

# Learners' Mathematical Personal Identities and Mathematics Learning

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## Abstract

I explore and describe LMPIDs and their implications for learners' achievements in mathematics and its learning. A qualitative research method was employed with a purposeful sample from one school in Gauteng Province, South Africa. Ten mathematics learners and three mathematics teachers were interviewed, and the learners' parents completed questionnaires. It became evident that mathematics learners' mindsets, beliefs, and attitudes are not isolated traits. They are socially constructed and shaped through relationships with others. Learners' mindsets influence their attitudes either positively or negatively. These mindsets substantially affect how learners engage with mathematics, their level of competence and determination, their level of excitement, as well as their confidence, whether they find mathematics interesting or dull, challenging or easy. These attitudes shape how they relate to mathematics. All these qualities impact the development of LMPIDs, which in turn influence their achievements. High-achieving mathematics learners are those who receive the necessary support to excel in mathematics and related learning. I offer recommendations, supported by the data, for effective mathematics learning and achievement in Gauteng Province, South Africa, and beyond.

## Keywords

Mathematics, LMPIDs, ML, Mindsets, Attitudes, Beliefs, Perceptions, Confidence, Competence

## 1. Introduction

Research on learners' mathematical identities, especially learners' mathematical personal identities (LMPIDs), has increased over the past two decades; however, it remains underdeveloped. Furthermore, despite the best efforts of researchers, teachers, and learners, achievements in mathematics and its learning remain low.

Most learners do not enjoy learning mathematics. For several years, research has shown that ongoing issues related to learning mathematics are linked to learners' behaviour, such as their interest, backgrounds, beliefs, determination, confidence, competence, willingness, anxiety, and motivation (Grootenboer & Zevenbergen, 2008; Bishop, 2012; Ali et al., 2014; Uwerhiavwe, 2014, 2022, 2023). Many mathematics learners hold unhealthy and unhelpful views regarding mathematics and its learning (Grootenboer & Zevenbergen, 2008).

In line with the above, the need to transform South Africa's education system was crucial. South Africa desperately required an educational system that fostered and strengthened democracy, human dignity, equality, and social justice. The curricula used during the apartheid era were authoritarian, content-heavy, and relied heavily on rote learning and memorization. As a result, South Africa's education system has undergone three major curriculum revisions to address the biases and inequalities of the past (Jansen, 1999; Department of Education, 2002; Weber, 2008; Barnes, 2009; Uwerhiavwe, 2022, 2023). Despite these curriculum changes, learners' achievements in mathematics remain consistently low, especially in rural schools, where mathematics performance is notably weaker compared to that in urban schools (South Africa). Several issues and challenges contribute to these enduring disparities. High school mathematics often fails to provide equal educational opportunities or the appropriate learning environment for all learners (Department of Basic Education, 2014; Department of Education, 2002; Uwerhiavwe, 2022, 2023).

Several factors have been identified as contributing to learners' low achievements in mathematics and its learning. These include 1) a poor foundational knowledge of mathematics, 2) the perception that mathematics is difficult and only some can succeed in it, 3) psychological fears or anxiety about mathematics, and 4) a lack of interest (Grootenboer & Zevenbergen, 2008; Adolphus, 2011; Bishop, 2012; Uwerhiavwe, 2014, 2022, 2023). Some researchers, such as Adolphus (2011), Bishop (2012), and Grootenboer and Zevenbergen (2008), argue that the lack of interest and low retention rates in mathematics are also linked to teachers' mathematical content and pedagogical knowledge. These factors may contribute to learners' low achievements in mathematics (Grootenboer & Zevenbergen, 2008; Adolphus, 2011; Bishop, 2012). This could be influenced by the high stakes or high status of the subject, as well as learners' mindsets towards mathematics and its learning. These factors affect the development of the learners' mathematical identities and their achievement in mathematics. Several aspects of these identities impact their performance, and in this paper, I explore mindsets, attitudes, beliefs, perceptions, confidence, and competence—crucial components of learners' mathematical identities.

### 1.1. Mindsets

Every learner develops a mindset. Mindsets are the core assumptions people form about human qualities, such as intelligence and abilities, as well as fundamental

beliefs about how people learn and what they do. Therefore, learners respond to challenges and setbacks differently during the learning process. In simple terms, a mindset is a belief about people's qualities, what they learn, and how they learn (Yeager & Dweck, 2012; Boaler, 2016; Tirri & Kujala, 2016; Uwerhiavwe, 2022, 2023). Learners' mindsets are crucial because research shows they influence different behaviours in learning. This, in turn, results in diverse learning outcomes (Tirri & Kujala, 2016). Two types of mindsets can develop in learners: a) Negative mindset, which leads to failure; this is known as the fixed mindset, and b) Positive mindset, which fosters success; this is called the growth mindset (Yeager & Dweck, 2012; Boaler, 2016; Tirri & Kujala, 2016; Bernecker & Job, 2019; Uwerhiavwe, 2022, 2023).

Mathematics learners' mindsets are the beliefs learners hold about themselves as mathematics learners. These beliefs influence the LMPIDs, which in turn affect their mathematics learning (Dweck, 2000, 2013; see also Vermeer, 2012a, 2012b). A more critical examination of mindsets and other dispositions—such as beliefs, attitudes, interests, perceptions, enjoyment, confidence, competence, perseverance, and motivation—reveals their intersection with LMPIDs. This intersection impacts and influences the achievements of mathematics learners in the subject (Bibby et al., 2007; Heyd-Metzuyanim, 2013). Grootenboer and Zevenbergen (2008) argue that little progress has been made in addressing issues like learners' psychological fear or anxiety of mathematics, along with their lack of interest, confidence, competence, perseverance, and low retention rates. These factors hinder learners from achieving success in mathematics and from enjoying the subject. The exploration of LMPIDs and their implications for learners' achievements is the focus of this paper, which aims to develop and improve mathematics learning (ML) in high schools. In this paper, I have examined the aspects—such as mindsets, attitudes, beliefs, perceptions, confidence, and competence—that most influence their ML.

## 1.2. Research Questions

The exploration of LMPIDs and their implications is framed by the following research questions in this paper:

- ✓ What is the role that mindsets play in LMPIDs?
- ✓ Is there a relationship between peers, teachers and family support and the LMPIDs and achievements?

In this paper, I explore literature on the concepts of identity, the influence of learners' dispositions on learning, as well as the emergence and construction of LMPIDs. I work with Dweck's mindset theory, which uses mindsets as a key component of LMPIDs. Next, I outline the methodology employed to explore LMPIDs, which includes the research design, data sources, and data analysis. The findings are presented under two broad themes in the following section. The findings are subsequently discussed, and conclusions are drawn in response to the research questions. Lastly, recommendations are provided.

## 2. Conceptual Framework

This paper primarily focuses on the concepts of LMPIDs and ML. It further examines how LMPIDs are influenced by social interactions, personal narratives of mathematics learners, and stories from mathematics teachers, peers, parents, and communities (Wenger, 1998; Friese, 2000; Anderson, 2007; Vinney, 2018). With this in mind, I reviewed studies related to the influence of learners' dispositions on learning as well as the emergence and development of LMPIDs.

