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STUDENTS' MATHEMATICS-RELATED BELIEFS AND ACADEMIC PERFORMANCE: CROSS-SECTIONAL STUDIES IN INDONESIA

DOCTORAL DISSERTATION

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ABSTRACT

Over the past century, there has been a dramatic increase in research about the factors behind students' performance in mathematics learning. Although there is no single answer to explain the factor behind mathematics performance, beliefs about mathematics have been shown to be the strong factors behind students' achievements. However, further questions arise about students' beliefs and their performance in mathematics learning. (1) Are the personal epistemological beliefs more specific or general domain? (2) Are students' beliefs about mathematics associated with their personal factors? (3) Do mathematical beliefs predict students' engagement in mathematics learning? (4) How do students' beliefs interact and determine each other with other non-cognitive factors in mathematics learning? (5) How do students believe in word problem-solving in mathematics? Based on these questions, this study-based dissertation attempts to address the issue of the generality-specificity domain of beliefs. Moreover, this dissertation explored how beliefs about mathematics education explain other non-cognitive factors and students' mathematics achievements. The first investigation provides empirical evidence of the differences in beliefs about knowledge in the different field studies. The second study provided empirical evidence about the stability and reliability of students' mathematics-related belief questionnaires in the Indonesian context, and this study revealed that students differ in terms of beliefs about mathematics based on their personal factors, such as their ethnicity. The third study pointed out that mathematical beliefs can explain mathematical engagement. The fourth study revealed that beliefs about mathematics and parents' educational level are associated with motivation and attitude in determining mathematics achievements. The fifth study revealed that most of the students in Indonesia implicitly believe that all word problems can be solved by performing routine operations. The findings of these studies provide empirical evidence on how to improve the quality of mathematics education in Indonesia.

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CHAPTER I. INTRODUCTION

1. General Introduction

1.1. Personal epistemological beliefs

The past thirty years have seen increasingly rapid advances in the studies of epistemological beliefs and their role in prompting academic performance. Epistemological beliefs refer to one conception of knowledge, how one comes to know, and what one knows. These epistemological beliefs, in many studies, have been shown to consistently affect academic performance in various aspects, such as motivation (Hofer & Pintrich, 1997), attitudes (Di Martino & Zan, 2011; Fishbein, 1963; Hannula et al., 2016), engagement (Metallidou & Vlachou, 2007; Warwick, 2008), and performance (Hofer, 2000; Markovits & Forgasz, 2017; Pongsakdi et al., 2019; Schommer et al., 2005).

The exploration of historical beliefs originated with Perry's investigation into how college students perceive knowledge, which is commonly referred to as personal epistemology or epistemological beliefs. The results of the study showed that many students viewed knowledge as absolute and that it came from authoritative sources (Schommer et al., 1992). Students believed that knowledge was either true or false and that the authority figures were the ones who held the answers to the truth. Surprisingly, by the end of the study, students began to see knowledge as more dynamic and less fixed.

After Perry's work, Limón (2006) identified three key differences in epistemological beliefs that align with Perry's work. These include the development approach, the system beliefs approach, and the epistemological resource approach. The development approach seeks to explain how epistemological beliefs change and develop over time, including the growth of epistemological meta-knowing. According to Mason et al. (2006), Kuhn's concept of epistemological development involves three levels of epistemological meta-knowing: declarative knowledge, procedural knowledge, and epistemological meta-knowing. This idea is similar to Kluwe's (1987) dichotomy of the metacognition knowledge component, where metacognition knowledge comprises procedural and declarative metacognition. As Csíkos (2022) explained, metacognitive declarative knowledge (knowing what) refers to beliefs or factual knowledge about one's own knowledge or general knowledge, while metacognitive procedural knowledge (knowing why) refers to the control or regulation of the process, including the monitoring and control of the process itself.

