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"I Am a Girl and I Deserve to be A Math Teacher": Mathematical Identity in Different Genders

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ABSTRACT

Background: Research on mathematical identity in different genders has attracted the attention of researchers in mathematics education and educational psychology. Mathematical identity refers to the mathematical perceptions of individuals in their engagement with mathematics. Although mathematics is often considered gender-neutral, empirical research suggests differences in mathematical identity between men and women. **Objectives**: This study aims to explore differences in mathematical identity between genders. **Design**: Qualitative research methods were used to obtain data on interest, recognition, competence, performance, and beliefs in mathematics, which are components of mathematical identity. **Setting and Participants**: The researcher selected one pair of prospective mathematics teacher students: one female and one male prospective mathematics teacher-student. One female prospective mathematics teacher-student with the pseudonym Fhema and one male prospective mathematics teacher-student with the pseudonym Malhe. **Data collection and analysis**: Three instruments were used to collect data; an initial math ability test, a mathematical identity questionnaire, and an interview protocol. Responses demonstrating interest, recognition, competence, performance, and beliefs about the nature of mathematics were coded from the transcripts of interviews. **Results**: The mathematical identity owned by female and male prospective mathematics teacher students differs in several components, namely interest, recognition, competence, performance, and beliefs in mathematics. **Conclusions**: In general, there were significant differences in mathematical identity between female and male mathematics teacher candidates. Internal and external factors contribute to forming different mathematical identities in both genders. Further understanding the mathematical identity of different genders is important for designing educational strategies promoting gender equality in mathematics education.

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Keywords: Mathematical Identity; Prospective Mathematics Teachers; Gender; Pre-Service Mathematics Teacher; Mathematics Education; Qualitative Research.

"Eu Sou Uma Menina E Mereço Ser Professora De Matemática": **Identidade Matemática Em Diferentes Gêneros**

RESUMO

Contexto: A pesquisa sobre a identidade matemática em diferentes gêneros atraiu a atenção de pesquisadores em educação matemática e psicologia educacional. A identidade matemática refere-se às percepções matemáticas dos indivíduos em seu envolvimento com a matemática. Embora a matemática seja frequentemente considerada neutra em termos de gênero, a pesquisa empírica sugere diferenças na identidade matemática entre homens e mulheres. **Objetivos**: Este estudo tem como objetivo explorar as diferenças de identidade matemática entre os gêneros. **Design**: Foram usados métodos de pesquisa qualitativa para obter dados sobre interesse, reconhecimento, competência, desempenho e crenças em matemática, que são componentes da identidade matemática. **Cenário e participantes**: O pesquisador selecionou um par de futuros professores de matemática: uma mulher e um homem como futuros professores e alunos de matemática. Uma aluna com o pseudônimo Fhema e um aluno com o pseudônimo Malhe. **Coleta e análise de dados**: Três instrumentos foram usados para coletar dados: um teste inicial de habilidade matemática, um questionário de identidade matemática e um protocolo de entrevista. As respostas que demonstram interesse, reconhecimento, competência, desempenho e crenças sobre a natureza da matemática foram codificadas a partir das transcrições das entrevistas. **Resultados**: A identidade matemática dos futuros professores de matemática do sexo feminino e masculino difere em vários componentes, a saber, interesse, reconhecimento, competência, desempenho e crenças em matemática. **Conclusões**: Em geral, houve diferenças significativas na identidade matemática entre candidatos a professores de matemática do sexo feminino e masculino. Fatores internos e externos contribuem para a formação de diferentes identidades matemáticas em ambos os sexos. Compreender melhor a identidade matemática de diferentes gêneros é importante para a elaboração de estratégias educacionais que promovam a igualdade de gênero na educação matemática.

Palavras-chave: Identidade Matemática; Futuros Professores De Matemática; Gênero; Professores De Matemática Em Início De Carreira; Educação Matemática; Pesquisa Qualitativa.

INTRODUCTION

Each learner forms their self-perception with mathematics. These self-perceptions are significant since an individual's reality frequently mirrors their self-perceptions. For instance, studies reveal a strong correlation between mathematics performance and an individual's self-perception of their mathematical ability (Bouchey & Harter, 2005; Huang, 2011; Skaalvik & Rankin, 1995; Sonnert et al., 2020). Motivation and perseverance in mathematics, as demonstrated by the number of math courses completed, are also correlated with self-perception (Simpkins et al., 2006), successful completion of education (Fall & Roberts, 2012)and the decision to pursue a career in STEM (Cribbs et al., 2016). Therefore, one's self-perception related to mathematics is important and interesting.

The concept of mathematical identity pertains to an individual's self-perception as a mathematical doer or learner, as well as the relationships, habits, attitudes, and beliefs that students must cultivate to become proficient mathematicians (Aguirre et al., 2013; Anderson, 2007; Grootenboer & Zevenbergen, 2007). Mathematical identity will drive how one engages with mathematics and interprets mathematical experiences (Tierney, 2021). For prospective mathematics teacher students, in particular, mathematical identity has a role in forming their identity in mathematics. It will impact perseverance and how the learning process will be carried out later when they become professional mathematics teachers. Therefore, recognizing or knowing the mathematical identity (the mathematical identity of prospective math teachers in this instance) is essential for the success of the mathematics learning process. By knowing the mathematical identity of prospective mathematics teachers, it is expected that a better understanding of how prospective mathematics teachers see themselves in mathematics will be obtained. Stakeholders can utilize this information to identify the causes of difficulties, failures, decreased motivation and other problems that may arise in prospective mathematics teacher students when learning mathematics.

Whether male or female, prospective mathematics teacher students are likely to have different perceptions and interests in mathematics. Significant differences in interest in mathematics learners of different genders were found in mathematics learning; females showed greater interest in learning mathematics than males (Subrahmanyam, 2021). The results of other studies, which demonstrate differences between genders in mathematical interest, also confirm this: women put in more effort than men when learning mathematics. (Høgheim & Reber, 2019). Furthermore, female students showed more interest in teaching math to others. The preliminary findings of this study are supported by previous research showing that female teachers are better than male teachers in implementing the learning process (Kawehilani, 2011). The next phenomenon is that many students still take mathematics education majors not because they want to become mathematics educators but to fulfil their parents' wishes. Based on the findings of the interviews that were done for preliminary research, information is also obtained that the lack of optimal mathematics competence is also a phenomenon found in prospective mathematics teacher students. Some of these phenomena are closely related to the mathematical identity of prospective mathematics teachers.

Previous research that found a correlation between mathematical identity and gender only showed that gender contributed to differences in mathematical identity; that is, males were associated with a stronger mathematical identity than females (Nosek et al., 2002). However, how mathematical identity differs in different genders has not been discussed in depth. The results of other studies indicate differences in mathematics related to males and females (APA, 2010; Kartono, 1992; Yazici & Ertekin, 2010). Differences in several aspects of mathematics also allow for differences in mathematical identity owned between males and females. The possibility of differences in the mathematical identity of different genders needs to be known because gender differences result in differences in mathematical abilities and the way mathematical knowledge is acquired.

In previous mathematical identity research, mathematical identity researchers have conducted research focusing on students at the school level (Gonzalez et al., 2020; Gweshe & Brodie, 2019; Hima et al., 2019a; Kaspersen & Ytterhaug, 2020), university students (Cribbs et al., 2021; McGee, 2015) and teachers (Gardee, 2019; Nanna et al., 2021). Mathematical identity research on university students conducted previously by Cribbs et al. (2021) & McGee (2015) was conducted on STEM students, not specifically on mathematics education students as prospective mathematics teachers. In addition, mathematical identity research on prospective teachers has also been conducted by several previous researchers (Haciömeroğlu, 2020; Heffernan & Newton, 2019; Lutovac & Kaasila, 2013). The results of a study conducted on prospective elementary teachers at a university involving a Finnish prospective elementary teacher and a Slovenian prospective elementary teacher showed substantial differences in the mathematical identities possessed by the research subjects despite striking similarities in terms of the mathematical background of the prospective elementary teachers (Lutovac & Kaasila, 2013). The similarity is that both subjects had negative past experiences in mathematics during the school year. Still, the difference is that the Finnish primary teacher candidates had a more positive mathematical identity than the Slovenian ones. The Finnish preservice teacher research subject's desire and self-confidence underpinned her desire to become a professional mathematics teacher who could make her students love mathematics. Although both studies were conducted on prospective teachers, the Lutovac & Kaasila (2013) did not look at the mathematical identity of prospective teachers in different genders and was conducted on prospective elementary school teachers in general, not specifically on prospective mathematics teachers. Therefore, this study seeks to contribute knowledge by exploring and describing the mathematical identity of prospective mathematics teachers in terms of gender differences.

THEORETICAL BACKGROUND

Mathematical Identity

Based on their perceptions and daily experiences with mathematics, a person's mathematical identity reflects how they see themselves in mathematics (Cribbs et al., 2015; Cribbs, 2012). The concept of mathematical identity focuses on students' self-perceptions and how their prior mathematical experiences affect how they view mathematics currently. The emphasis on mathematical identity includes other significant elements, such as attitudes, beliefs, emotions, and dispositions, rather than disregarding the significance of mathematical knowledge and skills (Grootenboer, 2020). It means that the cognitive aspect, mathematical ability, remains important when discussing mathematical identity. Furthermore, Philipp (2007) proposed A broader interpretation of mathematical identity that refers to how someone learns to think, act, and interact; it is the embodiment of their knowledge, beliefs, values, commitments, goals, and influences related to their involvement in a specific community of practice. When examining how individuals view themselves in relation to the community and how they participate in it, the term expands the scope of the role that their self-perception plays. It also means that mathematical identity is related to individual perceptions and considers aspects of one's community. Therefore, the definition of mathematical identity must include aspects of individuals' perceptions of themselves and the perceptions individuals believe others have of them (Philipp, 2007).

Mathematical identity can be interpreted as a construct that describes a person's relationship with mathematics. The construct can be used as a basis for developing instruments containing mathematical identity components. Crossley et al. (2018) provided an operational definition of mathematical identity as math self-concept, math interest, and math value. In line with Crossley et al. (2018), Hima et al. (2019) define mathematical identity as a way to see students' learning experiences (both personally and in groups), which are described as narratives related to learning experiences, motivations, strategies and other matters related to mathematics. The definition of mathematical identity presented by Crossley et al. (2018) and Hima et al. (2019) have in common that there is an element of interest or motivation in mathematical identity. In connection with this similarity, it turns out that interest is significantly related to motivation (Weber, 2009). Therefore, one's mathematical identity needs to be considered in terms of interest.

