Children's mathematics-related beliefs: An exploratory qualitative study in an Indonesian elementary school

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One of the factors that influences how students learn mathematics is their mathematics-related beliefs. Mathematics-related beliefs are important, but in Indonesia, there has been little research on mathematics beliefs in elementary schools and in relation to grade level and gender. This study aims to determine the general profile of elementary school students' beliefs related to mathematics in relation to grade level and gender. The approach used was exploratory-qualitative, with research illustrations selected from four students. Data were obtained from drawing analysis, interviews, and documentation. The results showed that: (1) the general profile of elementary school students' beliefs about mathematics education tends to be a mixture of traditional and constructivist beliefs; (2) traditional beliefs dominate the beliefs held by students about themselves; (3) the general profile of beliefs about the social context is traditional beliefs; (4) elementary school students' beliefs related to mathematics in relation to grade level show no special differences; and (5) elementary school students' mathematics beliefs in relation to gender show differences in beliefs related to mathematical abilities and orientation-goals.

Introduction

In the mathematics education research literature, belief is recognised as one of the essential factors that influence students' mathematical competence (Liviananda & Ekawati, 2019). Students' beliefs related to mathematics are not only important because they are related to their motivation to learn mathematics (Hidayatullah & Csíkos, 2024), but also because of their relationship with performance, motivation, and attitudes towards mathematics that vary (Heyder et al., 2020; Perera & John, 2020). These beliefs have a significant impact on students' interest in mathematics, their comfort during their learning, and their motivation to learn maths (Aguilar, 2021). Motivation is an important factor in learners' academic outcomes (Tareen et al., 2023). With strong beliefs, students tend to have a higher sense of belief in their own abilities, which in turn prepares them for the challenges of solving complex mathematical problems, because problem solving is not the resolution of a question, but overcoming a concern (Ergen, 2020).

A study by Wang (2021) revealed that 70% of elementary school students found the maths burden heavy, with most viewing it as a difficult and uninteresting subject. Research in Ethiopia by Ayele and Dadi (2016) found that 23.8% of students had negative beliefs about mathematics learning, with 0.2% being strongly negative, while the rest were neutral or positive. According to Öztürk et al. (2020), there is a correlation between individual maths beliefs and mathematical performance, suggesting that beliefs can affect poor maths performance. Meanwhile, studies show that teachers only focus on teaching content and ignore what students need (Gomez et al., 2020). Therefore, poor performance

in mathematics cannot be fully explained by cognitive test results alone, as evidenced by students' maths scores in Indonesia (Hidayatullah & Csíkos, 2024).

The role of gender is also significant in the formation of mathematical beliefs. Female students tend to have lower beliefs than males related to maths achievement (Markovits & Forgasz, 2017). This is contrary to the findings of Vuletich et al. (2020), which stated that women have stronger beliefs than men and confirmed the stigma that maths is a male domain. Men tend to believe that they are higher performers than women in maths, and women have similar perceptions (Dustan et al., 2022; Liou et al., 2021). It has been reported that in the United States, girls have more negative beliefs than boys. There were also significant differences in maths beliefs related to grade level. Students in lower grades tended to have positive beliefs in mathematics (Dahlgren Johansson & Sumpter, 2010), whereas upper-grade students more often expressed negative beliefs. The decrease in self-conceptions from grade 4 to grade 8 is a significant indication of this phenomenon (Liou et al., 2021). Students at the elementary level of education have a higher level of belief compared to secondary school students (Passolunghi et al., 2014), which shows that different educational contexts and maths learning experiences in different classrooms can affect the formation of mathematical beliefs (Hidayatullah & Csíkos, 2023).

Previous research has highlighted students' beliefs related to mathematics, but the main focus generallyhas been on junior high, high school, and (prospective) teachers (Geisler & Rolka, 2021; Gijsbers et al., 2020; Purnomo, 2017b; Purnomo et al., 2016), with limited research exploring mathematics-related beliefs at the elementary school level, particularly in relation to grade level and gender. A study by Hidayatullah & Csíkos (2022) using the theoretical framework by Op't Eynde et al. (2002) to investigate students' epistemological beliefs in mathematics, failed to provide a clear picture of the level of students' mathematical beliefs and the contribution from their personal backgrounds, such as gender, grade, and culture. In-depth research on elementary school students' beliefs related to mathematics is important to provide a more comprehensive picture of the challenges faced by elementary school students, and serve as a basis for overcoming negative beliefs and improving the quality of mathematics learning.