### 2.1. Identity

The concept of identity is a broad one in theories and research across education, the social sciences, and the humanities. Identity has been defined in many ways, with different definitions highlighting various aspects depending on the researcher's perspective and goals. From a sociocultural standpoint, identity is generally seen as the overall personality of an individual or a group (Friese, 2000; Gale, 2008). Anderson (2007) adopts a participative definition approach, stating that learners' mathematical "identity is used to understand how learners see themselves as learners in relation to their experiences in the mathematics classroom and how these experiences fit into their broader life experience" (p. 12). Anderson (2007) further states that:

In the learning of mathematics, learners' identities entail how learners perceive experiences and aspirations within their environment; therefore, a learner's identity, or 'who' they are, is formed by their relationships with other learners, peers, teachers, and parents, extending from the past and projecting into the future. Learners' identities are malleable and dynamic, ongoing constructions of 'who' learners are as a result of their participation with others in the experience of life. (p. 8)

Friese (2000), Anderson (2007), and Gale (2008) work within the sociocultural perspective of identity. This perspective enables the viewing of learners' experiences with ML from different angles, introducing new insights. Additionally, Friese (2000) and Gale (2008) adopt the individual attributes paradigm because it is the perception of a learner's self, which involves attributes such as mindsets, beliefs, attitudes, and ability.

Building on the above, a learner's mathematical identity (LMID) can be described as a complex relationship between a learner and mathematics, including their mathematical knowledge, experiences, and perceptions of themselves and others in the study of mathematics. An LMID encompasses various attributes, such as mindsets and beliefs, and how these relate to mathematics and learning. These attributes may have been substantially shaped by the learner's previous experiences in mathematics education. Consequently, they become essential to the learner's future engagement with mathematics (Grootenboer & Zevenbergen, 2008; Eaton et al., 2013; Mutodi & Ngirande, 2014).

Based on a discursive approach to understanding identity, Bishop (2012) argues

that an LMID refers to the ideas, often tacit, that a learner holds about who they are in relation to mathematics and its activities. This concept includes a mathematics learner's ways of talking, acting, and being, as well as how others position the learner in relation to mathematics. [Bishop \(2012\)](#) also contends that a learner's mathematical "identity is dependent on what it means to do mathematics in a given community, classroom, or small group. As such, identity is situated, learned, stable and predictable, yet malleable, and is both individual and collective" (p. 39).

For this paper, grounded in a critical understanding of the definitions above, an LMPID is conceptualized as the knowledge and understanding that the learner and others develop about the learner as a mathematics learner through the learner's prior, current, and anticipated experiences within the context of ML. In this way, how the mathematics learner perceives himself/herself and how others view him/her in learning mathematics mainly depends on the learner's mindsets, beliefs, attitudes, perceptions, confidence, competence, perseverance, interest, and enjoyment ([Boaler & Greeno, 2000](#); [Gale, 2008](#); [Heyd-Metzuyanim, 2013](#); see also [Uwerhiavwe, 2014, 2022](#)).

## **2.2. The Influence of Learners' Dispositions on Learning**

Besides mindsets, there have been other components and/or approaches to learners' mathematical personal identity (LMPID). As such, I have examined LMPIDs in terms of attitudes, beliefs, and perceptions, as well as the influences these dispositions have on their achievements in ML.

The low and high achievements of mathematics learners in mathematics and its learning are mainly due to the learners' attitudes, beliefs, and perceptions. These are also parts of LMPIDs. The studies reviewed here mainly focus on the three components of LMPIDs: attitudes, beliefs, and perceptions, as well as how these components affect learners' achievements in mathematics and their ML. [Mbugua et al. \(2012\)](#), [Heyd-Metzuyanim \(2013\)](#), and [Tshabalala and Ncube \(2013\)](#) identify reasons for learners' poor achievements in mathematics and its learning. Some reasons include learners' beliefs, perceptions, and confidence regarding mathematics and its learning, as well as their cultural backgrounds. [Maliki et al. \(2009\)](#) found in their study that there are good achievements in mathematics and its learning, and that having a positive attitude towards mathematics tends to reflect in a learner's performance (see also [Uwerhiavwe, 2022](#)). [Boaler et al. \(2000\)](#) argue that learners' perceptions of mathematics influence their achievements in the subject. With these points in mind, the three dispositions—attitudes, beliefs, and perceptions—are briefly discussed below.

### **2.2.1. Learners' Attitudes Concerning Learning**

In a quantitative study, [Tshabalala and Ncube \(2013\)](#) argue that high failure rates in mathematics may be linked to learners' attitudes—such as lack of interest, attentiveness, willingness, determination, and anxiety towards mathematics—as well as their understanding of the subject. These high failure rates result from LMPIDs developing from negative attitudes towards mathematics ([Uwerhiavwe,](#)

2014, 2022). Attitude is a key component of LMPIDs and can be used to identify and develop certain LMPIDs in mathematics studies. Maliki et al. (2009) state that attitude predicts behaviour. It can be inferred that some learners perceive mathematics as difficult because of their negative attitudes towards it. A negative attitude towards mathematics can substantially affect a learner's performance (Maliki et al., 2009). In a quantitative study with an inferential survey design describing existing phenomena, Maliki et al. (2009) highlight that high achievement in mathematics may be linked to learners' positive attitudes. As previously mentioned, mindsets influence learners' attitudes towards mathematics (Dweck, 2013; Uwerhiavwe, 2022; see also Vermeer, 2012b).

### 2.2.2. Learners' Beliefs Concerning Learning

Some mathematics learners strongly believe that the subject is inherently difficult, a daunting task. They think that mathematics is only for intelligent and talented learners (Tshabalala & Ncube, 2013; Ali et al., 2014; Uwerhiavwe, 2014, 2022, 2023). Uwerhiavwe (2014) suggests that most learners believe that when they are interested and determined, mathematics becomes easy and engaging (see also Uwerhiavwe, 2022, 2023). For example, Uwerhiavwe (2014) highlights the influence of positive beliefs on learners studying mathematics (see also Uwerhiavwe, 2022, 2023).

### 2.2.3. Learners' Perceptions Concerning Learning

In a qualitative study, Boaler et al. (2000) demonstrate that, despite being relatively successful at mathematics, many learners claimed to dislike the subject, some intensely. Boaler et al. (2000) attribute this dislike not only to the routine and practical nature of mathematics, which hindered their understanding—though that was substantial—but also to the perception that mathematics is complex, abstract, technical, and utilitarian. This conflicted with the learners' sense of self and their aspirations. Most of them linked their rejection of mathematics to their self-identity as learners and how they saw themselves in relation to the subject. Their responses indicated that the procedural presentation of mathematics made it less enjoyable, or some learners simply did not understand it. Though a few learners enjoyed mathematics, very few of those who liked it identified strongly with the subject. Their reasons for liking mathematics mainly relate to their perceptions of being good at it or to the fact that it was seen as a pathway to further education or employment, as noted by Boaler et al. (2000: pp. 9-10).

It is important to note at this point that the ML process does not occur inside a mathematics learner who is isolated in space; rather, it is rooted in a broad and specific social setting (Radovic et al., 2017). Before Radovic et al.'s (Radovic et al., 2017) assertion, Mbugua et al. (2012) found that mathematics learners' underachievement is caused by several factors, as previously mentioned: personal, economic, sociocultural, and others. In this paper, mindsets are included among these factors.

## 2.3. Emergence and Construction of LMPIDs

It is important to examine the emergence and development of LMPIDs in mathe-

mathematics classrooms. [Nasir and Cooks \(2009\)](#) suggest that identity construction is a psychosocial process that includes a psychological component—ego identity, a behavioural component—personal identity, and a social component—social identity. From a sociological standpoint, [Sfard and Prusak \(2005b\)](#) identify a dichotomy between two types of identities: actual or current identities and designated identities. [Heyd-Metzuyanim \(2013\)](#) highlights, from a narrative perspective on learners' mathematical identities (LMIDs), that learners' current mathematical identities relate to their present situations—for example, “I am a lousy mathematician,” “I am good at mathematics,” and “I have an average IQ.” Conversely, learners' designated mathematical identities are stories about how things are expected to be—for example, “I want to be in advanced mathematics,” “I want to be good at mathematics,” and “I want to be a mathematics teacher.” These concepts demonstrate that learners with different designated mathematical identities approach studying mathematics in distinct ways ([Heyd-Metzuyanim, 2013](#): p. 345). [Sfard and Prusak \(2005b\)](#) further argue that stories about individual mathematics learners might be “different relatively from one person to another, even contradictory sometimes; though unified by a family resemblance, they depend both in their details and in their general meaning on who is telling the story and for whom this story is intended” (p. 44). What a learner of mathematics believes to be true about themselves might not be what others observe in their actions ([Sfard & Prusak, 2005a](#)). In this way, it could imply that an LMPID formed about a particular mathematics learner might vary depending on who perceives it and how they perceive its development.