Gweshe & Brodie (2019) stated that mathematical identity is a story about one's confidence, beliefs and perseverance in mathematics. The term "mathematical identity" describes people's views and beliefs about their capacity to engage in and perform well in mathematical contexts, as well as their ability to use mathematics to improve their lives. It also encompasses an individual's perception of themselves and how others perceive them (in the context of doing things related to mathematics) (Martin, 2009). The different types of mathematical identities built by a person are also influenced by their relationship with mathematics, namely in how they view mathematics as a body of knowledge and how they engage with mathematics in society (Tossavainen et al., 2021). It means a person's belief in mathematics contributes to their mathematical identity. Furthermore, the mathematical identity referred to in this study is a self-portrait of a person related to mathematics, which includes a person's interests, abilities, perceptions, and beliefs about the nature of mathematics owned by a person.

Component of Mathematical Identity

The components of mathematical identity used in this study are interest, recognition, competence, performance, and belief in mathematics (Cribbs et al., 2015; Solomon, 2009). A more detailed explanation of the components of mathematical identity is presented in Table 1.

Table 1

Components of Mathematical Identity

	Components and Component Definitions	Sub-Components	Description of Sub-Component
Mathematical identity	**Interest** *Interest* is a person's desire, curiosity, and pleasure/enjoyment in learning and teaching mathematics.	Desire	The subject's desire to learn and teach math.
		Curiosity	The subject's curiosity is to learn math and learn how to teach math.

Components and Component Definitions	Sub-Components	Description of Sub-Component
	Enjoyment	The enjoyment the subject feels when learning and teaching math.
Recognition *Recognition* is a person's perception of how others (parents, teachers/lecturers, friends) perceive him/her and his/her perceptions about mathematics.	Parents	Subjects' perceptions of their parents' views on themselves about math.
	Friends	Subjects' perceptions of how their friends perceive them about math.
	Self	The subject's perception of theirself is related to math.
	Teacher/lecturer	The subject's perception of the lecturer's views on themselves about math.
Competence *Competence* is a person's ability and belief about their ability to understand and persist in mathematics.	Understanding beliefs	The subject's belief about their ability to understand mathematical material
	Persistence	The subject's persistence when learning math.
Performance *Performance* is the result of work and a person's belief in their achievements or accomplishments in math.	Performance beliefs	The subject's belief in his achievements or accomplishments in mathematics.
Belief about the Nature of Mathematics *Beliefs about the nature of mathematics* are a person's beliefs about the meaning of mathematics and the usefulness of mathematics in everyday life.	Meaning of math	What math means to the subject.
	Benefits of math	The usefulness of math in life according to the subject.

METHODOLOGY

Research Design

Convenience sampling was used to choose the universities that participated in the research. The initial author's workplace was conveniently located near the university, making travel to the location simple. Participants in the study were a group of second-year college students who volunteered to answer 18 questions about their mathematical identities (Kurniawati et al., 2022) and allowed us to access them as a glimpse into their mathematical identity. In addition, prospective research subjects were given a mathematics ability test to determine their initial mathematical ability. Before being done by prospective research subjects, the math ability test consisting of 10 questions was checked for quality by validating the questions to mathematics education experts about difficulty level, language, and mark allocation. From the initial math ability test results, one pair of prospective mathematics teacher students with equal mathematical abilities were obtained. The researcher then selected one pair of prospective mathematics teacher students: one female and one male prospective mathematics teacher-student. One female prospective mathematics teacher-student with the pseudonym Fhema and one male prospective mathematics teacher-student with the pseudonym Malhe.

Participants

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Individual interviews were done depending on when it was most convenient for each research subject. Before the interview, participants were requested to be completely honest, informed that their answers would be kept private and anonymous, and allowed to decline all questions. Sometimes, follow-up questions were posed to elicit more specific information. Samples of interview questions that delve into interviewees' knowledge of their mathematical identities are:

- Are you interested in math?
- How do others perceive your math skills?

- How confident do you think you are in understanding the math material?
- How do you think you feel about your math performance?
- What does math mean to you?

Data Collection Instruments

There are 3 instruments used to collect data: an initial math ability test, a mathematical identity questionnaire (Kurniawati et al., 2022), and an interview protocol. The initial mathematics ability test was used as an initial consideration when selecting research subjects. The research subjects' mathematical identities were generally or quickly discovered using the mathematical identity questionnaire. Then, the mathematical identity of prospective mathematics teachers was explored in depth by conducting interviews using interview protocol. The mathematical identity questionnaire and interview protocol were designed based on the components of mathematical identity, and the questions asked included interest, recognition, competence, performance, and beliefs about the nature of mathematics. Responses from highly agree (coded as 5) to strongly disagree (coded as 1) were selected by prospective participants. The sum of the individual item scores on the mathematical identity questionnaire was used to determine the overall score for each potential subject. The overall identity score was divided by the entire potential identity score of 90 and converted to a percentage to characterize the general mathematical identity of the prospective topic.

The scores from the prospective subject and mathematical identity were used to stratify the potential subjects into three groups. Based on the questionnaire replies, the prospective subject's mathematical identity score was categorized as generally robust (>70%), modest (69–50%), or largely fragile (<49%) (Gweshe & Brodie, 2019). In addition, prospective students were categorized into high, average, and low achievers according to the outcomes of their math tests. Furthermore, the two research subjects involved in this study were two prospective mathematics teachers with high achievers on their mathematical ability test and largely robust on their mathematical identity questionnaire results.

Data Analysis

Responses demonstrating interest, recognition, competence, performance, and beliefs about the nature of mathematics were coded from the transcripts of interviews. One narrative from these interviews was considered meaningful, reifying and approved (Heyd-Metzuyanim & Sfard, 2012). As a result, the main goal was to determine whether or not stories were important enough to reify identities. Reification was defined as statements that reveal a person's identity (Andersson et al., 2015; Sfard & Prusak, 2005), for example, 'I am good at mathematics'. Stories that demonstrated a student's emotions, such as feelings of being included or excluded, or clues to what the learner presumably considered important, appropriate, or desirable, were considered relevant (Heyd-Metzuyanim & Sfard, 2012) for instance, "you regret," demonstrates how students may appear to be speaking about others while referring to themselves (Heyd-Metzuyanim & Sfard, 2012). Some statements perfectly capture the identities of the students.

RESULTS AND ANALYSIS

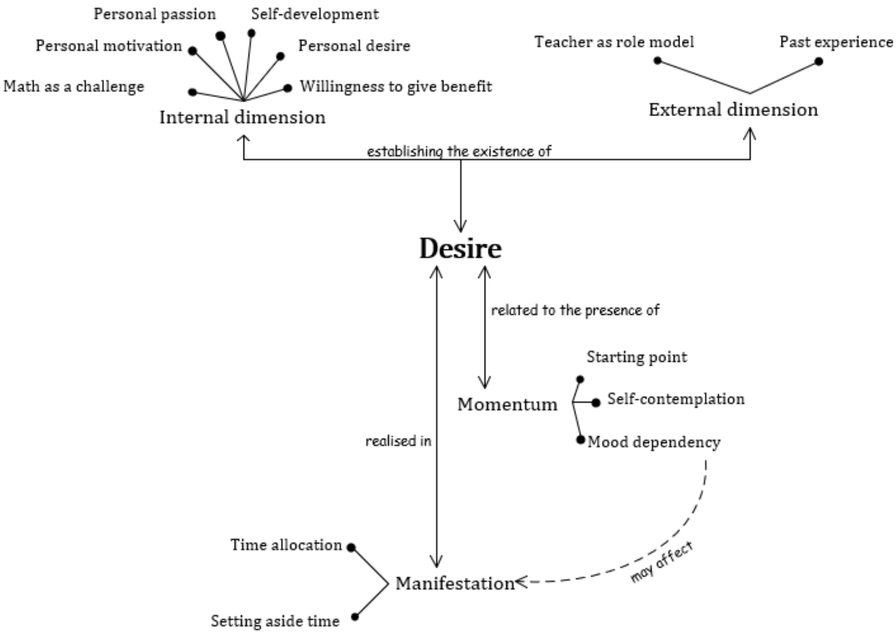
Mathematical Identity of Female Mathematics Teacher Candidates

Interest in Female Mathematics Teacher Prospective Students

Fhema desires to learn and teach mathematics, which is built for several reasons, both within the subject (internal dimension) and outside (external dimension). In the internal dimension, Fhema’s desire to learn and teach mathematics arises, for example, due to a personal passion, considering mathematics a challenge, a willingness to provide benefits, encouragement and personal will, and a desire to develop themselves. In the external dimension, Fhema's desire to learn and teach mathematics was caused by a positive experience related to a mathematics teacher who became a role model and manifested in concrete actions in the form of allocating and setting aside time to learn and teach daily. This desire is related to a certain momentum, namely the existence of mood dependency, and stems from the process of self-contemplation in grade twelve high school (as a starting point). In summary, the interest in the sub-component of the desire to learn and teach mathematics of Fhema is shown in Figure 1.

Figure 1

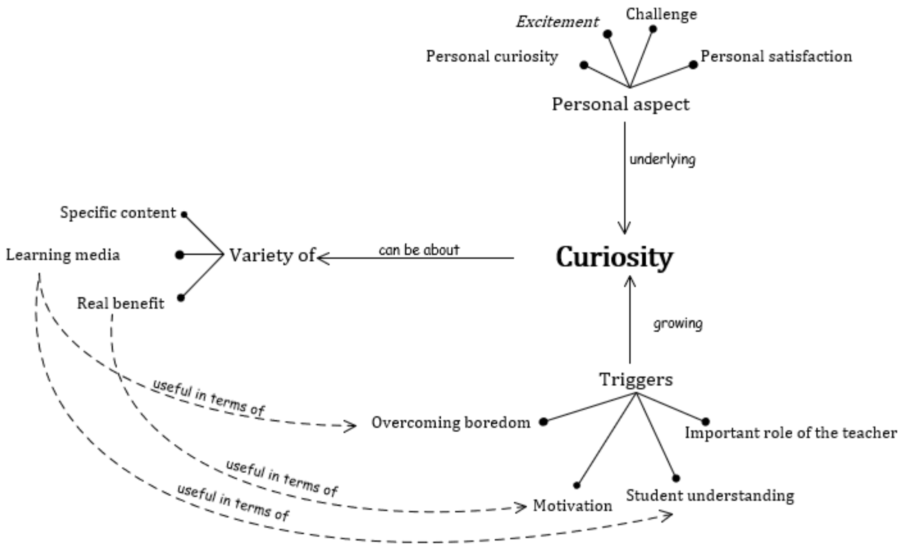
Fhema’s Interest Map (Sub-Component: Desire)



Fhema has a curiosity to learn and teach mathematics that comes from personal aspects, namely a sense of curiosity, excitement, and satisfaction and considers mathematics a challenge. Fhema's curiosity about mathematics is quite diverse, namely curiosity about the real benefits of mathematics, specific materials, and variations in learning media. Fhema’s curiosity is triggered by the desire to motivate, provide understanding to students, overcome students' boredom, and consider that one of the important roles of teachers is to be able to teach in various ways that suit classroom conditions. In summary, the interest in the sub-component of curiosity in learning and teaching mathematics of Fhema is shown in Figure 2.