With this in mind, our study aims to uncover the general profile of elementary school students' beliefs related to mathematics, as well as the relationship between these beliefs and grade level and gender. We aim to explore beliefs in aspects of mathematics education, beliefs about self, and beliefs about social context. Therefore, this study will address the following research questions:

1. What is the general profile of elementary school students' beliefs about mathematics education, beliefs about self, and beliefs about social context?
2. How are elementary school students' beliefs about mathematics related to grade level and gender?

Review of literature

Mathematics-related belief theory

Students' mathematics-related beliefs are defined as students' implicit or explicitly held beliefs about mathematics education, themselves as mathematics learners, and mathematics classroom context (De Corte, 2015). In addition to "belief", the terms conception, subjective knowledge, view, and perception can be used interchangeably according to the target and purpose and depending on the situation (McLeod & McLeod, 2002; Purnomo et al., 2016). In this regard, beliefs related to mathematics can be interpreted as an individual's subjective knowledge based on experience and expressed in a propositional attitude, view, and perception of the value of truth (Purnomo, 2016). Strong positive beliefs about mathematics education are important to instill early in life because beliefs related to mathematics influence the way we view, conceptualise, and learn mathematics (Markovits & Forgasz, 2017; Schoenfeld, 1992) so that it becomes the basis for action, the basis for change, and the basis for learning maths (Chapman, 2008).

The belief framework related to mathematics can be divided into three categories: beliefs about mathematics education, beliefs about oneself, and beliefs about the social context (Op't Eynde et al., 2002). The three aspects of mathematics-related beliefs are related to each other, as illustrated in Figure 1.

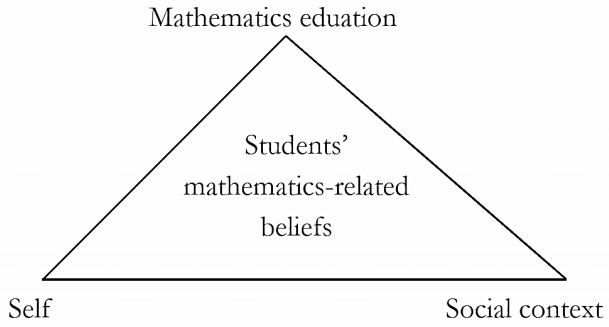

Figure 1: Students' belief system related to mathematics

We used the framework from Op't Eynde et al. (2002) to analyse students' beliefs by categorising each dimension into traditional and constructivist beliefs. A person's views related to maths beliefs are divided into two categories, namely traditional and constructivist beliefs (Purnomo, 2016; Purnomo et al., 2016). The first one, traditional beliefs, emphasises that mathematics is a subject that mostly involves factual formulas, rules, and procedures (Adnan et al., 2011; Purnomo, 2023). According to traditional beliefs, students are required to memorise formulas, symbols, rules, and their computational steps. A learning theory underlying traditional beliefs states that students will learn facts and concepts and understand material by absorbing content from teacher explanations, reading text explanations, and answering questions (Purnomo, 2016). Mathematical skills are acquired, mastered through guidance, and repeatedly practised in a

sequential and systematic manner (Šapkova, 2011). This is in line with Frank's opinion (in Op't Eynde et al., 2002) that students with traditional beliefs believe that the role of the mathematics teacher is to transfer knowledge and confirm that students accept the knowledge.

The second one, constructivist beliefs, focuses on a student-centred approach to learning mathematics. Students are encouraged to participate actively in the process of acquiring knowledge and to emphasise the importance of understanding concepts in mathematics. The constructivist view suggests that students' conceptions and understandings come from the construction of meaning when they are involved in the process of building interpretations of experiences (Applefield et al., 2000). The learning theory underlying constructivist beliefs suggests that understanding emerges only through students' prolonged engagement with connecting new ideas and explanations (Šapkova, 2011). Consequently, the capacity to use the skills comes only from experience with concrete problems that provide the experience to decide how and when to use the various skills. Constructivist beliefs focus on students playing an active role in the process of acquiring knowledge (Šapkova, 2014). Teachers who hold constructivist beliefs facilitate students' discovery and tend to give students the opportunity to develop solutions to their problems so that the teaching method is student centred.

There are various ways to measure students' beliefs related to mathematics. First, through quantitative questionnaires in the form of open questions (Purnomo et al., 2016), closed questions (Purnomo, 2017a) and qualitative picture analysis or drawing analysis (Dahlgren Johansson & Sumpter, 2010). Secondly, by seeking data using visual, verbal, and text-based methods (McDonough & Sullivan, 2014). Third, use animal metaphors (Midgeley & Trimmer, 2013). Animal metaphors can be used for research in elementary school because elementary school students know various things and types of animals (Markovits & Forgasz, 2017).