LMPID formation is shaped not only by competing and sometimes complementary discourses but also by how mathematics teachers and learners are positioned in the classroom. Although mathematics learners are “active agents in different discourses, learners contribute to negotiations about what it means to be a mathematics learner, as well as to know and do mathematics in the classroom” ([Noren, 2011](#): p. 98; [Bishop, 2012](#)). The participation of mathematics learners in discursive practices helps them understand their identities in mathematics and supports the construction of their LMPIDs ([Noren, 2011](#)). This suggests that the development of mathematics learners' stories or LMPIDs is not predetermined but rather created by humans. Stories and identities have authors and recipients—they are shaped collectively, even if told individually. They can also evolve based on the perceptions of the authors and recipients. Since stories and identities are discursively constructed, inquiry can explore them ([Sfard & Prusak, 2005a](#); [Uwerhiavwe, 2022](#)). Thus, an investigation into stories and identities could examine the LMPIDs that arise from narratives, which may also change according to how the authors and recipients perceive them.

I specifically review studies on the emergence of LMPIDs by examining how confidence and competence manifest in mathematics classrooms. Confidence and competence are linked to mindsets, with fixed and growth mindsets influencing confidence. Typically, competence is necessary for confidence. A learner's mindset

towards mathematics affects their competence in ML; this, in turn, impacts the learner's confidence in mathematics and their potential success in studying it. Mathematics learners who demonstrate confidence are often deemed competent. As previously discussed, every mathematics learner generally needs to be competent to be confident in the subject (Darragh, 2013). This is illustrated by Bishop's (Bishop, 2012) example of two learners interacting during a mathematics task, where one learner took the lead while the other listened. This indicates that the learner taking the lead was more competent and confident, enabling them to assume that role. Building on this, I have explored the LMPIDs that emerge from the learners' confidence and competence using a narrative approach in this paper.

In a qualitative research study, Darragh (2013) asserts that a substantial event in the learners' educational journey was when they started high school. At first, the learners lacked a sense of belonging. They did not feel accepted or comfortable within the school community. One of the learners describes her feeling of disconnection upon entering her first high school mathematics class:

Scared, just knocked on the door. Looked down. Went to a desk. And then, she didn't call out my name, and I called my name out and then she goes, oh, we all have to do a test, like in the day, and then I did the test and she told me to, the next day when I came to class, she told me to go to [another class], I didn't know where to go. (p. 221)

This excerpt shows what ML was for that learner at that point in time—mathematics is scary. The learner does not feel a sense of belonging. It is intimidating for her to take a mathematics test. This also highlights how intimidating the mathematics lesson can be for the learner (Darragh, 2013). This mathematics experience was like others in the study. Darragh (2013) argues that in a new setting, mathematics learners' stories suggested they had to show 'confidence' to succeed in mathematics. Based on Darragh's assertion, if mathematics learners do not feel they belong in the mathematics classroom or school community, it can negatively impact their confidence, competence, and interest in studying mathematics, as well as their mathematical personal identity. It is important to note that knowing people and having friends in the mathematics classroom are crucial for developing a sense of belonging.

Darragh (2013) concludes from her findings that the word 'confidence' is used in various ways, highlighting the different meanings and interpretations of the term. The way mathematics learners use the term 'confidence' in a specific way relates to their understanding of the subject. Learners have diverse perspectives about confidence. Some see confidence as a lack of fear, the opposite of being shy, or uncertain, and as having faith in their abilities. Others associate confidence with behaviours like raising a hand to answer, asking questions, or even debating with their teacher. Some view confidence as evidence of being 'smart'. In this regard, Graven (2003) notes that a mathematics learner with confidence is not afraid to face new challenges in ML; he or she believes in their ability to succeed. Confidence allows one to do what they want to do successfully. A learner's confidence

stems from their learning process and their understanding of their own limitations in mathematics. All these aspects have implications for constructing LMPIDs and probably influence how learners judge their own capability in mathematics.

Mathematics learners who perform confidently are characterized as being competent and are assumed to be smart (Darragh, 2013). Pipere and MiEule (2014) argue that several researchers, including Wenger (1998), Gee (2000), and Anderson (2007), highlight the key role of self-recognized and socially acknowledged competence in the construction of learners' mathematical identity. Mathematics learners develop an LMPID as competent mathematics learners. They are learners who demonstrate confident behaviour in the mathematics classroom (Darragh, 2013). Darragh notes that some learners risk excluding themselves from forming positive mathematical personal identities early on, during their transition to high school. "If confidence is deemed necessary for successful ML, then mathematics learners who are not comfortable displaying this confidence exclude themselves right from the start" (Darragh, 2013: p. 225). This affects the LMPIDs in ML and their achievement.

When learners of mathematics display confidence in the classroom, they are recognized by themselves and others as competent, which helps develop more positive LMPIDs. They can create new narratives of competence—this, in turn, could foster positive LMPIDs (Darragh, 2013). Darragh (2013) approaches this from a socio-cultural perspective using the narrative paradigm.

In a qualitative study, Bishop (2012) observes that during an interaction between two mathematics learners on a mathematics task, one learner took the lead in the conversation while the other listened. The learner who led was seen as more competent compared to the listener. "The listener adopted a position of inferiority by self-identifying as 'dumb' or taking up the leader's positioning of herself as 'stupid', or the leader took up a position of superiority." This could be influenced by the learners' mindsets and beliefs towards the subject (Bishop, 2012: p. 52). It is possible that the leader perceived the listener as being inferior to her. The listener confirmed her mathematical personal identity as less competent in the subject. It is worth noting that the statements a mathematics learner makes in discussions are influential and shape who they are and who they become (Bishop, 2012).

All the reviewed literature indicates the emergence of LMPIDs relating to learners' attributes. However, there are discrepancies in how studies approach their findings. Pipere and MiEule use mathematics learners' different life experiences and relationships with mathematics to construct LMPIDs. Darragh uses mathematics learners' experiences regarding their sense of belonging in the mathematics classroom as evidence of their confidence, competence, and intelligence. Meanwhile, Bishop examines interactions between two mathematics learners in a task to demonstrate their competence in the subject. This influences who they become—the LMPIDs. Mathematics learners can receive the necessary support to build confidence in the subject, and as a result, they will achieve better in mathe-