Figure 2

Fhema’s Interest Map (Sub-Component: Curiosity)



Fhema feels happy and enjoys learning and teaching mathematics. This feeling is referred to by the author as a supportive feeling, which includes pleasure when learning and teaching and personal satisfaction. Negative feelings (unsupportive feelings) have also been felt by Fhema, such as anxiety, guilt, sadness, and insecurity. Fluctuating feelings depend on specific moments and materials. Although they had experienced negative feelings, Fhema overcame these negative feelings by doing feeling management such as trying to think positively (positive thinking), motivating herselves, introspection, and exploring knowledge. In summary, the interest in the sub-component of enjoyment in learning and teaching mathematics of Fhema is shown in Figure 3. Overall, Fhema's interest map in learning and teaching mathematics is shown in Figure 4.

Figure 3

Fhema's Interest Map (Sub-Component: Enjoyment)

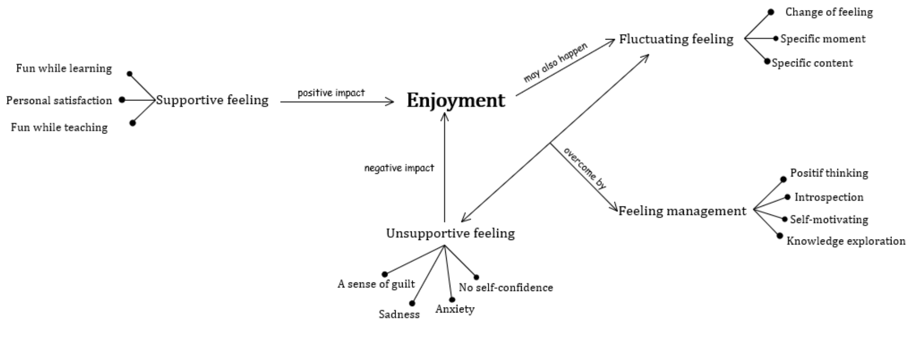
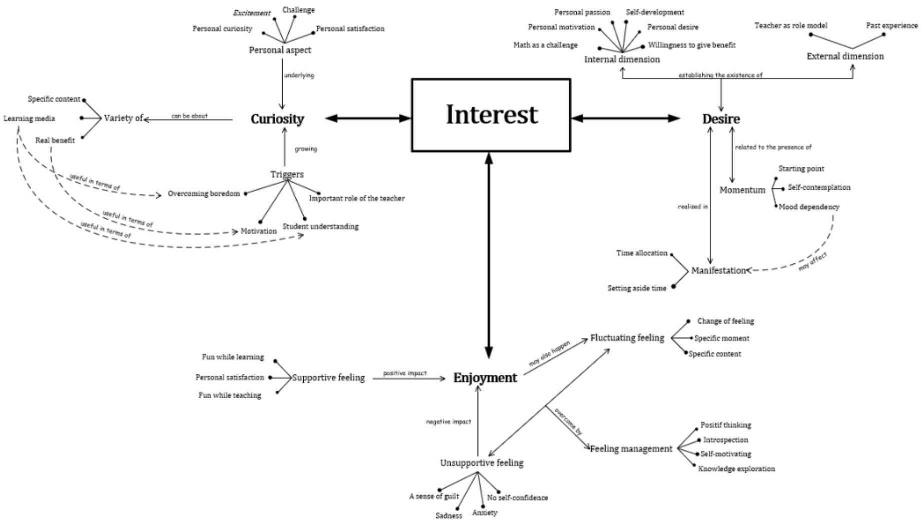


Figure 4

Fhema's Interest Map



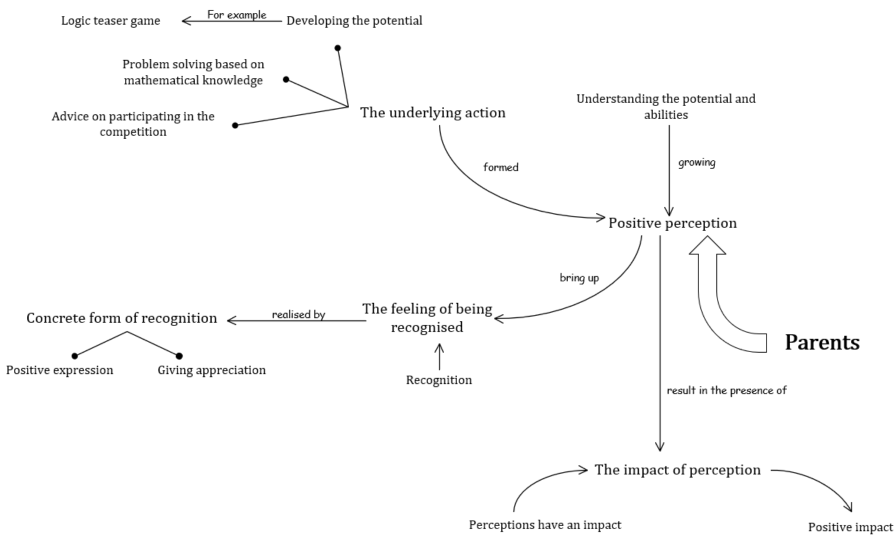
The study's results on the interest of female subjects align with previous research, which found that female students have higher interest and effort and lower anxiety in learning math. (Yunus & Ali, 2009). The desire to learn mathematics owned by a person plays an important role in explaining a person's learning behaviour in general (Ovsich, 2012). One of the behaviours that shows a person's desire is curiosity about something, in this case, mathematics. Curiosity significantly affects one's mathematical performance (Belecina & Ocampo Jr, 2016) In addition to one's desire and curiosity, one's interest can also be seen from the pleasure felt when doing mathematics-related activities. The pleasure a person feels when learning mathematics will positively impact their competency beliefs (Pinxten et al., 2014). As a result, one's interest in mathematics is consistently positively correlated with one's mathematics *performance*, especially in female students (Benbow & Stanley, 1982; Simpkins et al., 2006) When a student is interested in and finds math interesting, they will develop a positive attitude towards math (Arthur et al., 2014). It can also happen the other way around; someone who perceives math as boring will develop a negative attitude towards mathematics (Callahan, 1971). For example, increased negative attitudes or feelings (e.g. math anxiety) will be associated with *performance* deficits in mathematics (Casad et al., 2015; Liu, 2009; Pedro et al., 1981). However, about levels of anxiety or worry, at the right level, anxiety can also contribute positively to mathematics achievement; this occurs when the anxiety that a person feels can be used as a challenge to encourage better performance efforts (Yunus & Ali, 2009). In addition, mathematics learners' attitudes and interests are strongly correlated with the clarity or experience of their learning with their teachers (Campbell & Schoen, 1977). A person's interest will be closely related to future career choices (Arens et al., 2011). It explains that the role of teachers as good *role models is* necessary for learning, with the aim that students have a good educator model who can inspire them to become professional mathematics teachers.

Recognition in Female Mathematics Teacher Prospective Students

Fhema has a positive perception of how parents see her in mathematics based on several parental actions such as parents trying to develop Fhema's potential, encouraging Fhema to solve problems based on their mathematical knowledge, suggesting to participate when there is a competition, and training Fhema with games that hone logic when Fhema was a child. Fhema's perception of parental views has a positive impact on her. Fhema also feels recognized by parents for his mathematical abilities. The real form of recognition is positive expressions and appreciation by parents. In summary, the recognition in the sub-component of parents is shown in Figure 5.

Figure 5

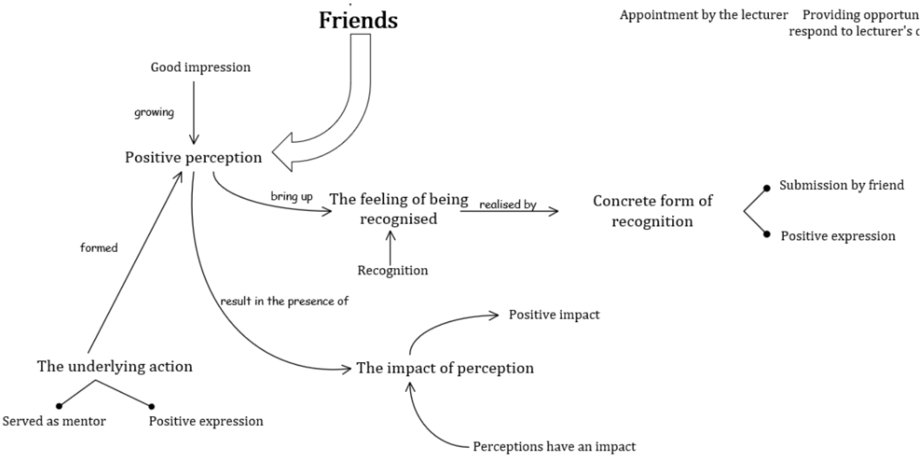
Fhema's Recognition Map (Sub-Component: Parents)



Fhema has a positive perception of how friends see her mathematics ability (this is because Fhema feels that friends give her a good impression), which is based on several actions of friends that underlie this positive perception (such as positive expressions from friends and she is often used as a mentor by friends). Fhema's perception of friends' views has a positive impact on her. In summary, the recognition in the sub-component of friends is shown in Figure 6.

Figure 6

Fhema's Recognition Map (Sub-Component: Friends)

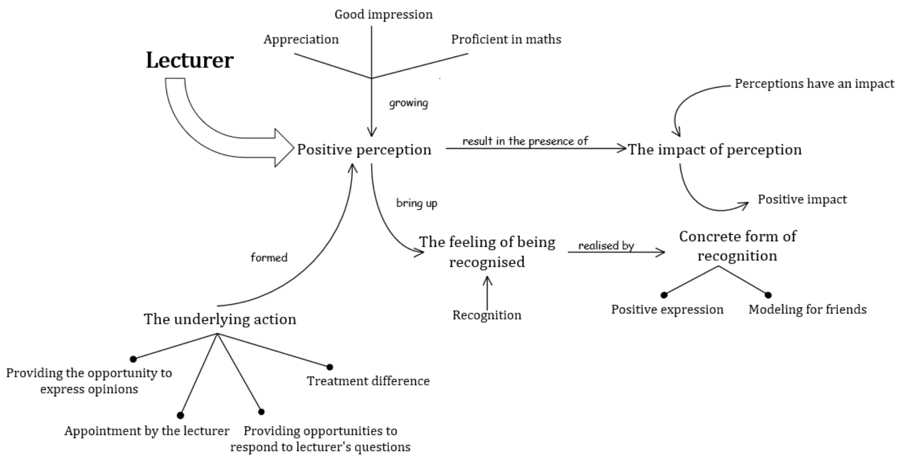


Fhema has a positive perception of how the lecturer sees Fhema in mathematics (the lecturer gives appreciation and a good impression and considers Fhema to be capable in mathematics), which is based on several actions of the lecturer that underlie this positive perception (for example, Fhema is often appointed by the lecturer, given the opportunity to speak and respond to the lecturer's questions, and there is different treatment between Fhema compared to other friends). The Fhema's perception of the lecturer's view positively impacts Fhema. Fhema also feels that the lecturer recognizes her mathematics ability; the form of recognition is a positive expression, and

Fhema is often used as a model for friends. In summary, the recognition in the sub-component of the lecturer is shown in Figure 7.