The epistemological resources approach focuses on achieving a better understanding of science learning by knowing the effect of epistemological resources on science learning (Limón, 2006). Differently from the previous concept, this concept argued that cognitive resources could be activated in a given context and another as different contexts would affect the different resources (Mason et al., 2006). One may view knowledge as transmitted stuff or knowledge as fabricated stuff (Louca et al., 2004). For instance, when a kid is asked how they know what's for dinner, this kid says, "Because my daddy told me!". This answer reflects that knowledge has been transmitted from other people or transmitted stuff. Meanwhile, when asked the kid how they knew their mom brought a present, the kid may answer, “I figured it out 'cause it’s my birthday.” This answer reflects the awareness of knowledge as something constructed or fabricated stuff (Louca et al., 2004).

The system beliefs approach emphasizes describing the nature, features, and structure of epistemological beliefs (Limón, 2006), such as Schommer's epistemological beliefs (Schommer et al., 1992) and personal epistemological beliefs (Hofer, 2000). Hofer (2000) argued that personal epistemological beliefs should be made up of discrete dimensions that are interrelated with each other. The core of the personal belief system is the nature of knowledge (how someone deals with beliefs and knowledge) and the nature of process knowing (how someone comes to know). The beliefs of the nature of knowledge may consist of certainty and simplicity of knowledge, and the nature of process knowing consists of the source of knowledge and justification of knowledge (Watson, 2020). Through her empirical investigation, the author proposed a discipline-focused epistemological beliefs questionnaire (DSBQ) to examine personal epistemology beliefs. Some research has been conducted in several Asian countries to explain personal epistemology beliefs among higher education students. According to Chai et al. (2010), the beliefs about knowledge (epistemology) held by pre-service teachers in Singapore significantly predict their teaching strategies. Similarly, Liem and Bernardo (2010) found that epistemology beliefs can predict intention among psychology students in Indonesia. Although studies on epistemological beliefs have been extensively conducted in some countries, investigations that compare epistemological beliefs across different educational backgrounds and cultures would be valuable to provide more comprehensive information about the importance of these beliefs.

1.2.The mathematics-related belief system framework

Although it has been reported that beliefs influence students’ motivation, behavior, and achievement (McLeod, 1992; Sangcap, 2010), there is no consensus concerning the definition of mathematical beliefs. It is difficult to precisely define belief because researchers have defined it based on their discipline. Then, what is the definition of beliefs in mathematics? How do students come to know about mathematics, what do students know about mathematics, and why do students have to know mathematics? These questions relate to students’ conceptions or epistemological beliefs in mathematics learning.

Schoenfeld (1985) defined mathematical belief systems as mathematical views that dictate how a person understands mathematics and solves mathematical problems. Beliefs in mathematics have also been defined as personal subjective knowledge of mathematics, mathematics tasks, and mathematics education that may be explicit and implicit (Csíkos et al., 2011; De Corte et al., 2000). They are concerned with the question of how students come to know about mathematics and what and why students have to know about mathematics related to the epistemological beliefs in mathematics. These are related to the belief systems in mathematics.

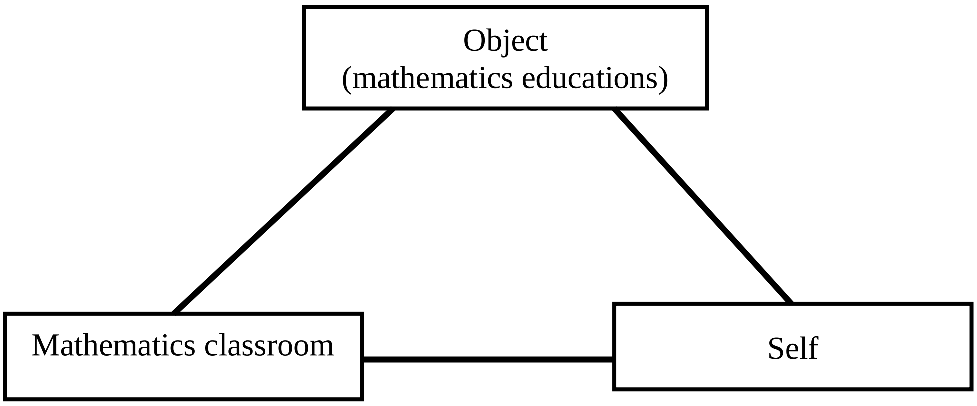

Fig.1. The theoretical framework of students’ mathematics-related beliefs (Op ’t Eynde & De Corte, 2003)

