melkamu, FG F]

[9] I want to study management in business and economics {expressing a future goal}. I think they have mathematics {expressing mathematics' use in future study}. If I succeed, I want to join there... From my experience in learning here, when we learn business and economics we see some mathematics. Therefore, in university also we will have mathematics in economics {expressing mathematics' use in future study, based on experiences in other school subjects} ... My uncle also told me {expressing use in a future study from family source}. He is a teacher. He advised me what to choose. If you choose this, you have this job opportunity, etc. {expressing influences of family members in the choice of future study}. Because at the national examination, my scores in social science subjects were good {expressing school rule}, he advised me to choose social science. My intention was to join natural science {expressing denial of capability to act, agency}. [Zenebech, FG E]

[10] We are now learning the theory; we are not into the uses {expressing the lack of usefulness in preparatory mathematics lessons}. We expect that we are going to use this theory in the fields of study we are going to be enrolled, because it will be related to mathematics, we hope to use it there {expressing reliance on the curriculum about use of mathematics in future study}. Otherwise, we do not have an idea about where to use it exactly at the moment. Since we are [natural] science students, we are going to be enrolled in fields that involve mathematics {expressing reliance on the curriculum about future use of mathematics based on membership in a school community}. [Fikadu, FG D]

[11] I want to study law {expressing a future study}. … I am not sure if it involves mathematics but I heard that it does not. I heard from people who have studied law {expressing doubt about mathematics' use in a future study based on out-of-school source}. ... My brothers studied law, medicine, and engineering {expressing community in family life activity}. [Haleluya, FG F]

[12] I think it helps me. If one wants to be logical, mathematics is important ... It also expands our horizon of thought {expressing the logic for learning mathematics}. … At least, mentioning that, "Having this as a key, you use it to open ... tomorrow." Then, the student will have a goal for learning that topic {expressing the logic for learning mathematics}. I have a cousin who graduated in psychology {expressing the family-life community}. … He told me that the two units in mathematics about calculus ... are the basis for economics {expressing usefulness of a mathematics topic for future study based on out-of-school source}. Now I am motivated to learn these topics {expressing comparative inclination} because I know I need them for tomorrow if I get the chance of be-

ing enrolled in economics {expressing the logic for learning mathematics}. [Melkamu, FG F]

[13] [I engage in mathematics] to get some knowledge {expressing inclination} because I have a target to meet {expressing mathematics' role in obtaining access to a future goal, exchange value}.... The reason for coming to school is that I have a target that I hope to meet {expressing motive for participating in the activity}. In order to meet that target {expressing motive for participating in the activity as rationale}, I have to work now {expressing comparative inclination}.... My target is to learn well and become someone in a field of study I like {expressing a recognition oneself as such}. ... I want to study medicine {expressing a future study}. [Beliyu, FG C]

[14] We work it here, {expressing action in the school activity} but we understand it when we do it on our own {expressing the division of labour: student role}. It does not mean that it is enough to see what is done [by the teacher], {expressing the division of labour: students' and teacher's roles}. Therefore, we have to try it at home {expressing action in the family-life activity}. ... It is useful for our future; if we have goal, in order to achieve it {expressing mathematics' role in obtaining access to a future goal}, we have to work from now {expressing inclination for engaging}.... We are here attending eleventh and twelfth {expressing rule} in order to attend university {expressing motive of the activity}. [Atnafu, FG B]