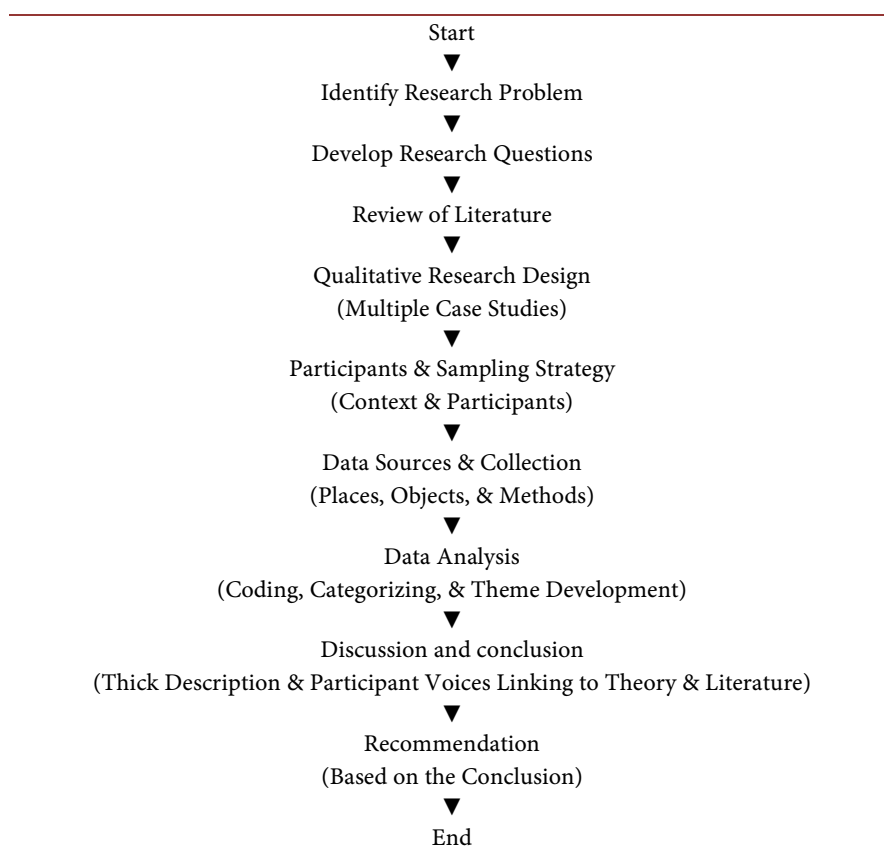
mathematics and its learning.

In this paper, I have focused on LMPIDs from the socio-cultural approach. In other words, I have positioned the construct of LMPIDs firmly within the sociological paradigm. I chose to highlight LMPIDs using the narrative category of paradigms, adopting a sociological framing. I also opted for a narrative approach because I understand the importance of capturing the voices of the participants—hearing mathematics learners’ perspectives on their own experiences, as well as the views of their mathematics teachers and parents about these experiences.

### 3. Methodology

The qualitative method preceded other approaches for developing LMPIDs and exploring emotional responses related to mathematics and its learning (Turney & Robb, 1971; Lerseth, 2013; Darragh, 2016; Uwerhiavwe, 2022; see also Neuman, 2000). This study aims to explore and describe LMPIDs and their effects on learners’ achievements in ML. Consequently, a qualitative research approach has been chosen as the primary research design, grounded in my professional knowledge landscape (Wilson, 2013; Uwerhiavwe, 2022, 2023) and the context of this paper. The following is a flowchart outlining the design of the qualitative research (Table 1).

**Table 1.** Flowchart of the qualitative research.



It is noteworthy that each step of the flowchart is subsequently discussed.

### 3.1. Qualitative Research Design

Qualitative research is “often exploratory in nature, as well as largely inductive, with reasoning moving from descriptions of specific detailed views and development of hypotheses to more general principles” (Curry et al., 2009; Suter, 2012: p. 55). O’Toole and Beckett (2010) argue that research is qualitative when the need arises to collect, interpret, and evaluate data that cannot be measured, such as participants’ statements and actions, as well as their underlying reasons. McMillan and Wergin (2002) highlight that qualitative research aims to understand the perspectives of participants. It assumes that reality is subjective and influenced by the context in which it is studied. Broadly speaking, a qualitative approach involves research that produces descriptive data, such as participants’ own written words, spoken words, or observable behaviours (Curtis & Pettigrew, 2010). I employed qualitative methods for data collection and analysis in this paper because they allow for an in-depth understanding of LMPIDs and their relationship to ML (Curtis & Pettigrew, 2010; Scott & Usher, 2011; Uwerhiavwe, 2022). This is due to its exploratory, largely inductive nature and interpretive approach, which makes sense of phenomena by interpreting the meanings people assign to them.

#### 3.1.1. Case Study Research Design

From the perspective of interpretivists, case studies provide researchers with an in-depth understanding, viewpoints, and ample opportunities to identify and note the attributes of LMPIDs that mathematics learners, teachers, and parents assert, as well as those that emerge from attributes such as mindsets, beliefs, attitudes, perceptions, confidence, and competence. This paper primarily seeks answers to research questions based on the social interactions of mathematics learners—that is, the relationships between the learners and mathematics. Since a case study is descriptive, interpretive, enlightening, and activating, and offers an in-depth understanding of viewpoints, making it well-suited for the goals of this paper, I chose to employ a collective case study as the methodology. This approach provided me with the opportunity to explore the attributes of LMPIDs and their connection to the study of mathematics (Creswell, 1998; O’Toole & Beckett, 2010; Cohen et al., 2011; Creswell, 2012; Uwerhiavwe, 2014, 2022).

#### 3.1.2. Context of the Paper and Participants

Identifying the relevant sample for this study was critical. I obtained the sample for this study through a purposeful sampling exercise (Cohen et al., 2011; Uwerhiavwe, 2022, 2023). A high school in the Gauteng Province of South Africa was the site of the research, involving Grade 9 mathematics learners, their mathematics teachers, and the learners’ parents. I chose this site for exploration based on its suitability.

For this study, learners’ mindsets and achievements in mathematics were key criteria used to select participants. I chose ten Grade 9 mathematics learners based on their narratives regarding their experiences with studying mathematics and learning it. I identified two categories of learners’ beliefs about themselves as

learners: fixed mindset and growth mindset. Accordingly, I selected five learners who appeared to hold a fixed mindset and five who appeared to have a growth mindset, based on their narratives. I explicitly aimed to learn about the experiences of all the Grade 9 mathematics learners. Regarding achievement levels, the learners' mathematics teachers helped classify them as low or high achievers based on their teaching observations and performance records in ML. Learners who scored between 40% and 59% (inclusive) in mathematics were classified as low achievers, since scores below 40% indicated failure. Learners scoring 60% or higher were classified as high achievers. The ten Grade 9 learners were chosen based on these attributes and their willingness to participate. They provided sufficient information for this paper.

### 3.2. Data Sources and Collection Methods

A primary method of data collection in this paper was through interviews, specifically formal interviews with the mathematics learners and their mathematics teachers. A formal interview involves social interactions where the respondent responds to specific questions posed by the interviewer (Seidman, 1998; Thorpe & Holt, 2008; Creswell, 2012). I used semi-structured interviews because this approach provides access to the stories of the study's participants and allows them to share their experiences related to important events relevant to the study. Conducting semi-structured interviews with the learners and their teachers revealed and clarified their experiences with mathematics and how it was learned. The ways these experiences influenced the LMPIDs and their implications for ML were also examined through the semi-structured interviews (Creswell, 2012; Uwerhiavwe, 2022). Another method of data collection in this study was a questionnaire. Questionnaires are tools used to gather data from participants through a series of questions and prompts created by the researcher (Creswell, 2012; Reddy, 2018). They allowed me to collect valuable and relevant information from the parents of the mathematics learners. The parents were unable to participate in face-to-face interviews due to their businesses, commitments, and other obligations. Therefore, I developed an unstructured questionnaire to address this issue.

Every participant was assured of confidentiality and anonymity. As such, no identifying details were included in this paper. I informed the learners, teachers, and the learners' parents that participation was voluntary and that they could choose to skip any questions. They also had the right to withdraw at any time if they felt uncomfortable. Participants were asked to give consent for the interviews, audio recordings, and completion of questionnaires, and I reassured them these would only be used for this study. They signed invitation letters to confirm their participation, which specified that all discussions were to be kept confidential.