Op ’t Eynde and De Corte (2003) argued that the structure of mathematical beliefs is grounded on the social life, schema or mental, and mathematics class context. Accordingly, the researcher defined mathematical beliefs as implicitly or explicitly held subjective conceptions students hold to be true about mathematics education, themselves as mathematicians, and mathematics class context. These beliefs are determined by close interaction with each other and students’ prior knowledge of their mathematical learning and problem-solving in the class. As a result, through this definition, the structure of epistemological beliefs consisted of three dimensions: (1) beliefs about mathematics education, which constitute beliefs about mathematics, mathematics learning and problem-solving, and mathematics teaching; these beliefs also represent students' conception about the nature and structure of knowledge and knowing in the schools (Op ’t Eynde et al., 2006), 2) beliefs about the self as a mathematician consisted of self-efficacy, control beliefs, and extrinsic-intrinsic goal orientation beliefs; 3) beliefs about mathematics in the class context consisted of beliefs about the role of the teachers and students, and beliefs about social-mathematical norms and practices in mathematics class (see figure 1). Accordingly, using this framework, a more comprehensive understanding of students’ conception of the nature of mathematics, conception of themselves as a mathematics learner, and conception of mathematics in the class context can be obtained.

Op ’t Eynde and De Corte (2003) developed a mathematics-related beliefs questionnaire (MRBQ) to describe students' tendencies toward mathematics. The first version of MRBQ was administered to study 365 14-year-old students in Flemish Junior High School. With exploratory factor analysis (EFA), four scales, including beliefs about 1) the role and function of teachers, 2) the mathematics self-competence, 3) mathematics as a social activity, and 4) mathematics as domain excellent, and forty-four items have been identified. MRBQ has been adopted in various countries. Diego-mantecón and Andrews (2008) examined the stability of validity and reliability of MRBQ, which involved students from Spain, England, Slovakia, and Ireland, and found that mathematics-relative beliefs have sensitivity about nationality and background. This study also found that more boys than girls reject the belief that mathematics is fixed knowledge. Wang et al. (2019) found that students hold high beliefs about mathematics.

In the literature review, mathematics-related beliefs have been associated with various aspects: Mathematics engagements, mathematics achievement, motivation, and attitudes are some of the areas where the impact of these beliefs has been studied (Csikos, 2011; Grootenboer & Marshman, 2016; Pehkonen & Pietilä, 2003; Schommer-Aikins et al., 2005; Skaalvik et al., 2015). For instance, when students view mathematics as a mere collection of facts, rules, formulas, and numbers, they may tend to prioritize memorizing these aspects over developing their reasoning abilities (Garofalo, 1989). Furthermore, a belief that a mathematics problem has only one correct solution can stifle creativity and limit critical thinking skills (Op't Eynde et al., 2003). A lack of self-belief can also adversely affect motivation to study mathematics (Habók et al., 2020).

1.3.The significance of mathematics-related beliefs

Mathematics has always been an essential part of human civilization, and its significance cannot be overstated (Gerard O'Regan, 2016; Restivo & Collins, 2018). In the era of technological advancement, we are constantly amazed by the accomplishments of humankind. Man can fly to the moon, explore the universe, and dive into the deepest ocean. Later, we became quite fascinated with artificial intelligence (AI), which allows us to obtain quick answers to many problems. Along with this technological advancement, mathematics consistently plays a fundamental role (Danesi, 2016; Hidayatullah, 2018). Therefore, when discussing the role of mathematics in building the modern world, we must pay attention to the beliefs and principles related to mathematics.

How can we motivate and encourage students to develop a strong interest in mathematics and master it? The answer depends on students' beliefs about mathematics. The beliefs that students hold about mathematics serve as the foundation for comprehending the world of mathematics education and provide the optimal strategies to shape mathematics ability. When students hold specific beliefs, such as the existence of multiple methods of solving mathematical problems, their involvement in addressing society's problems in the modern world may be affected. Mathematics-related beliefs are pivotal in developing students' critical thinking skills (Csíkos et al., 2011) and guiding them to deal with diverse types of information (Mason et al., 2010). With mathematics-related beliefs, students can grasp the nature of mathematics and how they can enhance their understanding of it (Op't Eynde et al., 2003). Developing beliefs concerning the usefulness of mathematics can motivate students to study math and exploit it in their future pursuits, such as engineering. Mathematics-related beliefs can also foster students' motivation to utilize what they have learned in school to develop technology since mathematics is also the language of science and technology.