Figure 7

Fhema's Recognition Map (Sub-Component: Lecturer)



Fhema's perception of herself is based on self-awareness, and Fhema feels she has potential in mathematics. However, this perception is still influenced by mood factors and self-comparison*, so Fhema feels unsatisfied with his* abilities. Fhema's perception of herself has an impact (positive or negative) on Fhema. In summary, the recognition of the sub-component of self is shown in Figure 8. Overall, Fhema's recognition map is shown in Figure 9.

Figure 8

Fhema's Recognition Map (Sub-Component: Self)

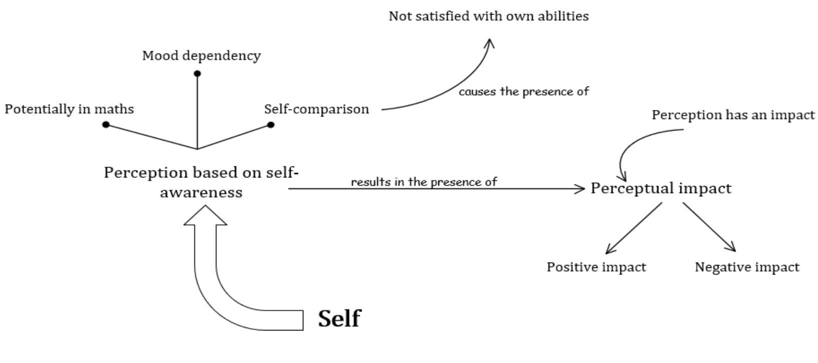
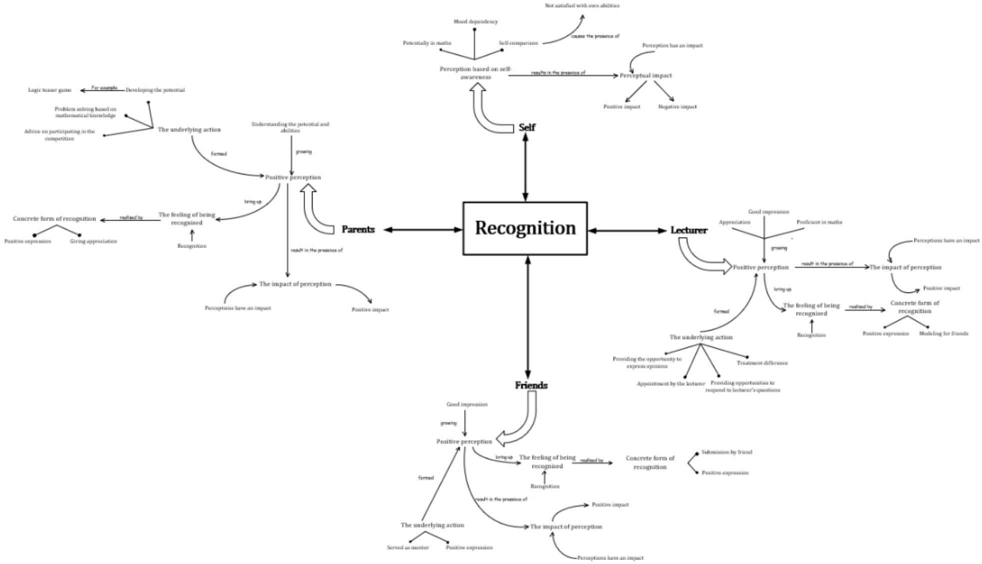


Figure 9

Fhema's Recognition Map



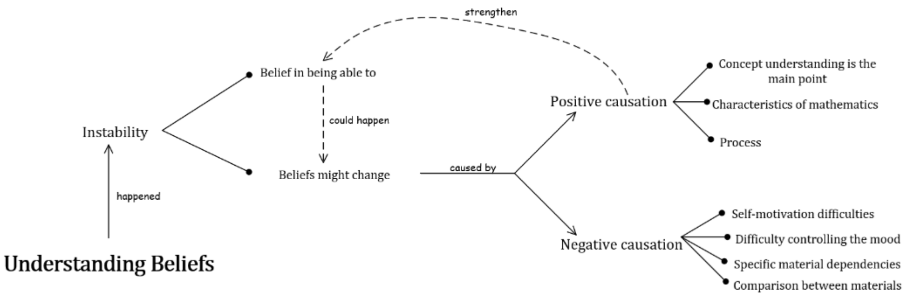
The study's results on the recognition of female subjects align with previous research, which found a significant positive correlation between gender (especially women) and mathematics self-concept. (Mejía-Rodríguez et al., 2021). Furthermore, concerning recognition in the sub-components of parents and lecturers, Piatek-Jimenez (2015) reported that individual encouragement and recognition by parents and teachers play a role in women's interest and perseverance in mathematics. Parental attitudes and beliefs are strongly associated with students' mathematical achievement and identity (Dickens & Cornell, 1993; Ercikan et al., 2005; Ethington, 1991; Frome & Eccles, 1998) to the extent that students' perceptions of parental attitudes were found to have a significant direct effect on female students' math scores (Ethington, 1991). In addition, Fennema & Sherman (1978) reported that differences in girls' perceptions of their parents' attitudes began in middle school and continued to develop through high school. In addition, perceptions of peers will also affect one's academic self-concept (Keller et al., 2023). It because self-concept related to peers will encourage a person to engage in individual comparisons (Hoxby & Weingarth, 2005). Therefore, a positive self-concept related to peer views contributes to one's academic self-concept. How one perceives oneself strongly correlates with one's achievements (Chapman et al., 2000).

Competence in Female Mathematics Teacher Prospective Students

Fhema has unstable beliefs (sometimes Fhema believes that she is capable, but sometimes this belief changes) about her ability to understand mathematics. It is based on the existence of positive causes (for example, Fhema feels that understanding concepts is the main point in mathematics, mathematics has a characteristic that always has a definite answer, and understanding mathematics requires a process) and negative causes (there are difficulties in motivating himself, controlling her mood, the dependence of specific materials, and the comparison between materials). In summary, the competence in the sub-component of understanding beliefs is shown in Figure 10.

Figure 10

Fhema's Competence Map (Sub-Component: Understanding Beliefs)



Fhema has persistence when learning mathematics, which is shown from the response (not antipathy to mathematics and taking a break when encountering difficulties) and the efforts made by Fhema (Fhema makes an initial effort to learn, then makes repetitions and searches for references using various types of media). Fhema's persistence is related to other factors, such as the experience of encountering difficulties and the type of material studied). In summary, the competence in the sub-component of persistent is shown in Figure 11. Overall, Fhema's competence map is shown in Figure 12

Figure 11

Fhema's Competence Map (Sub-Component: Persistence)

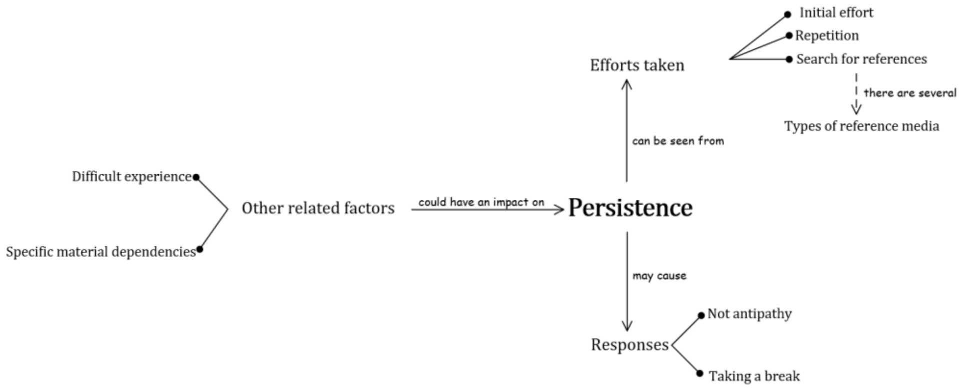
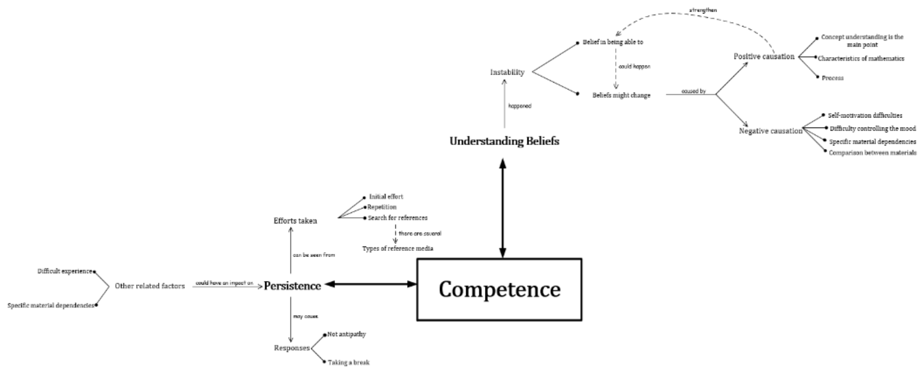


Figure 12

Fhema's Competence Map



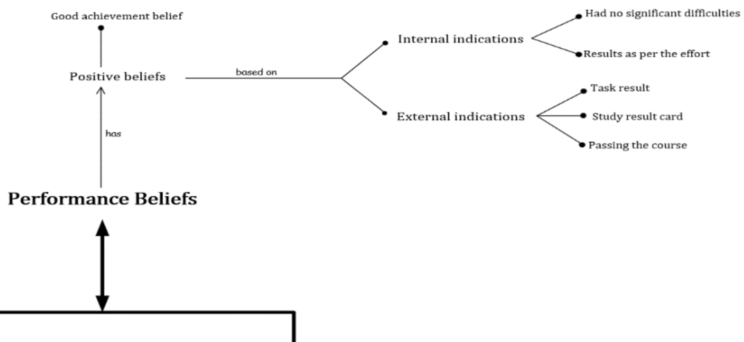
The research results on the competence of female subjects align with previous research, which found that women have high competence beliefs (Britner & Pajares, 2001). In line with these findings, studies in the field of science also show that women's competence beliefs tend to result from past experiences and verbal persuasion (Sawtelle et al., 2012). These competence beliefs positively impact achievement in math (Pinxten et al., 2014). In addition, factual performance on a given test is also influenced by competence beliefs (Arens et al., 2011). These research findings may explain why confidence in understanding the material in different domains impacts one's factual performance when completing tasks in a particular mathematics domain. A person's mastery of material and competence beliefs will determine their effort in mathematics and teacher and parental support, which also play a role (Chouinard et al., 2007). Therefore, the skill of managing mathematics competence beliefs is an important thing that needs to be mastered by mathematics learners because mathematics learners who cannot manage their competence beliefs and maintain negative competence beliefs tend to adopt avoidance behaviour when faced with learning situations (Ames, 1992).