Based on the above opinions, students' beliefs related to mathematics can be known in several ways, namely through quantitative questionnaires with Likert scales and visual, verbal, textual, and metaphorical methods. The method used to measure students' beliefs related to mathematics in our study is in the form of drawing analysis and interviews as the main data and documentation as supporting data. The drawing analysis method was used to explore mathematics-related beliefs and to accommodate the characteristic of elementary school students who enjoy drawing.

Method

Participants

This study utilised purposive sampling to select the research subjects. The criteria for the research sample included a willingness to participate, being elementary school students, high achievement in mathematics, and being in either lower or higher grade levels, irrespective of gender. The selected subjects, in consultation with the class teacher,

numbered four students: a male and female from grade 2, and a male and female from grade 4 (Table 1).

Table 1: Profile of research subjects

Subjects	Age	Gender	Grade	Maths report Sem 1 2022/2023
Student 1	8	Male	2	93
Student 2	8	Female	2	93
Student 3	10	Male	4	96
Student 4	10	Female	4	94

Table 1 indicates that the mathematics scores of students 1 and 2, each with a score of 93, place them approximately in the top 20% of their class of 27 students in grade 2. Similarly, Student 3's mathematics score of 96 places him in the top 10% of his class, while student 4's mathematics score of 94 places her in the top 20% among the 36 students in grade 4.

Data collection

The data collection for this study occurred over a three-day span, from 24 to 26 January 2023. On the first day, prior to the drawing activity, students were instructed to illustrate their typical experiences when learning maths. They were prompted with stimulus questions about what they learn in maths, the benefits of maths, and how maths differs from other subjects. Each student was asked to create one sketch during a one-hour session to visually represent their mathematics-related beliefs. Interviews in this study employed semi-structured or open-ended questions to probe into mathematics-related beliefs. The researcher asked a series of questions, and these could evolve throughout the interview. Documentation was used as corroborative evidence to validate students' mathematical achievements using report cards and student profiles. These interviews were conducted on the second and third days.

This research does not use prior ethical clearance procedures, but we guaranteed confidentiality for research subjects and all research subjects consented to participating voluntarily in the research. We disguised names using initials, ensured voluntary consent from research subjects, obtained permission from the school to involve students in this research, and fulfilled all procedures for working with elementary school children.

Data analysis

We began by identifying each drawing into categories that included the communication present in the drawing: a teacher's communication with his/her pupils, communication within the class, and the quality of communication in class (Pehkonen et al., 2011). A cross-check was conducted for the mathematical activities shown in the drawing: traditional and constructivism (Purnomo, 2016), and also considering location, subject, object, emotions, and attitudes (Hsieh & Tsai, 2018). The pattern of answers from the transcribed interview results was used to confirm and elaborate on what was meant in each drawing analysis. Results were then grouped into general categories, namely beliefs in

mathematics education, self-beliefs, and social context (Op't Eynde et al., 2002). In addition to matching the results of the drawing analyses and interviews, results were subjected to peer-debriefing among researchers.

Results

Topic 1: General profile of elementary school students' mathematics related beliefs

Each student drew according to the instructions to reflect their beliefs related to mathematics. The drawings are shown in Figure 2 for student 1, Figure 3 for student 2, Figure 4 for student 3, and Figure 5 for student 4. The results of the drawing analysis are presented and confirmed through interviews, which are then grouped into the three categories of students' beliefs related to mathematics.

Students' beliefs about mathematics education

Figure 2 illustrates a subject seated on a chair holding a pencil, with a teacher instructing mathematics in the classroom whilst writing on the blackboard. In addition, the objects depicted are chairs, pencils, books, an eraser, tables, a blackboard, doors, windows, and a ceiling fan.

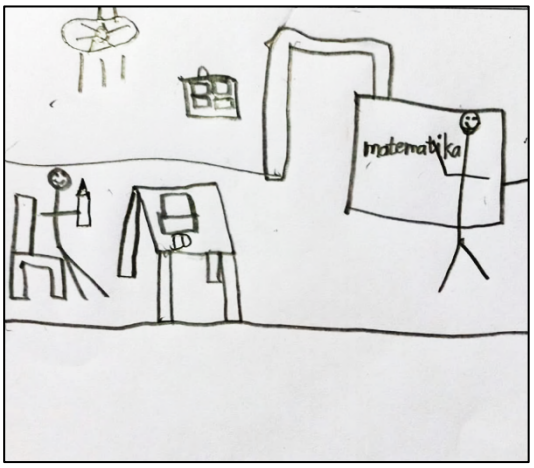

Figure 2: Student 1 drawing

Figure 2 suggests that the habit of learning mathematics involves sitting quietly, listening to the teacher, and practising mathematical tasks. According to interviews, Student 1 believes that mathematics is related to counting, solving problems, and is used in daily life, stating:

> Mathematics is a discipline encompassing addition, subtraction, and division… Yes, because it is for acquiring intelligence. In the future, when I purchase food, the vendor will not cheat me by providing insufficient change. That's the significance of studying mathematics.