In summary, mathematics-related beliefs are highly important for mathematics learning and modern society. These beliefs help shape an individual's understanding of mathematics, critical thinking, innovation, technology, economics, and society. By fostering positive mathematics-related beliefs, students are better equipped to succeed academically and contribute to the world in meaningful ways.

1.4.Context of the empirical studies

Indonesia is located in the south-east Asia. With a 278.033.357 population (www.worldometers.info), Indonesia has become the fourth country most populated. Indonesia has a unique education system context. Generally, there are public schools and private schools. Public schools are divided into public general schools under the Ministry of Education and Culture and public religion schools under the Ministry of Religion. Private schools are also divided into private general schools and private religious schools. Also, many informal institutional schools focus on teaching religion.

There are four levels of education: early childhood (playgroup and kindergarten, 3-6 years old), elementary education, six years (7-12 years old), junior high schools three years (12-15), senior high schools and vocational schools three years (15-18), and higher educations. Higher education consists of an undergraduate program, a master's program, and a doctoral program. Primary to junior high schools of public schools are free from tuition. For the tuition of senior high schools under the policy of each province. In some regions, such as East Java province, public senior high schools are free. The government also provides funding to support private schools. This is a unique system in Indonesia, where private schools also earn support funding from the government (Stern & Smith, 2016). Schools that gain funding support from the government are free.

Regarding academic performance, international surveys, such as TIMSS and PISA, showed that the Indonesian students' scores in mathematics, science, and reading were consistently below the average, even lower than that of neighboring countries, such as Malaysia, Thailand, etc. The TIMSS results showed that Indonesian math ranking was 36^{th} out of 40 countries in 2011 (Mullis et al., 2012) and 45^{th} out of 50 countries in 2015 (Mullis et al., 2016). The result of TIMSS was consistent with the result of PISA, which showed that Indonesian students' ranking for mathematics was 64^{th} out of 65 countries in 2012 (OECD, 2012), 64^{th} out of 72 countries in 2015 (OECD, 2015), and 74^{th} out of 79 countries in 2018 (OECD, 2018). A later survey from PISA in 2023 also showed that Indonesian students obtained very low scores compared to other countries. This result triggered a noisy debate among scholars. Many researchers also provide empirical evidence that Indonesian students suffer from mathematical achievement. For example, Kismiantini et al. (2021) pointed out that 53% of students' performance in mathematics was below average. Juniati and Budayasa (2020) stated that Indonesian students were afraid of mathematics courses.

Later, the Ministry of Education and Culture introduced the Freedom Curriculum (kurikulum Merdeka) as a new curriculum to respond to the long crisis of education in Indonesia and the loss of learning that occurred due to the pandemic situation (Kemdikbud, 2022). The characteristics of this curriculum emphasized three aspects: developing the soft skills and character of the students, focusing on the essential courses, and learning with flexibility (Kemdikbud, 2022). This curriculum has been expected to increase the academic performance of students, including mathematics achievements. The teacher's position becomes more critical to building the environment that improves students to increase their ability as expected in the Merdeka curriculum. In terms of mathematics education, this curriculum divided the mathematics objective into several phases: phase A (grade 1-2), phase B (grade 3-4), phase C (5-6), phase D (grade 7-9), phase E (grade 10), and phase F (grade 11-12). The objective of mathematics courses is to help students develop an understanding of mathematics, reasoning and proving mathematics, problem-solving skills in mathematics, communication and mathematics representations, mathematics connections, and mathematics dispositions. Therefore, schools and math teachers must know the fundamental question of mathematical achievements. As we discussed earlier, empirical research has shown that mathematics achievement has been found to be the result of beliefs in mathematics learning (Csikos, 2011; Csíkos, 2016; Greer et al., 2002; Schommer et al., 2005). However, the significant role of mathematical beliefs in academic outcomes has received little attention to date. As a result, this dissertation would provide a new understanding of how to achieve the main objective of mathematics learning in the Indonesian context.