Performance in Female Mathematics Teacher Prospective Students

Fhema has a positive belief in her achievement or work in mathematics (Fhema believes that she has a good achievement in mathematics). Fhema believes that she has a good achievement in mathematics based on several internal indications (for example, Fhema has not experienced significant difficulties so far and feels that the results obtained are by the effort) and external indications (for example, from the assessment results of assignments given by lecturers, study result cards and Fhema's success in passing the programmed courses). Overall, Fhema's performance map is shown in Figure 13.

Figure 13

Fhema's Performance Map



Fhema has a positive belief in her achievement or work in mathematics (Fhema believes that she has a good achievement in mathematics). Fhema believes that she has a good achievement in mathematics based on several internal indications (for example, Fhema has not experienced significant difficulties so far and feels that the results obtained are by the effort) and external indications (for example, from the assessment results of assignments given by lecturers, study result cards and Fhema's success in passing the programmed courses). Overall, Fhema's performance map is shown in Figure 13

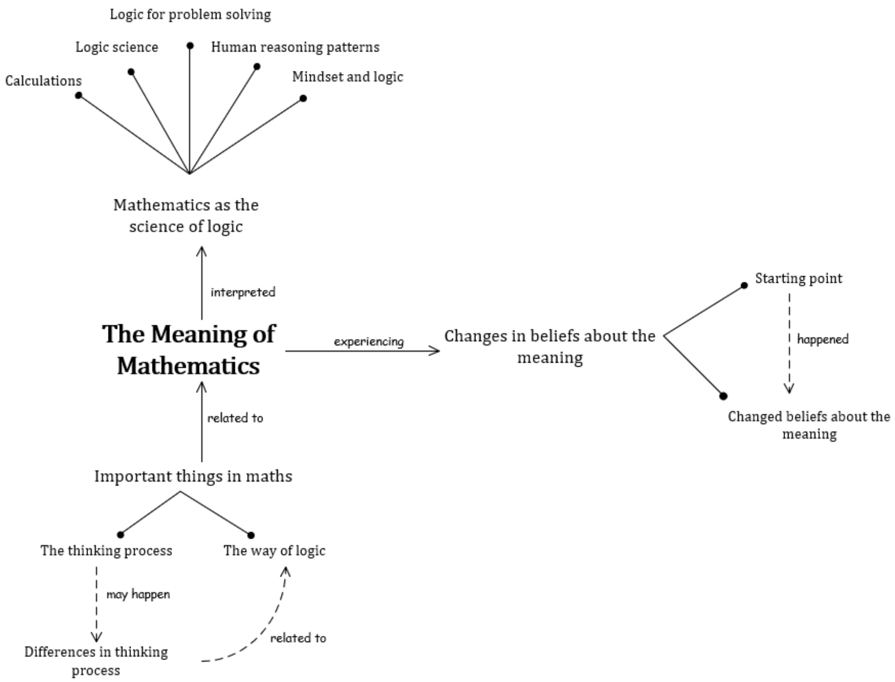
The results of the study on the performance of female subjects who have good achievement beliefs in mathematics are in line with previous research, which found that a person's beliefs about their achievement in mathematics are positively correlated with performance; when their beliefs increase positively, their mathematics achievement and performance will also increase (Fennema & Sherman, 1978; Simpkins et al., 2006). In addition, math learners will be more motivated to learn mathematics when they associate math success with their performance beliefs or effort, and vice versa (Arthur et al., 2014). One way to improve female students' performance beliefs is through mentoring relationships (Redmond et al., 2011; Reid & Roberts, 2006; Stout et al., 2011). The existence of mentoring relationships or contact with female experts will increase women's self-activity and encourage women's positive attitudes towards STEM, especially in mathematics (Dickens & Cornell, 1993). In addition, verbal reinforcement for female students can increase their confidence in their work/achievement and reduce their anxiety in mathematics (Genshaft & Hirt, 1980).

Beliefs about the Nature of Mathematics of Female Mathematics Teacher Prospective Students

Fhema believes in mathematics as the science of logic (mathematics is not only about calculations but also the science of logic, logic for solving problems that involve patterns of reasoning and patterns of human thought/logic). Fhema had experienced a change in the meaning of mathematics, namely when Fhema started college (starting point). In interpreting mathematics, Fhema felt that there were important things related to the meaning of mathematics, namely differences in thought processes and ways of logic. In summary, the beliefs about the nature of mathematics in the sub-component of the meaning of math are shown in Figure 14.

Figure 14

Fhema's Belief about the Nature of Mathematics Map (Sub-Component: Meaning of Math)



Fhema believes that mathematics is beneficial to human life (mathematics is useful as a guide in the problem-solving process); these benefits can be grouped into 2 types, namely, seen concretely and abstractly. The belief about the benefits of mathematics owned by Fhema precisely changed when he started college (starting point*)*. In summary, the beliefs about the nature of mathematics in the sub-component of the benefits of math are shown in Figure 15. Overall, Fhema's beliefs about the nature of mathematics are shown in Figure 16.

Figure 15

Fhema's Belief about the Nature of Mathematics Map (Sub-Component: Benefits of Math)

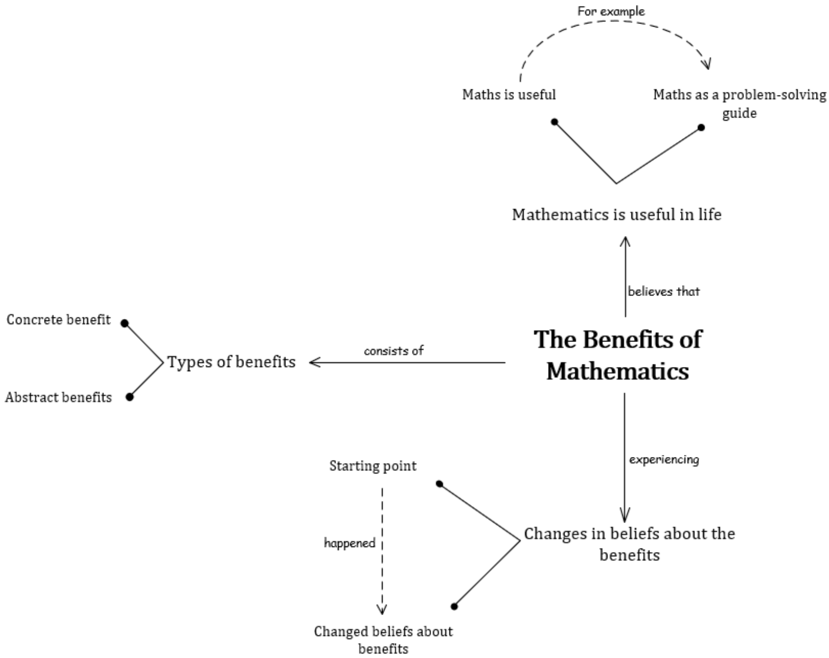
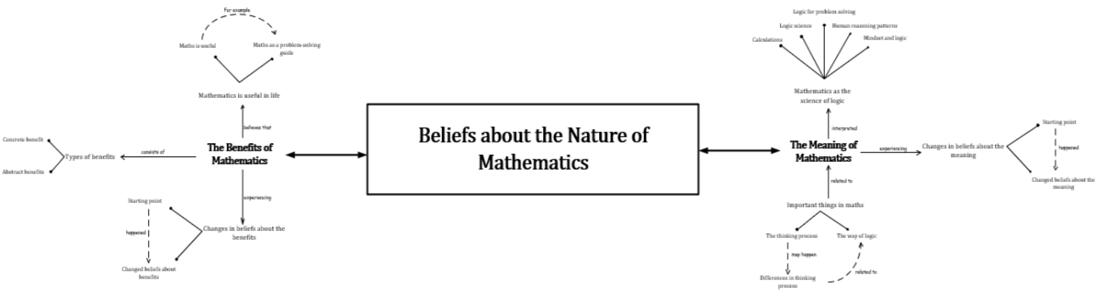


Figure 16

Fhema's Beliefs about the Nature of Mathematics Map



The research results on beliefs about mathematics held by female subjects, specifically about the benefits of mathematics in everyday life, align with previous research, which found that beliefs in the benefits of mathematics are positively correlated with mathematics achievement. (Fennema & Sherman, 1978; Pedro et al., 1981). Such mathematics beliefs are also related to the performance and sustainability of engaging in mathematics (Meece et al., 1990; Simpkins et al., 2006; Watt et al., 2006). The importance of the benefits of mathematics believed by female mathematics learners is one of the most influential predictors of persistence in mathematics (Fennema & Sherman, 1978; Meece et al., 1990; Pedro et al., 1981). In addition, beliefs about the usefulness of mathematics and its importance for future careers are predictors of mathematics performance and have a direct positive effect on one's performance expectations (Iben, 1991; Meece et al., 1990).

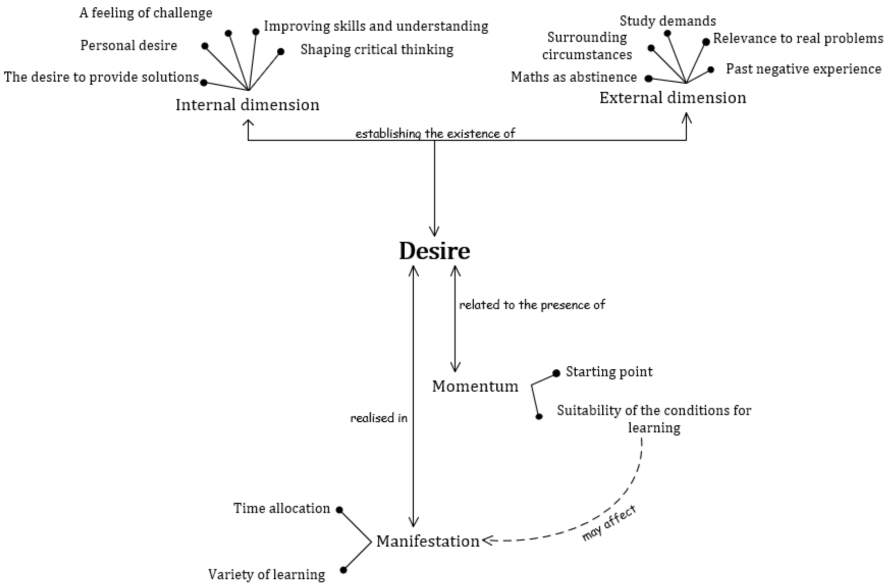
Mathematical Identity of Male Mathematics Teacher Candidates

Interest in Male Mathematics Teacher Prospective Students

Malhe has a desire to learn and teach mathematics, which is built from internal dimensions (the feeling of being challenged, personal desire, desire to provide solutions, develop critical thinking patterns, and improve skills and understanding) and external dimensions (triggered by the surrounding environment, learning demands, the relationship between mathematics and real-life problems, past negative experiences, and the perception of mathematics as a taboo). This desire is realized by allocating learning time and the desire to vary learning methods. Malhe's desire began to emerge during college (starting point); besides, the allocation of learning time for Malhe was adjusted to Malhe's condition. In summary, the interest in the sub-component of the desire to learn and teach mathematics of male prospective mathematics teachers is shown in Figure 17.