Thus, Student 1 maintains the conviction that mathematics is a science of computation, employed in daily life. The implication is that success in mastering mathematics is achieved through more frequent practice.

Figure 3 illustrates that Student 2 perceives mathematics education as a subject centred on counting and arithmetic operations. This interpretation is based on "2 + 5 = ?" written on the blackboard.

Figure 3: Student 2 drawing

During interview, Student 2 expressed the following:

> Mathematics encompassing operations such as addition, subtraction, multiplication, division, and so many types… It's important, because you need good aspirations for maths, as you will need to apply mathematics later… Yes, maths is for, for example we are selling.

Thus, Student 2's belief is a blend of traditional and constructivist views. Student 2 believes that maths such as addition, subtraction, multiplication, and division is important in everyday life because it is related to aspirations and economic activities.

Student 3 illustrates the belief in mathematics education through Figure 4 that maths is related to counting operations, such as "1+1 = 2, 1×1 = 1, and 1÷1 = 1". Through interview, Student 3 conveyed:

> Maths is a science that is quite useful for everyday life… It is quite important because, to help in the future, maybe the work requires maths… For example, when shopping, it can confirm whether it is correct, for example, the money or the price… The activity is like playing smartphones... Then maybe when doing problems, when studying.

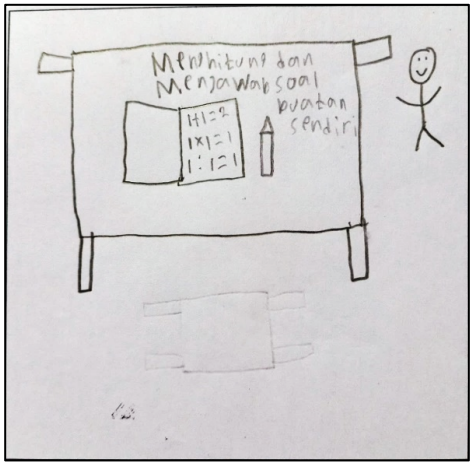

Figure 4: Student 3 drawing

Thus, Student 3's belief is mix of traditional and constructivist beliefs, besides mathematics being viewed as basic arithmetic operations, mathematics is also a useful science in everyday life related to future professions, economic activities, playing, and learning.

Figure 5 by Student 4 shows a subject sitting and studying. The objects displayed are a table, chair, pencil, book, and the subject themselves. The arrangement of the images appears to overlap, and the images that are specifically emphasised are thicker than the images of other objects, namely the hands and writing tools. In other words, learning mathematics is by listening, taking notes, and practising on books. Similar to other subjects, based on further interviews, Student 4 stated that:

> Maths is a subject that includes counting… Yes, division, multiplication, addition, or subtraction… Because later, if we can count when we buy goods or sell goods, we cannot be lied to; we can count goods or money.

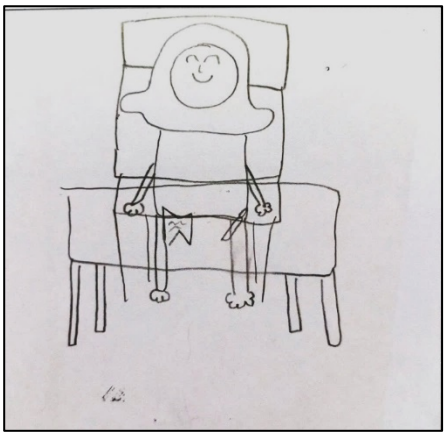

Figure 5: Student 4 drawing

Thus, the belief held by Student 4 is that mathematics is a lesson related to arithmetic operations such as division, multiplication, addition, or subtraction and is useful for life activities such as counting objects and economic activities.

The beliefs related to mathematics education for each student are summarised in Table 2 based on the drawing analysis and interview results. Students 1, 2, 3, and 4 demonstrate a composite profile of beliefs about mathematics education, amalgamating both traditional and constructivist beliefs.