### 3.3. Data Analysis

In this paper, the qualitative data analysis involved making sense of transcripts derived from the audio-recorded interviews with mathematics learners and their

mathematics teachers, as well as the completed questionnaires from the parents of mathematics learners, by identifying and examining themes that addressed the research questions (McMillan & Schumacher, 2010). A crucial purpose of qualitative data analysis is to uncover emerging themes, patterns, concepts, insights, and understandings from the collected data (Patton, 2002; Uwerhiavwe, 2014, 2022, 2023). According to Sutter (2012), “qualitative studies often make use of an analytic framework—A network of linked concepts and classifications to understand an underlying process. That is, a sequence of events or constructs and how they relate” (p. 344). In the analytical framework, I employed inductive analysis to make the data analysis explicit, coherent, and stronger. This was achieved by tentatively presenting a set of codes and classifications of the data collected, which identified the components and LMPIDs that emerged to reveal the themes, stories, patterns, experiences, connections, and occurrences relevant to the study’s research questions.

In transforming the raw data into a readable format, all audio-recorded interviews and completed questionnaires were transcribed. An iterative process of data coding was carried out through thorough reading and re-reading of the transcripts, enabling a comprehensive identification of relevant codes that reflect the personal identities of the mathematics learners, which developed (Mercer & Ryan, 2010; Uwerhiavwe, 2022). As conceptualized, LMPIDs include the components—mindsets, beliefs, perceptions, attitudes, competence, and confidence. All the coded data were analysed in relation to the emerging themes and relationships.

It is crucial to note that Dweck’s mindsets theory provided the foundation for analyzing data related to LMPIDs from a socio-cultural perspective. This enabled a thorough identification of relevant codes reflecting the LMPIDs, which are developed in connection with mathematics learning. As a result, all the coded data were analyzed.

#### **4. Findings**

Findings were derived from various types and sources of data, as well as different data collection methods, which allowed for a deeper and clearer understanding of the participants and locations studied. Questionnaires and interviews were conducted with the mathematics learners, their mathematics teachers, and the learners’ parents to ensure data triangulation. Through the interviews, I gained a richer understanding of how mindsets are shaped within the school and classroom context. Consequently, this paper concludes with what is commonly referred to as a dense or thick description (Check & Schutt, 2012). A dense description provides a vivid picture of the research participants within their cultural and situational contexts, including details, emotions, and social relationships that connect the participants. It captures the voices, feelings, actions, and meanings of those involved, offering a detailed account of their expressions and experiences in the specific research setting (Check & Schutt, 2012; Ponterotto, 2006: p. 541). The interviews and questionnaires employed in this research aim to generate such a dense

description, as described by [Check and Schutt \(2012\)](#).

The views of the participants are presented under two broad themes: (a) attitudes and beliefs about mathematics and LMPIDs, and (b) classroom experiences and performances with LMPIDs. Symbolic names (see [Table 2](#)) are used for the participants to ensure confidentiality and anonymity in the paper.

**Table 2.** Abbreviations for participants' symbolic names.

Participants' Symbolic Names	Participants' Description
FBGH	Black girl learner with a fixed mindset who is a high achiever in ML.
FBGL	Black girl learner with a fixed mindset who is a low achiever in ML.
FBBL	Black boy learner with a fixed mindset who is a low achiever in ML.
FWGL	White girl learner with a fixed mindset who is a low achiever in ML.
FWBH	White boy learner with a fixed mindset who is a high achiever in ML.
GBGH	Black girl learner with a growth mindset who is a high achiever in ML.
GBGL	Black girl learner with a growth mindset who is a low achiever in ML.
GBBH	Black boy learner with a growth mindset who is a high achiever in ML.
GWGH	White girl learner with a growth mindset who is a high achiever in ML.
GWBL	White boy learner with a growth mindset who is a low achiever in ML.
Mr. T <sub>1</sub>	Mathematics teacher of FWGL, FWBH, GBGH, GBGL and GWGH.
Mrs. T <sub>2</sub>	Mathematics teacher of FBGH, FBGL and GBBH.
Mr. T <sub>3</sub>	Mathematics teacher of FBBL and GWBL.
P <sub>FBGH</sub> , P <sub>FBGL</sub> , P <sub>FBBL</sub> , P <sub>FWGL</sub> , P <sub>FWBH</sub> , P <sub>GBGH</sub> , P <sub>GBGL</sub> , P <sub>GBBH</sub> , P <sub>GWGH</sub> and P <sub>GWBL</sub>	Parents of FBGH, FBGL, FBBL, FWGL, FWBH, GBGH, GBGL, GBBH, GWGH and GWBL, respectively.

It is noteworthy that brief excerpts from each category are provided as typical examples throughout the data set. These are shown below.

#### 4.1. Attitudes and Beliefs about Mathematics and LMPIDs

Achievements in mathematics and its learning are closely connected to learners' attitudes and beliefs about the subject ([Furinghetti & Pehkonen, 2000](#); see also [Grootenboer & Hemmings, 2007](#)). These attitudes and beliefs regarding mathematics and the emerging LMPIDs discussed in this paper are shaped from a socio-cultural perspective based on learners' narratives. In this paper, a mathematics learner's attitude towards mathematics refers to the positive or negative actions and feelings the learner has developed towards mathematics and its learning ([Gafoor & Kurukkan, 2015](#); [Marchis, 2013](#)). A mathematics learner's belief is the acceptance of something without proof, particularly in the context of mathematics and its learning. This mainly stems from learners' experiences and influences their effort to learn mathematics as well ([Kloosterman, 2002](#); see also [Uwerhiavwe, 2022](#)).

Regarding attitudes and beliefs, the overall findings show that most mathemat-

ics learners believe that mathematics can be interesting and enjoyable if they focus a bit more; moreover, if they are determined, committed, competent, and confident. Only a few stated otherwise for a few reasons. These are illustrated in the excerpts below.

FWBH stated that mathematics is fascinating:

I do say that mathematics is easy, interesting, exciting, and inspiring [smiles]. Mathematics is interesting, actually. I believe that mathematics is a good subject, and it can get you far if you are interested in it.

GWGH agreed that mathematics is fun and fascinating; however, it requires attention and dedication:

I think mathematics is really very hard at times, but it is fun and interesting. Anyways, I like mathematics and it is my path. I am very active in my mathematics class because I think it is just my personality. I am a very outgoing person, I really like work, and I love writing a lot [smiles]. Mathematics is very interesting. Mathematics is very interesting because you learn new things every single day in mathematics, and the more you learn mathematics, the more you find it easier and very interesting for you. Ermm, mathematics is a subject that needs attention and commitment. I describe myself as really dedicated and hardworking towards my work in ML, but I could be lazy at times [in ML]. My belief in mathematics also is that you should not say you cannot do it. When you practise and practise mathematics, you will find out that you can do it, and it will become interesting. Just like what you, Mr. Abel, told us, "Practising mathematics makes one understand and have a good grip of it", this honestly works for me.

In the same vein, FBGH noted that she is determined and committed to ML. As such, she completes her mathematics tasks on time:

Yes, Sir! I am determined in ML. I am very committed to mathematics because I do my work every now and then. I meet my mathematics teacher, Mr. T<sub>1</sub>, to always check my work so that I can practise it. My attitude towards ML is ermm, I am very noisy in ML [smiles], but I do the work that is expected of me at the end of the day. However, I feel sad and frustrated when I am stuck on a mathematics problem. More so, when I look at the problem, I just feel that it is going to take ages to get it right.