Figure 17

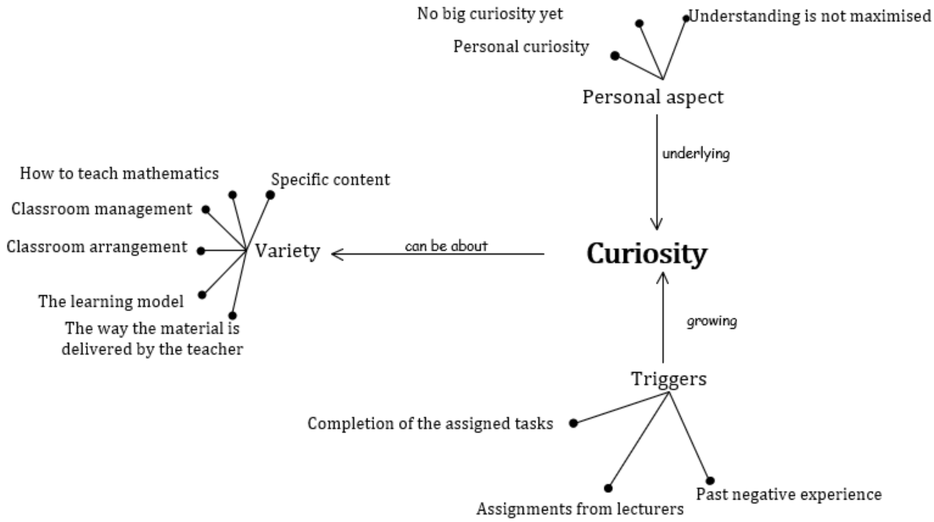
Malhe's Interest Map (Sub-Component: Desire)



Malhe has a curiosity to learn and teach mathematics originating from personal aspects (the existence of personal curiosity due to an understanding that has not been maximized even though the curiosity is not so great). The variety of curiosity of Malhe includes curiosity about certain materials, how to teach mathematics, classroom management, classroom arrangement, learning models, and how the teacher delivers material). Malhe's curiosity is triggered by the demands of completing assignments given by lecturers and past negative experiences related to learning mathematics. In summary, the *interest* in the sub-component of curiosity in learning and teaching mathematics of male mathematics teacher candidates is shown in Figure 18.

Figure 18

Malhe's Interest Map (Sub-Component: Curiosity)



Malhe felt happy when learning mathematics (supportive feeling), although Malhe also had some negative *feelings* (unsupportive), such as boredom, boredom, anxiety, lack of confidence, and feelings of embarrassment. This fluctuating feeling occurs at specific moments, such as during exams, when the pleasure that has not been maximized is caused by ignorance about the questions, lack of understanding, and provision of knowledge that is not yet qualified. Malhe tries to overcome these negative feelings in several ways (feeling management), such as calming down, washing his face when anxious, and consistently learning to add insight. In summary, the *interest* in the sub-component of *enjoyment* in learning and teaching mathematics of male prospective mathematics teachers is shown in Figure 19. Overall, Malhe's interest map in learning and teaching mathematics is shown in Figure 20.

Figure 19

Malhe's Interest Map (Sub-Component: Enjoyment)

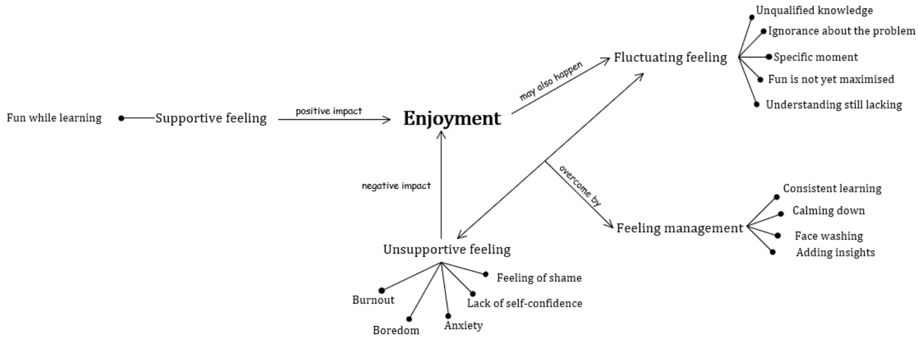
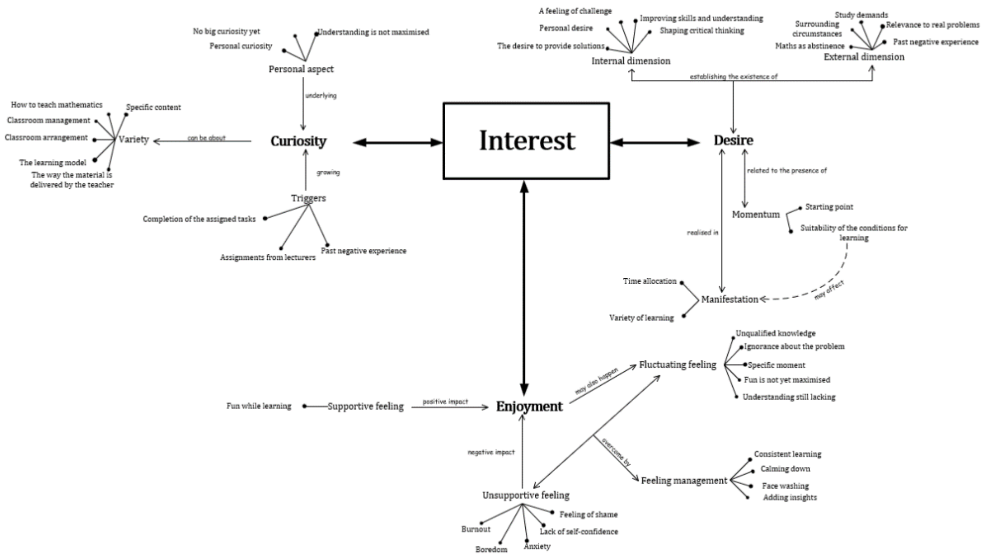


Figure 20

Malhe's Interest Map



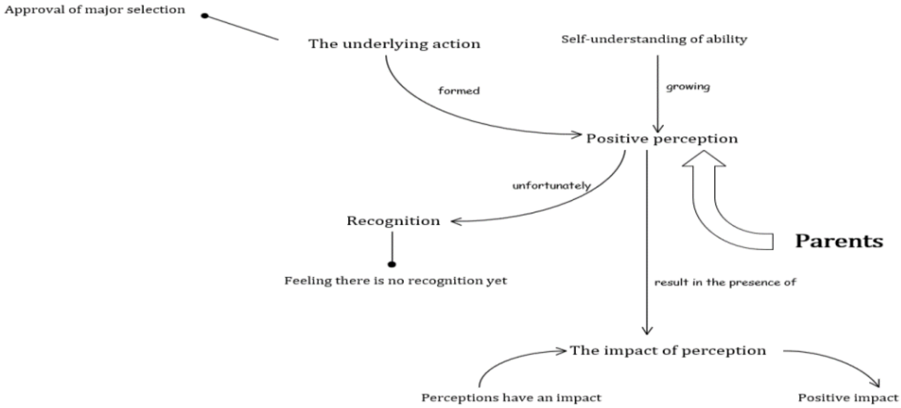
The study's results on male subjects' interests align with previous research, which states that students' interests can be stimulated by their curiosity or by things that are still little known to them (Jingsong, 2003). Maintaining the existence of students' interest in mathematics is of utmost importance because, without interest in learning, students will tend to go into learning with a lack of depth of understanding; the depth of understanding and engagement of students in learning is due to their interest (Arthur et al., 2014). In addition, the teacher's role in learning contributes to one's interest in learning mathematics. Teachers are motivated to provide good and enjoyable learning for students, which influences students' interest positively in mathematics and the methods and approaches used in teaching mathematics (Arthur et al., 2014). Furthermore, the role of the teacher and learning activities in constructivist classrooms are expected to provide an environment that motivates and directs students to problem-solving despite students' different knowledge bases, experiences and motivations (Arthur et al., 2014). Some of these findings provide explanations that reinforce why male subjects' interest in mathematics is related to past experiences of less pleasant math learning by teachers during school.

Recognition in Male Mathematics Teacher Prospective Students

Malhe has a positive perception of how their parents see Malhe's abilities (this is because Malhe feels that Malhe's parents understand Malhe's abilities) based on the actions of Malhe's parents, who approved the choice of major. This perception has a positive impact on Malhe. Unfortunately, Malhe feels that he has never received recognition from his parents. In summary, the recognition in the sub-component of parents is shown in Figure 21.

Figure 21

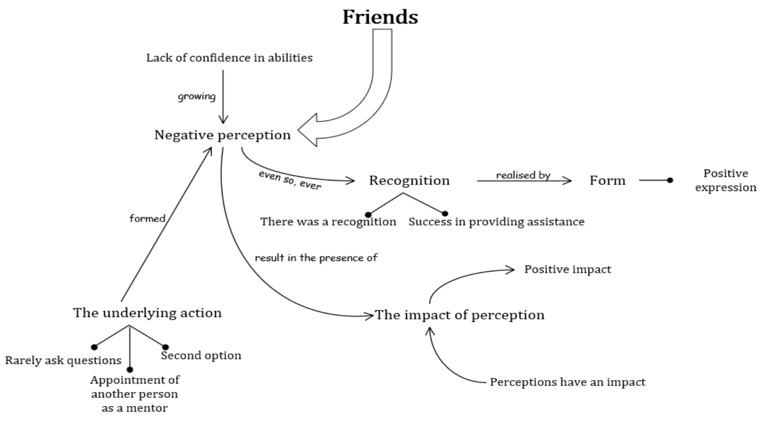
Malhe's Recognition Map (Sub-Component: Parents)



Malhe has a negative perception of how friends see Malhe's ability (Malhe feels that friends do not believe in Malhe's ability) based on several actions taken by his friends (for example, friends rarely ask Malhe and appoint others as mentors and make Malhe as a second option). Malhe's perception has a positive impact on Malhe. Malhe once felt recognition from friends, namely when Malhe succeeded in assisting friends. The recognition was in the form of positive expressions from Malhe's friends. In summary, the recognition in the sub-component of friends is shown in Figure 22.