Table 2: Students' beliefs about mathematics education

Subject	M/F	Beliefs about mathematics education	Belief classification
Student 1	M	Maths is the study of counting by doing problems, a subject that is important for life and being smart. Maths is an easier subject than art. Maths is also used in everyday activities. Problems can be solved in one or more ways, depending on the level of difficulty. Good teaching is teacher-centred, with classroom teaching, questions and answers, and note-taking.	Traditional and constructivist
Student 2	F	Maths is the study of arithmetic, an important subject as it relates to our goals. Maths is easier than art if you are focused. Maths is useful in life and is used in everyday activities. Problems can be solved using more than one method. Teaching is best centred on the teacher explaining the material and writing down the method.	Traditional and constructivist
Student 3	M	Mathematics is the study of arithmetic using counting operations, a science that is useful in life and important for pursuing professions in the future. Maths is an easier subject than art; it is useful in life and is used in everyday activities. Problems are solved in one or more ways, depending on the type of problem. Teaching is best centred on the teacher explaining the material first and then giving the problems.	Traditional and constructivist
Student 4	F	Maths is a counting subject and is important for daily life; it is a subject that is easier to understand than art. Maths is useful and used in life. Problems can be solved in one or more ways, depending on the level of difficulty. The best teaching is teacher-centred; by explaining the material well, students pay attention to the teacher and count in the book.	Traditional and constructivist

Students' beliefs about themselves

Self-belief is generally interpreted as students' beliefs about themselves or about learning very specific tasks (Robas et al., 2020). It is evident from Student 1 in Figure 2 that

learning mathematics makes students happy. Student 1 said that he had a good feeling when learning because there were questions. From Student 1's interview:

> I really like it. It's fun to understand.
> Yes, it's still fun.
> Yes, there are questions. If there are no questions, it's boring. Ooo, yes, the questions are a bit exciting. (Student 1)

Similar to Student 1, Student 2 describes himself in Figure 3 as having a sense of enthusiasm and being able to solve maths problems. Student 2 has a feeling of liking the maths that he has learned. From Student 2's interview:

> I like it; I like… thematically the most. The thing is, sometimes it's easy, sometimes it's hard. It's just fun to memorise. (Student 2)

The interpretation of Figure 4, which is a description of the beliefs about oneself by Student 3, is that she is happy when studying mathematics. Student 3 has a love for things that have to do with maths because it feels challenging and makes her happy. Student 3 conveyed through the interview:

> Happy again.
> I like it quite a bit.
> I don't know; I feel happy and challenged by the problem. (Student 3)

The interpretation of Figure 5 is that Student 4 seems to feel happy when learning mathematics. Similar to Student 3, Student 4 has a love for maths because of the diverse material. Student 4 likes to do things related to maths because he can count. Through the interview, Student 4 conveyed the following:

> Umm like. Because we can count. (Student 4)

Beliefs related to mathematics in the aspect of beliefs about oneself in each subject have been partly presented through the descriptions above. Then, based on the narratives and interviews, they can be summarised as in Table 3.

Table 3: Students' beliefs about themselves

Subject	M/F	Beliefs about themselves	Belief classification
Student 1	M	Believes that she likes learning maths because of the questions, has a sense of excitement and a little fear when going to the exam, feels that her ability is better than her friends, and can understand the material learned. Believes they can learn difficult material on their own. Believes that completing assignments and getting grades is important because it is an assessment. The purpose of learning maths is to be smart and have fun.	Traditional

Subject	M/F	Beliefs about themselves	Belief classification
Student 2	F	They are convinced that they like, enjoy, and are enthusiastic about memorising, have doubts when going to exams, feel that their abilities are less than their friends, and believe that they are able to understand the material studied. Believes they can learn difficult material on their own if they study hard. Believes that completing assignments and grading assignments are important for motivation and assessment. The purpose of learning maths is an obligation that can count.	Traditional
Student 3	M	Convinced of liking and enjoying being challenged by questions, having palpitations and a little fear when going to exams, feeling more capable than his friends, and not fully confident of understanding all the material, he is confident in self-learning difficult material by studying previous material and can control confidence in his own way. Believes that completing assignments and grades is important for evaluation, motivation, and assessment. The purpose of learning mathematics is to make fun of it and use it for life.	Traditional
Student 4	F	She is convinced that she likes and enjoys maths because she can count, feels scared and worried when going to the exam, feels her ability is less than her friends, and believes she understands the material. They are less confident in learning difficult material on their own because they need help from the teacher and can control their beliefs in their own way. Confident that they can complete their assignments and that their grades are important because they serve as assessment and motivation. The purpose of learning maths is to be able to count and learn more deeply.	Traditional

According to the explanation in Table 3 above, Students 1, 2, 3 and 4 have traditional beliefs about themselves in terms of the general profile of elementary school students' beliefs related to mathematics.

Elementary students' beliefs about social context

Beliefs in the social context refer to the role and function of teachers, the role and function of students in their own classroom, and the socio-mathematical rules and practices in the classroom.