The mathematics teachers of the learners also confirmed that it is not because they lack a positive attitude toward mathematics and its learning. Most of the learners love mathematics and are interested in it, but it is simply that they (the teachers) are actually trying to get the mathematics learners focused because some of the learners can become distracted and tend not to concentrate. Mr. T<sub>1</sub> noted:

I can say the learners love what they are doing because some of them say they are going to choose pure mathematics, which means they love mathematics. So, they (learners) have positive attitudes towards the subject. Some of the

learners ask for help when doing difficult problems. When the learners find an easy way of doing a mathematics problem, I see that they are very interested. I think the learners are listening in the classroom; ermm, that would give me the impression that they are concentrating. 70% of the learners, if it is a topic they easily relate to, then they focus. If it is a topic that is hard, they lose concentration.

Agreeing with Mr. T<sub>1</sub>, Mr. T<sub>3</sub> remarked this about his mathematics learners:

As for interest, not all of the learners show that interest in mathematics [smiles]. You can see the enthusiasm in some of the learners who want to learn mathematics. Some of the learners are interested in ML. The learners concentrate in the classroom. But I have noticed something; ermm it is not 100% of the learners who are always focusing. Sometimes, after a break period, you find some of the learners are tired. Ermm, we do not know what they are eating during the break period(s) [smiles]. Some learners are usually very tired, especially during the last period. This is a challenge and a contributing factor which we neglect. Ermm, we have sharp learners of mathematics those ones, who do their work without any problems. Then we have the learners that are not so sharp but are determined. Though they are struggling, they want to go far; they have already made up their minds that they want to do mathematics, so they take every opportunity to come and ask questions because they always want to know. Another type is the lazy learners of mathematics—they are just tired all the time; they do not even struggle to learn mathematics. It is even a struggle for them to take up their mathematics textbooks. You have to force them and say, take out your books, write this, and do this. More so, I will say that learners can effectively learn mathematics if they are motivated and have the belief that they can do it because ML starts from the mind.

Mrs. T<sub>2</sub> observed that her mathematics learners' concentration in the mathematics classroom is also affected by their level of maturity:

Yes, the learners concentrate in the classroom. Nevertheless, it depends on how the topics are introduced and presented to them. Their level of maturity, Grade 9 is very low—when you tell them (learners) to take out your mathematics, what, what and what; they will not pay attention. But when you say yoooh to them, and say today we are doing this, they will pay attention to you.

Most parents also confirmed that their children enjoy mathematics and find it interesting. They (the children) concentrate but occasionally lose focus. As a result, they say that the subject is not easy. This is shown in an extract of P<sub>FBGL</sub>:

She says mathematics is interesting; she enjoys the teaching and classes and voices understanding when taught.

P<sub>FWGL</sub> agreed that their daughter finds mathematics interesting, but she does not

study the subject at home, is not passionate about it, hates struggling with mathematics problems, and gives up when she is stuck:

She says mathematics is interesting because no matter how difficult a problem is, there is always a way of solving it to arrive at the answer. Furthermore, she says mathematics is like life, there is always a problem to solve. However, she does not read and practise mathematics at home. Her attitude toward mathematics is that she is not passionate about mathematics. She gives up on difficult problems most time. She hates struggling with mathematics. She does not ensure she gets to the root of a difficult problem when stuck.

Additionally, P<sub>GBGL</sub> affirmed that GBGL focuses, but mathematics is not easy for her when she does not concentrate:

My child says she concentrates; mathematics is difficult when she does not concentrate.

Following the above, learners' confidence is a vital aspect of mathematics learners in ML. In this paper, a learner's confidence refers to their self-assurance, a belief in their own ability to succeed or excel at mathematics and its learning (Parsons et al., 2011; Dabell, 2017). To this end, GBGL claimed she is confident in ML:

I will describe myself in ML as being confident. I know I am good at mathematics [laughs] from my marks and confidence.

Similarly, Mr. T<sub>3</sub> claimed that his learners are gaining confidence:

Learners build confidence based on what they have been taught and what they have learned. So far, since I have been here [in this school], I have noticed that most of my learners are growing in confidence. Most of them said: last year, I scored 40%, but now I am getting more and more marks. So, they (most learners) are growing in confidence and understanding.

P<sub>GBGH</sub> agreed that their daughter, GBGH, is confident in doing mathematics:

She has explained to me that she enjoys ML more this year as she understands it more and has confidence in calculating mathematics problems.

In contrast, FBBL stated that he does not have confidence in studying mathematics:

I do not have confidence in mathematics because ermm when the teacher, Mr. T<sub>3</sub> asks a question and I would not know it or how to answer it because everyone will be looking at me, and ermm I am afraid and do not know what they (the teacher and other learners) are going to say. I will be shy, maybe when I give the wrong answer, and all learners in the classroom will look at me.

FWGL concurred:

I do not have confidence in mathematics because ermm, if I do work in mathematics—like equations, I lose confidence and feel like I will not ever get it. To this effect, I stop doing it.

Similarly, FBGL noted that she feels unhappy when she gets stuck while trying to find a solution to a mathematics problem, as she lacks the self-confidence to study mathematics:

It is clear that I do not have the type of confidence that mathematics needs. When I am stuck on a mathematics problem, I get angry. Anyways, I console myself by saying: I was not created to be smart in mathematics just like I am not designed by God to be good at mathematics.

Mrs. T<sub>2</sub> stated this about her learners:

There are those (learners) I must encourage and tell that yes, you can do mathematics. This set of learners lacks the self-confidence to do mathematics.

P<sub>FBBL</sub> mentioned that their son has a lack of confidence in ML:

No, he does not show any signs of being confident in mathematics.

In general, Mr. T<sub>3</sub> noted that his mathematics learners have some negative attitudes and beliefs about mathematics and its learning:

The learners do not want to be part of mathematics anymore. However, I am trying to build them, but you have some of them who have the mindset or belief that “mathematics is tough for me”, it is difficult, and other stuff, yeah. Even some of the learners’ parents play the same role; they will tell you ‘my child is not a mathematics child’ when you discuss these attitudes with them (learners’ parents), and when you correct the learners’ parents, they will say, no, no, no, that learners can be ‘bad’ [sic] in mathematics; and nothing can be done about it. But I must say here that all these ‘bad’ notions about mathematics start from their (learners’) homes and are conceived in the mind already, as well as making the learners unwilling, not motivated, ermm not: interested, determined and competent in ML. I will say that learners can effectively learn mathematics if they are motivated and have the belief that they can do it, because ML starts from the mind.

The above excerpts revealed that GBGL described herself as good and confident in ML. P<sub>GBGH</sub> affirmed that GBGH enjoys mathematics at the moment, and she has confidence in solving problems. Mr. T<sub>3</sub> asserted that he has noticed most of his learners are developing confidence, and they become confident as their knowledge grows. Mrs. T<sub>2</sub> agreed that some of her mathematics learners are very confident about the subject. However, there are conflicting statements: P<sub>FBBL</sub>, FWGL, and FBGL declared that they do not have confidence; FWGL further explained that he does not have confidence because when he tries to solve problems, he feels like he will never get the answer right. He loses confidence. In support, P<sub>FBBL</sub> noted that FBBL does not show any sign of being a confident learner. Mrs. T<sub>2</sub> mentioned that some of her mathematics learners she encouraged, telling them they could do mathematics—these learners lack self-confidence. Mr. T<sub>3</sub> reported

that his learners do not want to study the subject. He tried to dispel the learners' beliefs that the subject is too tough for them and worked to change their negative attitudes. Mr. T<sub>3</sub> further shared that these 'bad' notions about mathematics originated in the learners' home environments and are firmly fixed in their minds. As a result, they are unwilling, unmotivated, and uninterested, believing they cannot be competent in mathematics.

Considering all the above abstracts, while attitudes and beliefs do influence the level of performance and concentration in mathematics and its learning, other factors such as maturity and tiredness also affect performance and concentration in ML. This indicates that the lack of concentration is influenced by factors beyond attitudes and beliefs. Tiredness and lack of focus also seem to stem from learners perceiving mathematics as a difficult subject. This holds true for both low- and high-achieving mathematics learners.