1.5.Present dissertation

This dissertation is presented in a study-based format. It comprises five empirical studies that investigate a range of issue-related beliefs about mathematics, from the conceptual to interconnection with various aspects. I identified several gaps in the literature during an extensive review, which prompted me to conduct empirical studies in the present dissertation. First, despite many empirical studies examining the dimensionality of personal epistemological beliefs, these studies need to clarify whether epistemological beliefs in the Indonesian context and different field studies have sensitivity to domain study. Sensitivity means significant differences in epistemological beliefs based on the field study. Moreover, few studies have compared the relationship between personal epistemology beliefs and other personal factors, such as field study, ethnicity, achievements, attitudes, etc. Consequently, the study of personal epistemology beliefs should be conducted.

Second, taking into account the theoretical framework, the significance of mathematics-related beliefs, and the importance of investigating students' mathematics-related beliefs in Indonesia, I choose the mathematics-related beliefs framework as the main in this dissertation. This framework not only entailed the epistemology of knowledge in mathematics but also constituted the conception of self-ability and perception of mathematics in the class context (Op't Eynde et al., 2003). However, this framework has been developed in European countries (Op't Eynde et al., 2003, and most of the adaption of the MRBQ has been conducted in Western countries (Diego-mantecón & Andrews, 2008). It is rare to find empirical evidence about the stability, validity, and reliability of this instrument in Asian countries. Moreover, there is a dearth of information on the extent to which Asian students perceive about mathematics education.

Third, there is a dearth of empirical studies examining the significant role of mathematics-related beliefs in mathematical engagement. The intermediation between the two has also received little attention. Fourth, there are several literature reviews that suggest that beliefs are closely associated with attitudes and emotions. McLeod (1992) argued that beliefs are more focused on cognition, while attitudes are more focused on emotions. However, the two are intertwined. Unfortunately, there are limited studies that have investigated the interrelation and intermediation of mathematics-related beliefs with other aspects, such as attitude and motivation, to promote mathematics achievements. This has led to an incomplete understanding of how we can improve the quality of mathematics learning. Fifth, limited studies regarding students' implicit beliefs about problem-solving and their implication to realistic word problems. Accordingly, the purpose of this dissertation is to (1) explore and compare students' personal epistemology beliefs in a different field study with various personal backgrounds, (2) adapt and examine students' mathematics-related beliefs system, (3) investigate the interrelation and intermediation between students' mathematics-related beliefs systems and mathematical engagement, (4) examine the interrelation and intermediation between students' mathematics-related beliefs system, attitude, motivation, parents' educational level, and mathematics achievements, (5) investigate students' response toward realistic problem and their mathematics-related beliefs about word problems. The general research questions (RQs) of this dissertation are listed below:

1. RQ1: What information can be obtained by investigating personal epistemological beliefs in the Indonesian context?
2. RQ2: To what extent are the validity and reliability of instruments measuring mathematical beliefs stable in the Indonesian context, considering the majority of previous studies have been conducted in Western countries? What are the characteristics of Indonesian students' beliefs about mathematics?
3. RQ3: Do mathematical beliefs predict behavioral and emotional engagement among primary education students?
4. RQ4: What insight can be discovered from the investigation of beliefs, attitudes, motivation, and achievement?
5. RQ5: How do students' implicit beliefs about mathematical word problems manifest in the Indonesian context?

1.6.Structure of the dissertation

As explained in the previous sections, this dissertation focuses on explaining students' beliefs about mathematics education and their relationship with mathematics achievements and other non-cognitive factors. This dissertation consisted of four main sections. Chapter 1 of this dissertation highlights the general definition, mathematics-related beliefs framework, beliefs significance, research context, and the organization of the dissertations. Chapter II elaborated on the general methods of the dissertation.