Mathematical beliefs about the social context include beliefs about the role and function of teachers and students in their classroom, and socio-mathematical rules and practices within the classroom. The beliefs about Student 1's social context depicted in Figure 2 illustrate that when the lesson begins, the teacher explains the material in front of the class and writes it on the blackboard, then the students in the chairs sit down to write and do

maths. When in class, the teacher teaches by writing and teaching on the blackboard, while students pay attention and write in books. According to Student 1.

> In maths lessons, sometimes it is written that the subject is in front of...
> Paying attention while writing in the book, you know. (Student 1)

Figure 3 indicates that Student 2 was active in class by answering the questions on the board when asked. During the lesson, the teacher will give a session of storytelling activities and teach how to solve the problem. The teacher's way of teaching in class is to explain and write on the board using methods so that understanding is easy. After students understand, there will be a question-and-answer session, and student representatives will come forward to discuss the problems. Then what Student 2 does in class is listen, understand, and work. The following is Student 2's statement.

> Yes, sometimes we will look up.
> First it is explained; sometimes it is written on the blackboard, and you are told to write it down if it is not understood. If it's understood, it'll be called into question. If it is questioned, then one person comes forward and writes on the blackboard.
> Yes, listen, then if you know, you can just answer. (Student 2)

The interpretation of Figure 4 is that when learning maths, students write in their notebooks to answer questions. When learning, the maths teacher will review the lesson material, then explain the new material, give examples of problems and how to do them, write on the blackboard and be asked to take notes, and work on problems. Meanwhile, what students do is listen to the teacher explain the material and work on problems. Student 3 gave this answer:

> First, the teacher repeats lessons that have been understood, then teaches new material, gives how to do it, then does the questions.
> Then they give problems and give grades.
> Yes, it is written on the blackboard; yes, sometimes I am told to write it down.
> From the beginning, I listen to the teacher explain the material, then I do the problems. (Student 3)

Student 4 describes himself in Figure 5 as having beliefs about the social context in the form of sitting and watching the teacher teach, writing, and solving problems. When learning, the teacher uses the question-and-answer method, explains the material, students take notes, and students work on problems. The activities that students do include paying attention to the teacher and working on problems. Student 4 conveyed:

> At the beginning, greetings, then prayer, first read bismillah, then guess, first multiplication or division, then tell the new material, explain the new material, then tell to write down, then give questions to do.
> If the teacher explains, I pay attention, and then they give me the problems; I do the problems myself; I don't cheat. (Student 4)

Beliefs related to mathematics in the aspect of beliefs about the social context of each subject have been partly described in the descriptions above. Then, based on the narrative and interview results obtained, they are summarised in Table 4.

Table 4: Students' beliefs about social context

Subject	M/F	Beliefs about social context	Belief classification
Student 1	M	Feeling that the teacher in class plays a role in teaching by explaining the material and writing on the blackboard. Feeling that students should pay attention and understand the material, feeling that they are active in class, and feeling that friends play a role in helping when they are struggling. When learning, they pay attention to the teacher, write in books, do problems, and believe they can solve the problems they face.	Traditional
Student 2	F	Feeling that the teacher's role in class is to teach and write on the blackboard, model problems, give problems, and help students who are still struggling. Feeling that students should pay attention, feel that they are active, and that friends play a role in helping when they are struggling. When they learn to listen, understand, and then work on problems, they believe they can solve the problems they face.	Traditional
Student 3	M	Feeling that the teacher in class plays a role in reviewing, explaining material, giving examples of problems and how to solve them, giving problems, and helping students who feel difficult. Feeling that students should pay attention to the explanation of the material and work on problems, feeling that they are active, and feeling that friends play a role in helping when they are struggling. When learning, students should listen to the teacher who explains, write in the notebook, work on problems from the teacher, and believe they can solve the problems faced.	Traditional
Student 4	F	They felt that the teacher in class asked questions, explained the material, took notes, worked on problems, and helped students who were still doing it wrong. Feeling that students should work honestly, feeling that they are active, and feeling that friends play a role in helping when they are struggling. When learning math, answering greetings, sitting in a chair, paying attention to the teacher when explaining the material, writing and working on problems, and believing that they can solve the problems faced.	Traditional

Based on the research results and the presentation in Table 4, the general profile of beliefs about the social context of the four students is traditional beliefs. The four subjects believed that the teacher's role in the classroom was to teach by explaining the material, writing on the blackboard, giving questions, and helping students' difficulties when working on problems. The four student subjects felt that they played an active role when

learning by answering the teacher's questions in front of the class. The four subjects also felt that friends played a role in helping each other when they had difficulty solving problems in maths. They solve problems by finding solutions first, then ask for help from others if they have not found a solution.