Figure 22

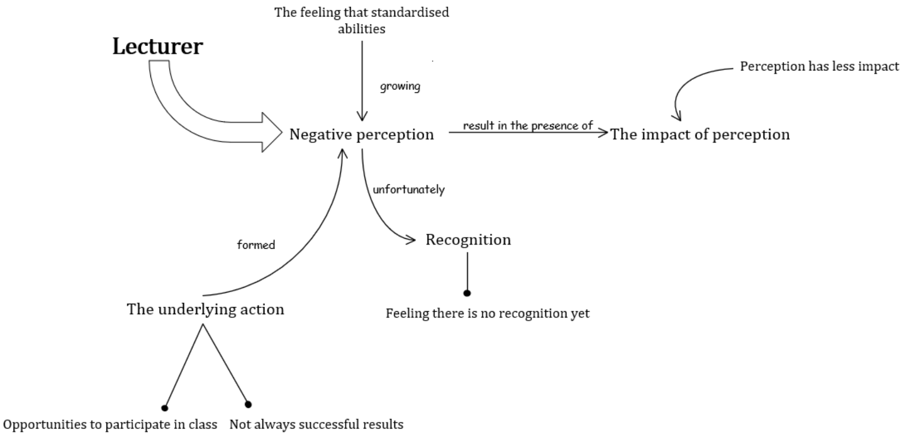
Malhe's Recognition Map (Sub-Component: Friends)



Malhe has a negative perception of how the lecturer sees Malhe's ability (Malhe feels that the lecturer sees the ability he has as only a standard ability) based on the actions of the lecturer, who rarely provides opportunities to participate in class (or when the opportunity to participate is given, Malhe has not been able to show successful results), Malhe's perception of the lecturer's views has little impact on Malhe (this is due to the intensity of meetings with lecturers who are less than friends). Malhe also feels that the lecturer has never recognized his mathematics abilities. In summary, the recognition in the sub-component of the lecturer is shown in Figure 23.

Figure 23

Malhe's Recognition Map (Sub-Component: Lecturer)



Malhe has a negative perception of himself about his mathematics ability (Malhe feels that his mathematics ability is still standard based on the scores obtained, so he needs to improve his ability). However, this perception turns out to positively impact Malhe; namely, Malhe becomes more active in learning. In summary, the recognition of the sub-component of self is shown in Figure 24. Overall, Malhe's recognition map is shown in Figure 25.

Figure 24

Malhe's Recognition Map (Sub-Component: Self)

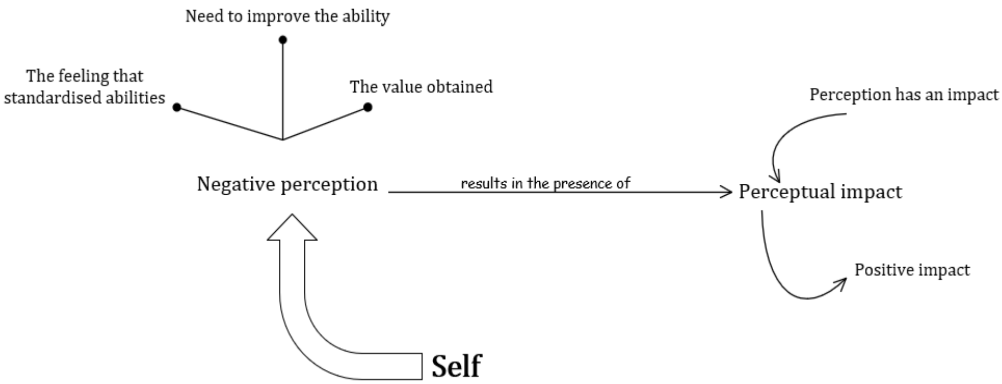
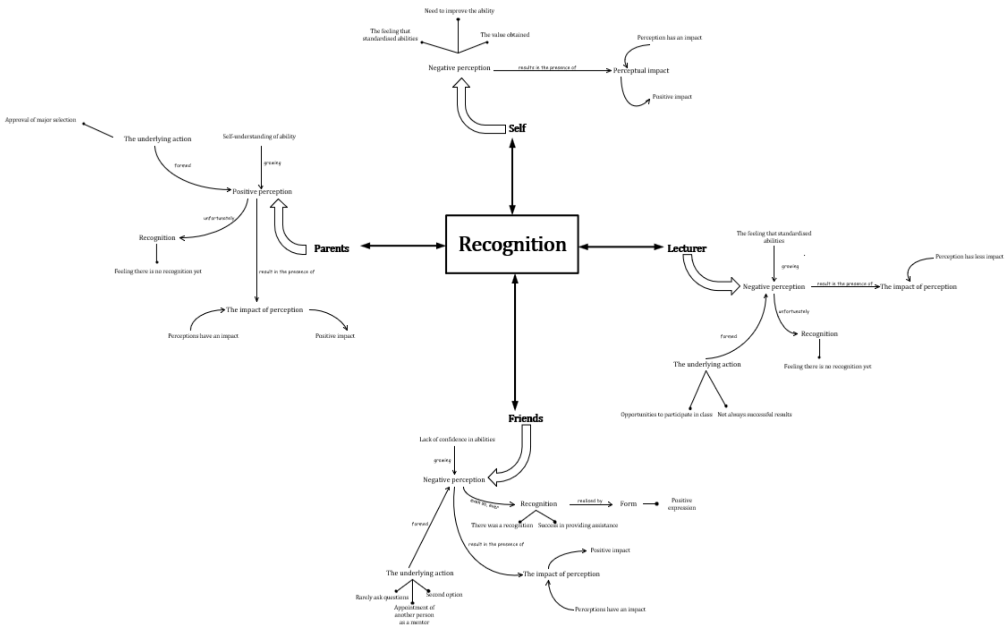


Figure 25

Malhe's Recognition Map



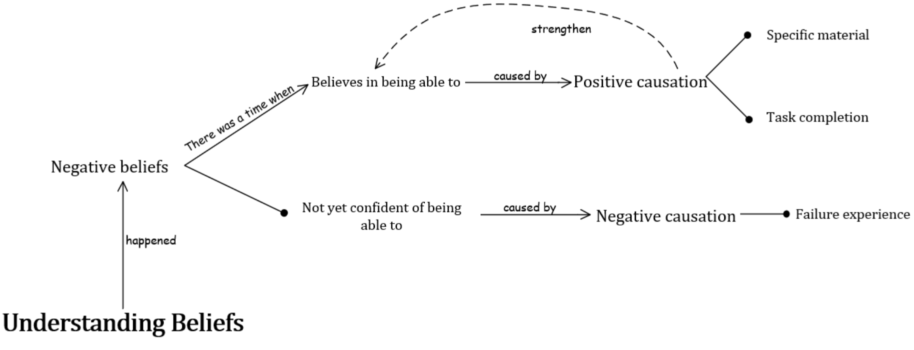
The study's results on male subjects' recognition align with previous research which found that parental involvement and perceptions correlate with one's mathematical self-concept (Mejía-Rodríguez et al., 2021). Being recognized as a "math person" by others has a greater effect on the mathematical identity owned (J. D. Cribbs, 2012). In this case, the support or perception of teachers is as important as that of parents (Chouinard & Karsenti, 2005). Furthermore, existing stereotypes identify mathematics as a male domain (Cvencek et al., 2011; Nosek et al., 2009; Smyth & Nosek, 2015). However, this stereotype does not generally apply in all countries, especially Indonesia. For example, in high-performing countries such as Singapore, China, and Korea, boys score higher on average in math self-concept than girls. In low-performing countries such as Saudi Arabia, Oman, and Bahrain (in this case, including Indonesia), boys have a lower mathematical self-concept than girls (M. O. Martin et al., 2016). It is reinforced by previous research findings stating that parents have significantly lower academic expectations for boys in most countries (Mejía-Rodríguez et al., 2021).

Competence in Male Mathematics Teacher Prospective Students

Malhe has negative beliefs about his ability to understand mathematics (Malhe does not yet believe that he is capable). Their belief in understanding mathematics owned by Malhe is related to the existence of positive causation (when completing tasks on certain materials, Malhe becomes convinced that he is capable) and negative causation (Malhe tends to feel that he does not believe he can understand mathematics due to the experience of failure when learning mathematics). In summary, the competence in the sub-component of understanding beliefs is shown in Figure 26.

Figure 26

Malhe's Competence Map (Sub-Component: Understanding Beliefs)



Malhe has persistence when learning mathematics, which is shown from the response (not antipathy even though he felt hopeless) and the efforts made by Malhe (trying to keep learning, deepening his understanding of tasks to solve math problems, looking for references, asking questions and discussions with friends) even when Malhe is experiencing learning difficulties. In summary, the competence in the sub-component of persistent is shown in Figure 27. Overall, Malhe's competence map is shown in Figure 28.

Figure 27

Malhe's Competence Map (Sub-Component: Persistence)

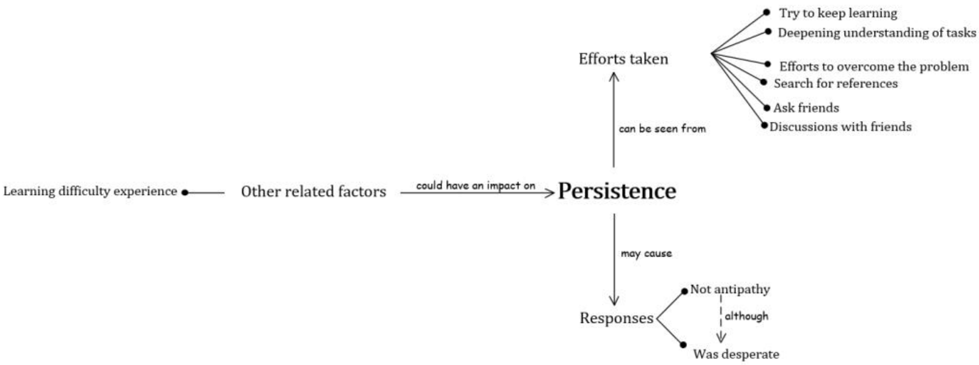
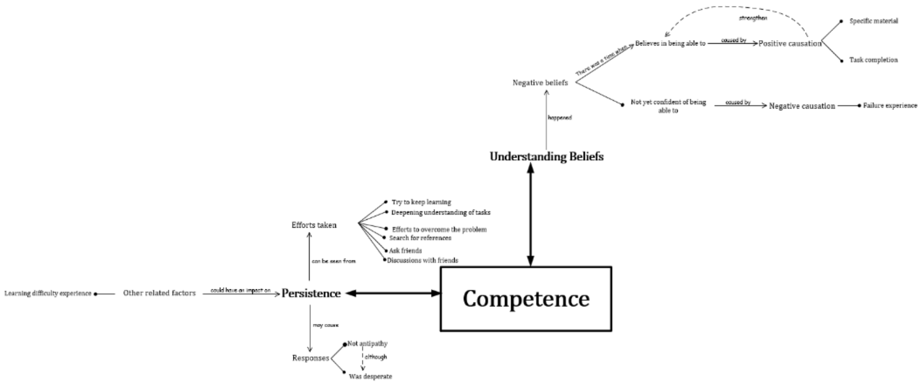