Chapter III is composed of five empirical studies. Study 1 examined whether or not students' epistemological beliefs differ based on their field study. The research compared the epistemological beliefs of students in mathematics education and primary teacher education departments, as well as those in a field study. The study also considered factors such as gender and parents' education. The results of this research can help determine whether more specific belief constructs are necessary. If students from different fields of the study hold similar epistemological beliefs, then the questionnaire used is appropriate. However, if there are variations in personal epistemological beliefs based on the field of study, then more specific belief constructs are required. The findings of Study 1 were published in the *Revista Education Distancia Journal.*

The finding of Study 1 affirmed that specific belief instruments are needed to measure mathematical beliefs. Study 2 focused on evaluating more specific beliefs in mathematics learning. In study 2, the adaptation of the mathematics-related beliefs questionnaire was conducted. The study provided empirical evidence of the stability and reliability of MRBQ in the Indonesian context. In addition, individual differences have been recorded in terms of mathematical beliefs. The results of this research have been published in the *Journal on Efficiency and Responsibility in Education and Science.*

After the MRBQ became available for Indonesian students, I used this instrument to evaluate students' beliefs about mathematics education and their significance on learning outcomes. Then, study 3 focused on investigating the role of explicit mathematical beliefs in promoting mathematical engagement. Through this study, a deeper understanding of whether mathematical beliefs also affect mathematical engagement or not is expected to be obtained. Suppose the result of study 3 indicated that mathematical beliefs could promote mathematical engagement. In that case, there is a possibility that mathematical beliefs would also encourage other aspects, such as motivation, attitudes, and mathematics achievement. The findings of this study were published in the *Education 3-13 Journal.*

Since study 3 confirmed that mathematical beliefs predict mathematical engagement, the focus of study 4 is to explore how mathematical beliefs associate and determine motivation, attitude towards mathematics, and mathematics achievements. Study 4 also introduced a structural model that examined how these variables, as well as parents' educational level, affected mathematics achievement. The results of study 4 have been published in *The Asia-Pacific Education Researcher Journal*.

Furthermore, there is a lack of information on the extent to which students hold implicit beliefs about problem-solving in mathematics learning. Study 5 emphasized the investigation of students' implicit beliefs about realistic word problems in mathematics learning. The result of study 5 has been published in *Pedagogika Journal*.

Finally, Chapter IV is composed of a general discussion about the findings of this study, the limitations, suggestions for future research, and the implications for the theory and teaching practices. In the general discussion, I discussed the general findings of my study based on each empirical study.

2. Methods

2.1. General procedure

This dissertation used a study-based dissertation (SBD) format that combines five empirical studies. Generally, each empirical study of this dissertation used a quantitative approach. First, every adaptation of the questionnaire and test instruments was translated into Indonesian. Experts and mathematics educators reviewed the instruments (questionnaires and tests). The review by mathematics educators is important because they know deeply about the appropriate sentences for students in secondary schools and primary education. Second, the IRB of the doctoral school of education, the University of Szeged, has provided a letter of permission. This letter was sent to the principals in Indonesia. Communication about the data collection technique was conducted with the principals and the teachers. Third, the collection data process was conducted with the active cooperation of the teachers and the schools. Indeed, the data collection of these studies was not conducted consecutively. However, the sequence and the combination of empirical studies in this dissertation were connected and complemented each other to explain the role of mathematics-related beliefs in mathematics learning. Most of the data collection for each study took around one month. The data collection for study 1, study 2, and study 5 were conducted in 2021-2022. Furthermore, study 4 was conducted in 2022. The last data collection was conducted in 2023 for study 3. Fourth, the data analysis was conducted to answer the research questions.

2.2.Participants

Study 1 focused on the investigation of personal epistemological beliefs in the different field studies. Accordingly, the sample of study 1 involved 276 students from two departments, mathematics education and primary teacher education. Study 2 examined students' mathematics-related beliefs in secondary schools in Indonesia. Study 2 involved 539 students from secondary schools, grades 8-9. Study 3 examined the interrelation and intermediation between mathematics-related beliefs and mathematical engagement, which involved 500 students from elementary education, grades 5-6. Study 4 examined the interrelation and intermediation between mathematics-related beliefs, attitude, motivation, parent educational level, and achievement among primary education and involved 894 primary education students, grades 5-6. Study 5 examined implicit beliefs and their influence on problem-solving. Seven hundred fifty-seven students participated in study 5, grades 5-6.