Topic 2: Elementary school students' mathematics beliefs in relation to grade level and gender

Based on Tables 2, 3 and 4 above, no specific differences were found in the aspects of beliefs about mathematics education and beliefs about the social context, both with regard to grade level and gender. There were no differences in the aspect of beliefs about oneself at the grade level, but there were two findings in the gender aspect. First, male students felt confident that their mathematics ability was better than that of their friends, while female students felt their mathematics ability was less when compared to their friends. Second, male students have a goal of learning maths for one reason because maths makes them feel happy, while female students have a goal of learning maths for one reason, so that they can count.

Discussion

Elementary students' beliefs about mathematics education

The general profile of the beliefs about mathematics education of the four subjects in our sample was a mixture of traditional and constructivist beliefs. All four subjects believed that mathematics is related to counting and is also useful for everyday purposes. Counting in this case relates to arithmetic operations such as multiplication, division, addition, and subtraction. This is in line with what Adnan et al. (2011) said; conventional beliefs emphasise that mathematics is a subject that primarily involves factual formulas, rules, and procedures. However, the focus seems to be primarily on aspects related to basic calculations in mathematics. Based on these findings, it makes sense to explore the mathematics curriculum to not only focus on one aspect, which in this context is basic arithmetic, this exploration could involve incorporating concepts beyond basic arithmetic, such as pattern, geometry and measurement. Emphasis like this not only expands students' mathematical knowledge but also enriches their vocabulary, which is very important not only for mathematics but also for other academic subjects. In addition, the students in our sample believe that mathematics is an important subject, useful, and used in their everyday lives. Students believe that understanding mathematics will make life easier and that mathematics learned at school is useful for life (Kibrislioğlu & Haser, 2015). This opinion can be related to the constructivist view, which suggests that students' conceptions and understanding come from the construction of meaning when students are involved in the process of building interpretations of experiences (Applefield et al., 2000).

According to mathematics-related beliefs research by Kibrislioğlu & Haser (2015), there are multiple ways to solve a problem in mathematics, but students didn't believe that the teacher's method was the only possible solution. For the four students, they believed that

the best mathematics teaching was teacher-centred, with the teacher's role being to transfer knowledge and confirm that students acquire the knowledge (Op't Eynde et al., 2002). According to traditional beliefs, students master mathematical skills through guidance and repeatedly practising them sequentially and systematically (Šapkova, 2011).

Elementary students' beliefs about themselves

Traditional beliefs are the predominant profile of elementary school students' beliefs in mathematics, from the perspective of their own beliefs held by Students 1, 2, 3 and 4. The four students believe they have a sense of liking and pleasure when learning mathematics for several reasons, such as maths which has many problems, memorising, being challenged by problems, and being able to count. This is in accordance with a finding (Dahlgren Johansson & Sumpter, 2010) that most students in the lower grade levels view mathematics as something that is fun. Other studies have indicated that in traditional beliefs, students memorise their formulas, symbols, rules, and computational steps (Adnan et al., 2011). However, in our study, all four students experienced fear when going to an exam. Students 1 and 2 are confident in their ability in mathematics and are superior to their friends, while Students 2 and 4 feel that they are less confident in their abilities when compared to friends in their grade. Students 1, 2 and 4 are confident that they can understand the material, but Student 3 is not fully confident that he can understand all the material. Related to the meaning of belief about oneself, which relates to learning very specific tasks (Robas et al., 2020), the task value of the four subjects shows that they are confident that they can complete the task and most of them feel that grades are important as an assessment.

One of the factors that influences self-belief is control belief (Iskender, 2009). Control beliefs about learning relate to how much control one feels to achieve positive and desired outcomes (Manavipour & Saeedian, 2016). Regarding control belief, Students 1, 2 and 3 are confident they can learn on their own by studying the previous material and studying hard, while Student 4 feels less confident about having to learn on her own, if learning difficult material because she needs teacher assistance. Mathematical skills are possessed, mastered through guidance, and repeatedly practised sequentially and systematically (Šapkova, 2011). However, it is important to be aware that attributing control to external factors, such as teachers, may result in low achievement expectations (Pintrich, 2003).

A factor that also affects self-belief is goal orientation, which is the opinion that defines goal orientation, which is the reason or purpose of a person to achieve a goal so as to create self-belief (Pintrich, 2003). Goal orientation is the goal or reason used in achievement behaviour or achieving something (Schunk et al., 2014). In this study, Student 1's learning objectives were to feel happy and smart; Student 2 studied maths because it was an obligation and to be able to count; Student 3 aimed to be happy and would be useful in life; and Student 4 studied to be able to count and learn. This is in line with research by Purnomo et al. (2016).