To explain the influences on mathematics learners' mindsets, attitudes, and development of their beliefs, as well as their impact on achievements, whether they are low or high achievers, I examined their classroom experiences and performances, which led to the emergence of LMPIDs.

#### **4.2. Classroom Experiences and Performances with LMPIDs**

Learners understand who they are in terms of mathematics and its study based on their experiences with peers and teachers in mathematics classrooms. A substantial portion of a learner's knowledge is influenced by these factors—experiences in the classroom (Anderson, 2007; Mutodi & Ngirande, 2014). Therefore, in this paper, a mathematics learner's classroom experiences are defined as the activities that occur during mathematics lessons. During these lessons, a learner, their peers, and the teacher engage in interactions, actions, and reactions that lead to both understanding and increased achievement in the subject. These classroom experiences help identify who the learners are in the process of learning mathematics (Anderson, 2007). A mathematics learner's performance reflects the extent to which they have achieved specific goals in mathematics and its learning. In this context, a goal or outcome can be considered a good understanding and the attainment of higher marks. In other words, a learner's performance indicates the knowledge gained and skills developed in mathematics and its learning (Amasumomo, 2014; Bhat, 2013; Steinmayr et al., 2017).

The classroom experiences, performances, and the emerging LMPIDs of mathematics learners discussed in this paper are examined from a socio-cultural perspective, based on the participants' narratives as well. The overall findings regarding support indicate that all mathematics learners reported benefiting substantially from support. The learners noted that they receive support from peers, as well as from their mathematics teachers and family members or parents. In this paper, "peers' assistance" refers to the help or support provided by classmates. Classmates support each other with knowledge, experience, emotional, social, or practical help in the classroom (Wilken, 2013; Howard, 2017; Columnist, 2018).

Assistance from a mathematics teacher is understood as the support that teachers provide to their mathematics learners within the classroom (Grootenboer & Hemmings, 2007; Bojuwoye et al., 2014). Therefore, help from a learner's parents or family members is regarded as any support they give to the learner regarding ML.

The mathematics learners pointed out that support was mainly available when they made mistakes, did not understand, or received very low marks. In other words, support seemed to occur when learners were not performing as expected in mathematics and its learning. When they performed well, support appeared to be lacking. The mathematics learners also indicated what kind of support they received.

FBBL said that his classmates help him whenever he asks for assistance:

Some of my classmates are really clever, so they understand the work. When I ask them for help, they do help me. My brother is really, really good at mathematics, too. He explains to me when I am stuck on mathematics problems. However, he explains to me if I let him know of it when he finds me struggling, or not happy doing mathematics. If my brother does not understand the problem(s), he will tell me not to be crossed, that I should leave it and ask my teacher when I get to school. Also, my peers assist me in mathematics; when we are working in a group, we do assist each other. That is the essence of group class work.

What this learner (FBBL) is saying is that he receives help in the classroom. He also gets assistance from his brother at home. In this case, it appears that the issue with support at home is that people do not seem to be patient.

GBGL confirmed that learners receive support when they ask for it:

When my peers do not understand something, and they know and see that I understand it, they come to me, and I help them out.

It appears that this learner (GBGL) typically does not receive support from her peers but instead offers support to other learners when they seek her out.

FWBH indicated that he receives support from home. However, his family members are very careful not to give him the answers he needs; instead, they help him understand how to approach and find the answers. This is shown in the excerpt:

My family members assist me with my mathematics homework when I ask for assistance. However, they gave me methods but no answers.

Another learner of mathematics, FBGH, stated that she receives support from her mathematics teacher. If the teacher is unavailable, her sister assists her, and if her sister is also unavailable, her peers step in to help. The benefit of her sister helping is that she (the sister) uses Grades 10 and 11 textbooks and guides her through exercises from the textbooks. This is evident in the extract:

I meet my mathematics teacher, Mr. T<sub>1</sub>, to always check my work so that I could practise it. Furthermore, if my teacher is not available, I ask my sister to also check

for me; and every week, I would go over some examples and exercises on my own. My sister assists me when I ask for assistance from her in ML. She has textbooks for Grades 10 and 11; so, she takes out exercises from those textbooks and goes through them with me, Sir. My peers assist me as well in mathematics group class work when I ask them.

All the mathematics learners indicated that they found the support beneficial, and it allowed them to perform better in mathematics. They also confirmed that the support was available at school, at home, and with their peers.

Regarding the mathematics teachers, they indicated that most of the time, when they were willing to provide support, there was not enough time to offer the assistance that the mathematics learners needed. Concerning the issue that time is never enough and teachers struggle to meet their expectations, a mathematics teacher then attempts to utilize peer support. What the teacher does is utilize the high-achieving mathematics learners to help others. Here is an excerpt from Mr. T<sub>1</sub> that points to this:

I have learners, like four or five, who are very smart. I ask those smart learners to help their peers, those other learners who do not understand. I do not have enough time for my lessons. The reason is ermm, the learners come with misconceptions, and some of the topics in mathematics were window addressed from the previous year. Again, ermm, mathematics requires that it should be practised every day and a learner must do two hours of mathematics a day. Also, the learners say mathematics is useful because of the inspiration they have from me now, they see the importance. They even say they want to do pure mathematics. So, they can see and know the use of mathematics. But the issue is that it is never enough, it is never enough. However, I do my part as a teacher by ensuring that I squeeze out time to attend to my learners always [smiles]. I do peer teaching—I allow them to teach one another, but not during the lessons because of the time limits. However, when I teach them over the weekend, I invite other teachers. Ermm, I allow them to do peer teaching.

Similarly, Mr. T<sub>3</sub> also indicated that he not only uses peer support but also involves mathematics learners from other grades to assist Grade 9 mathematics learners:

When the learners get stuck on problems, some of them either go and ask someone who is smart in the classroom, or I go and help. But at times, I cannot get to all of them. I usually say to them, come at break period. One thing I have done last year was I called a boy in Grade 11 who is very good at mathematics and relates very well with them [the learners] by helping. Actually, I have two smart boys in mathematics in Grade 11 whom I normally call to come and help them, so that they (learners) can have different tastes in teachers. Sometimes, I call the learners whom I have taught to come and help them.

From Mrs. T<sub>2</sub>'s perspective, she noted that family members do come to school when needed and do provide support. This is demonstrated in the excerpt:

The learners' family members give me support regarding the learning of mathematics of their child(ren) whenever the need arises. When you call the learners' family members to bring learners for extra classes, they do; when you call them to buy something for their child(ren) to assist them in mathematics, they try and do it; and so on [sic].

Regarding the learners' parents, they indicated that they are available to provide, to the best of their ability, the support their children need when needed. However, some parents of mathematics learners mentioned that they are available to support their children, but they are often too busy. As a result, mathematics learners are not always around for their parents to assist them with schoolwork. Ideally, support should come from school, at home, and among peers, but it seems to mainly occur when mathematics learners are not performing well or their mathematics performance is declining. These points are illustrated in the following extracts:

A parent of a mathematics learner, P<sub>GWB</sub>, confirmed that they (family members) go through their son's difficult mathematics problems with him:

My family members contribute to his ML. For instance, I do put him through his difficult mathematics problems. Furthermore, his aunt put him in mathematics extra lessons.

FWGL's parent (P<sub>FWGL</sub>) agreed, noting that although their daughter (FWGL) can be lazy at times in doing mathematics, her older sister does support her:

FWGL is committed to mathematics. She always tries to make a little effort in mathematics calculations. Although she sometimes becomes lazy, her elder sister is always there to help.