2.3.General description of the studies in the present dissertation

Various statistical methods were performed to answer the research questions, such as Pearson correlation, t-test, regression, exploratory factor analysis (EFA), confirmatory factors analysis (CFA), and Full structural equation modeling (SEM). Data analyses were processed using SPSS 25, MPlus 8.5, and SMART PLS 3.0. First, the validity and reliability of the instruments should be evaluated. Normality was checked before the data analysis. Second, the data analysis was conducted by selecting the appropriate methods to answer the questions and hypothesis. The data analysis involved Pearson correlation, regression, t-test, exploratory factor analysis (EFA), and structural equation modeling (SEM). Exploratory factor analysis and confirmatory factor analysis were generally used to examine the construct validity of the instruments. The number of factors was decided to consider the scree plot, cumulative variance explained, interpretability, Kaiser–Meyer–Olkin (KMO) coefficient to measure the adequacy of samples, and Barlett's test of sphericity to examine data in the factor analysis, including orthogonal Varimax rotation to determine the factor structure matrix (Henson & Roberts, 2006). Comparative Fit Index (CFI), The Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and SRMR were the main criteria used to see whether or not the model fit (Arifin & Yusoff, 2016; Benson et al., 2020; Harrington, 2009; Henson & Roberts, 2006; Ho, 2006). According to van de Schoot et al. (2012), the cutoff criteria for CFI, TLI > 0.9, and RMSEA < 0.8 are acceptable. Convergent validity and discriminant validity were also evaluated in the present study. The convergent validity of my instrument was evaluated by referring to their average variance extracted (AVE). According to Hair et al. (2019), the value of (AVE) should be higher than 0.5. The discriminant validity was evaluated by employing Heterotrait Monotrait (HTMT) 90. The internal consistency of the items was evaluated by performing Cronbach alpha. The Cronbach alpha is the most commonly used to evaluate the index of reliability in the educational and psychological fields (Gliner et al., 2017). Table 1 summarizes the characteristics of each empirical study in the present dissertation.

Table 1

General description of five empirical studies in this dissertation

No	Title	Sample and Instruments	Data analysis
1	The dimensionality of personal beliefs ; the investigation of beliefs based on the field study. (Hidayatullah, Csíkos, & Wafubwa, 2023)	Sample: 276 students in higher education (mathematics education department and primary teacher education department). Instruments: Discipline-focused epistemological beliefs questionnaire (DSBQ]; Hofer, 2000), GPA, and attitudes questionnaire	1. CFA and Cronbach alpha 2. Descriptive statistics 3. Independent sample t-test 4. One-way ANOVA 5. Regression analysis
2	Exploring students ' mathematical beliefs : gender, grade, and culture differences. (Hidayatullah & Csíkos, 2023a)	Sample: 536 students in grades 8-9. Instruments: Mathematics-related beliefs system questionnaire (MRBQ]; Op 't Eynde & De Corte, 2003)	1. EFA, CFA, and Cronbach alpha 2. Descriptive statistics 3. Independent sample t-test 4. One-way ANOVA
3	Beliefs in mathematics learning and utility value as predictors of mathematics	Sample: 500 students in grades 5-6 Instruments: Mathematics-related beliefs system questionnaire (MRBQ]; Op 't Eynde & De Corte,	1. Descriptive statistics 2. Partial-least square structural equation

	engagement among primary education students: the mediating role of self-efficacy. (Hidayatullah, Csíkos, & Syarifuddin, 2023)	2003) and mathematical engagement questionnaire (Skinner et al., 2009)	modeling (PLS-SEM)
4	The role of students' beliefs, parents' educational level, and the mediating role of attitude and motivation in students' mathematics achievement. (Hidayatullah & Csíkos, 2023c)	Sample: 894 students in grades 5-6 Instruments: Mathematics-related beliefs system questionnaire (MRBQ]; Op 't Eynde & De Corte, 2003), motivation (PISA), and attitudes questionnaire(Al-Mutawah & Fateel, 2018), mathematics score	1. CFA, and Cronbach alpha 2. Descriptive statistics 3. Structural equation modeling (SEM)
5	Students' responses to the realistic word problems and their mathematics-related beliefs in primary education. (Hidayatullah & Csíkos, 2023b)	Sample: 757 students in grades 5-6 Instruments: Realistic word problem test in mathematics (Csíkos et al., 2011; Greer et al., 2002)	1. Cronbach alpha 2. Descriptive statistics 3. Independent sample t-test 4. Mann-Whitney 5. Coefficient contingency