Elementary students' beliefs about social context

Student differences are one of the fundamental factors that influence teachers' choices in teaching (Gelmez-Burakgazi, 2020). Based on the research results, the general profile of beliefs about the social context of the four students is included in traditional beliefs. All four students believe that the role of the teacher in the classroom is to teach by explaining the material, writing on the blackboard, giving questions, and helping students' difficulties when working on problems. This is in accordance with the theory conveyed by Šapkova (2011). The research on traditional beliefs is based on learning theory, which states that students will learn facts and concepts and understand the material by absorbing the content from the teacher's explanation or reading the text explanation and answering questions. This is also in line with research by Kibrislioğlu & Haser (2015) that students perceive the teacher's role as teaching the steps of how to solve problems and transferring knowledge, while the students' role in class is to pay attention to the teacher. Students 1, 2, 3 and 4 felt that they played an active role when learning by answering the teacher's questions in front of the class. The four students also felt that friends played a role in helping each other when they had difficulty solving problems in maths. These findings are in line with research conducted by Kibrislioğlu & Haser (2015), who found that students are encouraged to discuss and help each other solve maths problems.

Our study shows that the main activities carried out by Students 1, 2, 3 and 4 when learning mathematics are listening to the teacher's explanation, recording material, and doing problems. This is relevant to the traditional belief that mathematical skills are mastered through guidance and repeatedly practising skills sequentially and systematically (Šapkova, 2011). The four students can solve the problems they face by looking for solutions first and then asking for help from others if they have not found a solution.

Elementary students' beliefs about mathematics in relation to grade level

One study (Dahlgren Johansson & Sumpter, 2010) found that students in the lower grades had positive attitudes towards maths, while students in the higher grades had mostly negative attitudes towards math. In contrast to that result, our study did not find specific differences existing between students at the low and high grade levels in the aspects of beliefs about mathematics education, beliefs about themselves, and beliefs about the social context. The difference between the results of previous research and the results of our study is that there are many factors influencing students' mathematics-related beliefs, both internal and external. Therefore, schools need to encourage this aspect of student development in a school environment where learning is the main goal (Beatty & Campbell-Evans, 2020).

Elementary students' beliefs related to mathematics in relation to gender

With respect to gender, no specific differences were found in the aspects of beliefs about mathematics education and beliefs about the social context. However, there were findings of differences in mathematics-related beliefs that emerged in the aspect of beliefs about self. First, in the aspect of beliefs about oneself, male students feel confident that their

mathematical abilities are more than their friends, while female students feel their mathematical abilities are less when compared to their friends. Some other studies have also found that female students who scored higher had lower self-belief than male students (Leder, 2015; Markovits & Forgasz, 2017). Likewise, some male gender studies show better maths skills in arithmetic than females, due to their spatial abilities. Second, in the aspect of beliefs about oneself, male students have a goal of learning mathematics because maths makes them feel happy, while female students have a goal of learning mathematics so that they can count.

Conclusion

The profile of elementary school students' mathematics-related beliefs held by Students 1, 2, 3 and 4 comprises a mixture of constructivist beliefs and traditional beliefs. The aspect of beliefs about oneself is traditional belief; and the aspect of beliefs about the social context is also traditional.

With respect to grade level, no specific differences were found regarding students' beliefs related to mathematics in low and high grades. With respect to gender, in the aspect of beliefs about self, it was found that male students believed that they had more mathematical ability, while female students felt that they had less mathematical ability than their friends. In addition, male students have one of the goals of learning mathematics being that maths makes them feel happy, while female students aim to be able to count.

A suggestion for Student 1 is that he needs to maintain his self-efficacy (beliefs about himself). Student 2 and Student 4 need to increase their self-belief so that their self-efficacy becomes stronger (beliefs about themselves). Student 3 needs to increase mathematics-related beliefs in order to better understand the material (beliefs about self).

Class teachers are advised to facilitate student learning by considering students' mathematics-related beliefs. If students have traditional beliefs, teachers can facilitate by using traditional mathematics learning that emphasises practice. If students have traditional and constructivist beliefs, teachers can teach with a combination of traditional mathematics learning, modern mathematics learning (new maths), and current mathematics learning.

Limitations and further research

The main limitation in this study is that the subjects are limited to a small number of students with high learning achievement in mathematics, so this study cannot be compared with research on students' mathematics-related beliefs based on a more diverse sample. Our research was exploratory qualitative in design, not quantitative research that can be more readily generalised. However, it is hoped that after knowing a description of elementary school students' mathematics related-beliefs, future researchers can conduct quantitative research with greater confidence about attaining more readily generalisable results. In addition, our findings may help classroom teachers to seek alternative,

interesting and fun learning activities, focusing not only on exercises but also adding hands-on activities.

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