Another parent of a mathematics learner, P<sub>GBGL</sub>, noted that GBGL's peers do come to the house, and the learners work together. In this case, the parent offers support not only to their child but also to the group of learners working in their home:

I will say here that my daughter's peers come around most of the time. I do ask them to study a little before playing. Most times they listen by teaching themselves how to find some mathematics solutions before playing.

The above extracts indicated that mathematics learners receive the support they need at home from their parents (family members) and sometimes their peers, as well as the support from their peers, mathematics teachers, and other Grade mathematics learners at school. Furthermore, this support appears to be provided mainly when the learners are not performing well in mathematics. If learners make mistakes on mathematics problems, they receive support. If they are stuck on problems, they get assistance. If they fail at mathematics tasks, they are sup-

ported. High-achieving learners also receive support to help them perform better in mathematics and its learning.

Drawing from all the above extracts, the data of the study indicate that all the mathematics learners claimed they benefit greatly from support. The mathematics learners indicated they receive the support they need in the subject at home from their parents (family members) and sometimes from their peers as well, as well as the support they need from their peers, mathematics teachers, and other Grade mathematics learners at school.

## 5. Discussion and Conclusion

The participants in this study generally perceive mathematics learners' attitudes and beliefs towards mathematics and its learning as natural (Mill, 1998; Lee, 2005; Uwerhiavwe, 2022). This influences the mathematics learners' mindsets (fixed and growth) regarding the subject and its learning—all of which affect the LMPIDs they develop in ML. It is important to note that some mathematics learners have a positive mathematical mindset, while others have a negative one. The data show that learners with a positive mindset (growth) tend to develop positive LMPIDs in ML. Conversely, those with a negative mindset (fixed) mostly develop negative LMPIDs in ML; however, in some cases, a few learners with a fixed mindset have developed positive LMPIDs in ML. This suggests that even a mathematics learner with a fixed mindset can develop positive LMPIDs in ML. Overall, the data indicate that mathematics learners' attitudes and beliefs about mathematics and its learning are socially constructed [that is, human-made].

The data also show that mathematics learners' mindsets, beliefs, attitudes, confidence, competence, and the emerging LMPIDs regarding mathematics and its learning are not just psychological or individual traits. They are influenced by the environment, including the classroom, combined with home-based and other experiences. It is important to understand that mathematics learners' mindsets and the resulting LMPIDs are not solely psychological; rather, they have a sociological basis. These are not internal qualities but are shaped by personal experiences—constructed by the environment, home, school, and community—that influence learners' mindsets, which then affect the LMPIDs. Learners' attitudes and beliefs about mathematics are actively shaped through their experiences (Kloosterman, 2002; Hannula et al., 2004; Asante, 2012; Marchis, 2013; Uwerhiavwe, 2022). This process, in turn, impacts the development of LMPIDs.

It is important to recognize that the attitudes and beliefs of most mathematics learners are shaped by their classroom experiences, the support they receive from peers and parents, and their comfort level within the mathematics classroom. All these factors influence and mould their mindsets towards mathematics and its learning. With this in mind, I agree with Radovic et al.'s (Radovic et al., 2017) assertion that the ML process does not occur inside a mathematics learner who is isolated in space; rather, it is rooted in a broad and specific social setting. Similarly, I also agree with Sfard and Prusak's (Sfard and Prusak, 2005a) claim that the de-

velopment of mathematics learners' stories and/or their mathematical identities [i.e., LMPIDs] are socially constructed—not God-given, but human-made.

Generally, mathematics learners' mindsets, beliefs, and attitudes are not inherently individual traits. They are socially constructed and developed through interactions with others. Furthermore, it emerged that parental (family) support is also very important for learners' effective mathematics learning. For example, when a parent provides support for their child's mathematics learning, that child tends to develop a positive mathematics mindset, which in turn benefits their constructed LMPIDs. The child carries this mindset and the developed LMPIDs into the mathematics classroom, becoming excited about mathematics and its learning, and engaging enthusiastically with the subject. They feel comfortable during mathematics experiences, and this is reinforced by their mathematics teacher. Conversely, if a parent promises support but fails to provide it, the child may develop a negative mathematics mindset, which can negatively influence their constructed LMPIDs. The child then carries this mindset and these LMPIDs into the classroom and may feel unenthusiastic and uncomfortable about mathematics. Therefore, it is essential to recognize that a mathematics learner's positive or negative mindset affects their LMPIDs and achievement in ML. Accordingly, I agree with Dweck's (Dweck, 2013) and Uwerhiavwe's (Uwerhiavwe, 2022) assertion that mindsets shape mathematics learners' attitudes towards the subject and its learning.

In summary, mathematics learners' mindsets are shaped through their relationships with others in ML. These mindsets affect their attitudes, either positively or negatively. Learners' mindsets greatly influence how they practise mathematics, including their levels of competence and determination, feelings of excitement or lack thereof, and their confidence. They also impact whether learners find mathematics interesting or boring, difficult or easy. These attitudes, in turn, influence how they relate to mathematics. All these attributes contribute to the development of LMPIDs, which subsequently affect learners' achievements in mathematics and their learning process.

Aligning with Uwerhiavwe (2022), theorists use terms such as mindsets, beliefs, attitudes, confidence, capability, understanding, excitement, commitment, interest, liking, disliking, enjoyment, fear, phobia, daunting, abstract, and complex. These are internal psychological phenomena that mathematics learners either possess or lack. With that in mind, there is a need to use clearer language so that learners and others will believe that these attributes (such as mindsets, beliefs, attitudes, confidence, capability, understanding, excitement, commitment, enjoyment, scariness, and interest) are not innate. They are not traits that people are born with or that are God-given; rather, they are socially constructed (human-made). "We need to take responsibility for their construction. We are damaging mathematics learners' and others' lives by making them believe that they are naturally unable to do mathematics. Mathematics learners should be given a positive and enabling environment for effective ML" (Uwerhiavwe, 2022, p. 3526). A positive and enabling environment means that the learners' mathematics teachers,

their (learners') parents, and peers must be supportive.

Building on the above, mindsets play a crucial role by influencing the LMPIDs, which in turn affect learners' achievements in mathematics and its learning. Regarding the second research question, there is a relationship between mathematics learners' peers, their teachers, and family support, and the LMPIDs and achievements.

The following research topics are proposed for future exploration based on this paper:

- ✓ Learners' Mathematical Identities in Urban High School;
- ✓ Analysis of the Relationships between Learners' Mathematical Identities and their ML;
- ✓ Mindsets, Learners' Mathematical Identities and ML;
- ✓ Is Mindset an Appetite for ML?
- ✓ Mindsets: Drivers for Learning;
- ✓ Fixed Mindset: A Driver for Underachievement in ML;
- ✓ Growth Mindset: An Appetite for ML.

## 6. Recommendation

The following recommendations are made based on the conclusions of this paper:

- ✓ People need to be socialized into the understanding that mindsets, beliefs, attitudes, confidence, capability, understanding, excitement, commitment, comfort, interest and other components of LMPIDs are not natural [God-given]. They stem from the learners' experiences [human-made]. We need to recognize that everyone is capable of learning mathematics when given the right opportunities.
- ✓ All should be aware that mathematics learners who are classified as high-achieving learners, rather than low-achieving learners in mathematics and its learning, are the ones who do get the support needed to enable them to perform better in mathematics and its learning. More so, mathematics learners should be given a positive and enabling environment for effective ML. Simply put, mathematics learners should be given the necessary support they need to be competent and confident about the subject, then they will achieve better in mathematics and its learning as well.

This paper alone may not alter any conflicting views some people hold regarding ML, LMPIDs, and their implications. Given this reality, it is advisable that further research be conducted in other provinces of South Africa and in other countries.

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### Conflicts of Interest

The author states no conflicts of interest concerning the publication of this paper.

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