Figure 28

Malhe's Competence Map



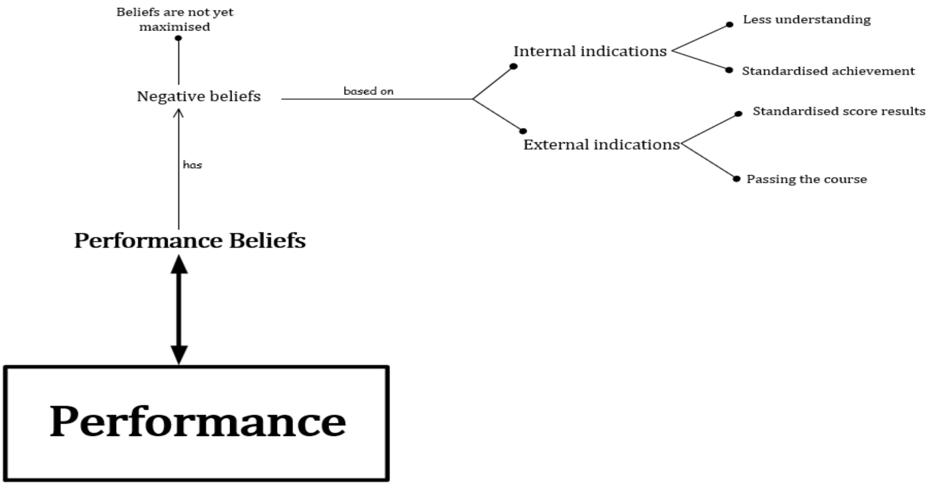
The study's results on the competence of male subjects align with previous research, which found that men's competence beliefs tend to be based on past mastery experiences (Sawtelle et al., 2012). Past math experiences or achievements can positively predict math competency beliefs in the future (Pinxten et al., 2014). Some findings also support the hypothesis that achievement goals influence competence beliefs (Greene et al., 1999; Middleton et al., 2004). In addition, high competence beliefs in a person are related to the effort exerted by a person because the person has felt competent in a particular domain (Pinxten et al., 2014). It is a good reason why people struggle to understand the material when they do not believe they are competent in that area. In addition, teachers also play a role in shaping students' competency beliefs. When teachers provide support and make students feel confident in their competence, students' academic skills will also improve (Patrick et al., 2007).

Performance in Male Mathematics Teacher Prospective Students

Malhe had negative beliefs about his achievement or work in mathematics (Malhe felt that his achievement in mathematics was not optimal). Beliefs about the results of Malhe's work were based on internal indications (Malhe felt that his understanding of mathematics was still lacking and his achievement was standard) and external indications (Malhe felt that the results of the grades he obtained were standard even though he passed all the courses in the program). Overall, Fhema's performance map is shown in Figure 29.

Figure 29

Malhe's Performance Map



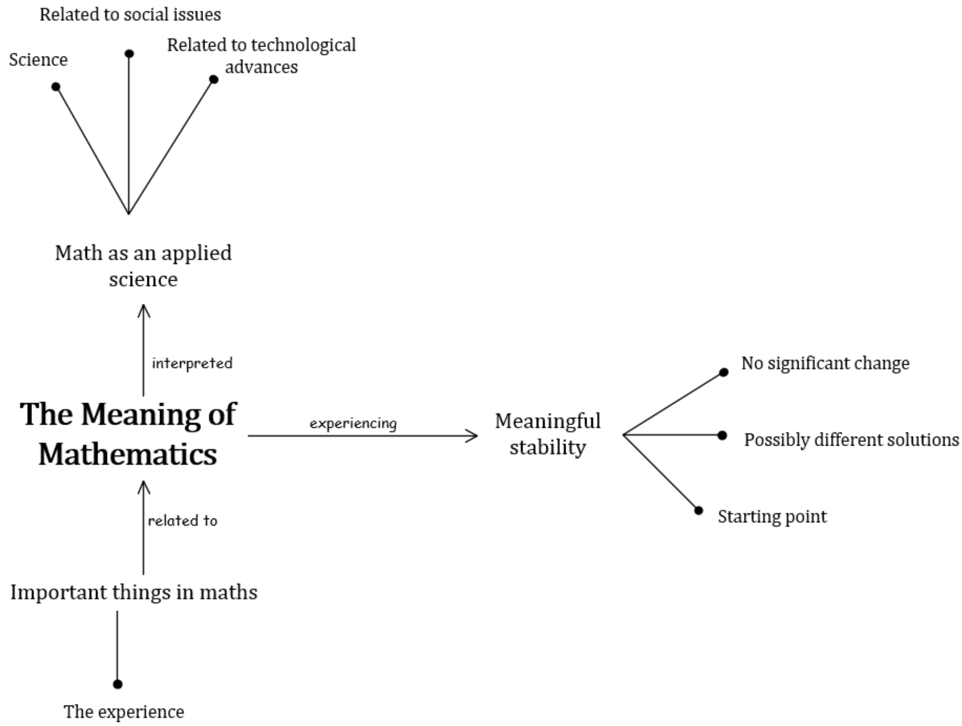
The results of the study on the performance of male subjects are supported by previous research, which states that students' beliefs about their academic potential lead to performance outcomes, which are important factors and influence many aspects of behaviour, for example, how strongly a person persists on a task and how well they achieve. (Bandura, 1997; Skinner, 1995).. These findings may explain why people with negative performance beliefs have negative factual performance. However, performance beliefs may differ from factual performance outcomes (Lock et al., 2013). For example, although a person feels they perform well in a domain, their factual performance results do not match. Therefore, a realistic and mindful assessment of one's achievement beliefs is necessary (Stetsenko et al., 2000).

Beliefs about the Nature of Mathematics of Male Mathematics Teacher Prospective Students

Malhe has beliefs about the meaning of mathematics, namely mathematics as an exact science applicable in human life (mathematics is interpreted as an exact science related to social problems and technological progress). Beliefs about the meaning of mathematics owned by Malhe tend to be stable (Malhe's beliefs about the meaning of mathematics have been owned since the beginning of learning mathematics and have not undergone significant changes; the meaning of mathematics for Malhe has remained the same since Malhe studied mathematics, what may differ is the solution to mathematical problems). The beliefs owned by Malhe are based on Malhe's experience. In summary, the beliefs about the nature of mathematics in the sub-component of the meaning of math are shown in Figure 30.

Figure 30

Malhe's Belief about the Nature of Mathematics Map (Sub-Component:



Meaning of Math)

Malhe believes that mathematics is beneficial to human life (mathematics is useful for solving problems, for example, by using mathematical knowledge and utilizing mathematical formulas to solve problems; this belief has been owned since he was in college (*starting point*). The benefits of mathematics can be categorized into concrete benefits and abstract benefits. In summary, the beliefs about the nature of mathematics in the sub-component of benefits of math are shown in Figure 31. Overall, Malhe's beliefs about the nature of mathematics are shown in Figure 32.

Figure 31

Malhe's Belief about the Nature of Mathematics Map (Sub-Component: Benefits of Math)

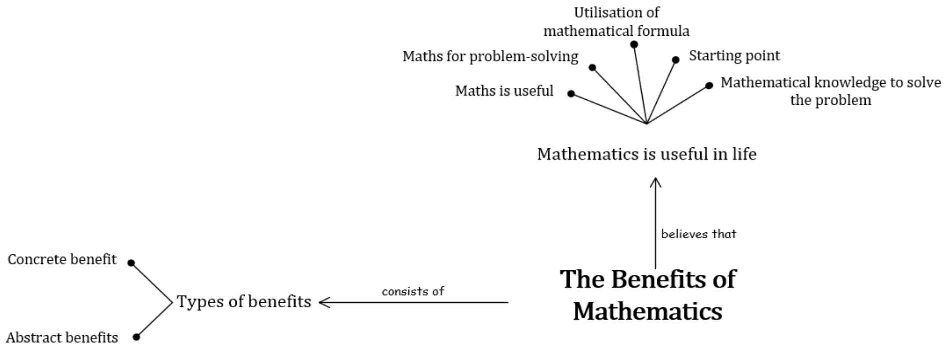
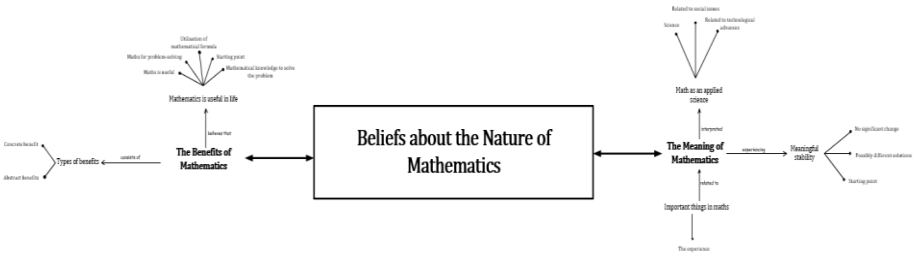


Figure 32

Malhe's Beliefs about the Nature of Mathematics Map



The results of research on beliefs about mathematics held by male subjects are by previous research, which states that, in brief, the beliefs of male subjects are classified as instrumentalist beliefs, considering mathematics as a discipline of exact science with rules and procedures that must be memorized rather than a dynamic and constantly evolving field of science from human creation and discovery as a cultural product (Ernest, 1989). Instrumentalist-type beliefs are evident from the male subject's acknowledgement of his mathematical beliefs. Furthermore, previous research findings also support that mathematics teachers more widely hold the instrumentalist belief than the problem-solving type (Paksu, 2008). Although male subjects believe that mathematics does not change, male subjects also believe that solving mathematical problems may differ between individuals. This male subject’s beliefs are supported by previous research, which states that most mathematics teachers believe that mathematical problems can be solved in many ways and do not focus on only one way (Zakaria & Musiran, 2010).

CONCLUSIONS

The mathematical identity owned by female and male prospective mathematics teacher students differs in several components. For example, in the interest component, the interest possessed by female prospective mathematics teachers tends to be influenced by internal factors that are stronger than external factors. It is the opposite for male prospective mathematics teachers. In the recognition component, female prospective mathematics teachers have positive self-perceptions in all sub-components of recognition. In contrast, male prospective mathematics teachers have perceptions that tend to be negative in the sub-components of lecturers and friends. Female prospective mathematics teacher students believe they are capable and persistent in learning mathematics and perform well in mathematics. In contrast, male prospective mathematics teacher students believe their mathematics ability is still average. Both female and male students believe mathematics has meaning and benefits in human life.

AUTHORS’ CONTRIBUTIONS STATEMENTS

A.D.K. conceived the presented idea, developed the theory, built the questionnaire, collected the data, and analyzed the data. All authors actively discussed the results reviewed and approved the final version of the work.

DATA AVAILABILITY STATEMENT

The data presented and supporting this research results are available at a reasonable request to the first author, A.D.K.

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