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CHAPTER II. EMPIRICAL STUDIES

Study 1

The dimensionality of personal beliefs; the investigation of beliefs based on the field study

(Hidayatullah et al., 2023)

The dimensionality of personal beliefs; the investigation of beliefs based on the field study

La dimensionalidad de las creencias personales; la investigación de creencias a partir del estudio de campo

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Abstract
The purpose of this study is to examine whether personal epistemological beliefs are more sensitive to domain study or not. We also examine the relation of this belief with other relevant factors such as parent education, gender, attitude, and academic performance. Two hundred seventy-six students from mathematics education and primary teacher education participated in this study (15 % male and 85% female, mean age = 20.65). A quantitative approach was used in the present study. The finding of this study suggested that certainty of knowledge and attainability of the truth are more specific domains. Mathematics education students hold stronger beliefs about the certainty of knowledge than primary teacher education students, the principle in mathematics is unchanging, and most of the truth in mathematics is already found. In contrast, the beliefs about the justification for knowing and the source of knowledge are more general domains. We found mathematics education students and primary teacher education are equal in their beliefs about the justification for knowing and the source of knowledge. The influence of these beliefs on academic performance is significant. In both field studies, personal epistemological beliefs correlate with attitudes toward academic performance. Both Male and female students in the mathematics education and primary teacher education department are equal in personal epistemological beliefs. This study contributes to improving students' academic performance in higher education. **Keywords:** beliefs, attitudes, performance, parent education, gender.

Resumen
El propósito de este estudio era examinar si las creencias epistemológicas personales son más sensibles al estudio del dominio o no. También examinamos la relación de esta creencia con otros factores relevantes como la educación de los padres, el género, la actitud y el rendimiento académico. Participaron en este estudio 276 estudiantes de educación matemática y de magisterio de primaria (15 % hombres y 85 % mujeres, edad media = 20,65). En el presente estudio se utilizó un enfoque cuantitativo. El hallazgo de este estudio sugirió que la certeza del conocimiento y la posibilidad de alcanzar la verdad son dominios más específicos. Los estudiantes de educación matemática tienen creencias más sólidas sobre la certeza del conocimiento

que los estudiantes de formación docente primaria, el principio de las matemáticas no cambia y la mayor parte de la verdad en las matemáticas ya se encuentra. Por el contrario, las creencias sobre la justificación del conocimiento y la fuente del conocimiento son dominios más generales. Encontramos que los estudiantes de educación matemática y la formación de maestros de primaria son iguales en las creencias sobre la justificación del conocimiento y la fuente del conocimiento. La influencia de estas creencias en el rendimiento académico es significativa. En ambos estudios de campo, las creencias epistemológicas personales se correlacionan con las actitudes hacia el rendimiento académico. Tanto los estudiantes masculinos como femeninos en el departamento de educación matemática y el departamento de formación de maestros de primaria son iguales en creencias epistemológicas personales. Este estudio contribuye a mejorar el rendimiento académico de los estudiantes de educación superior.
Palabras clave: creencias, actitudes, desempeño, educación de los padres, género.

1. Introduction

The growth of digital technology in the 21st century changed many things in various aspects (Danesi, 2016; Hidalgo-Cajo & Gisbert-Cervera, 2021; Wang Ng, 2018). In the educational context, the integration of digital technology has been conducted massively and affected the changes in teacher-student interaction patterns (Danesi, 2016). In social life, modern jobs require new skills beyond cognitive ability because digital technology has eliminated human roles in some aspects (NRC, 2011). OECD has conceptualized 21st-century skills and competencies for a learner. These are cognitive, intrapersonal, and interpersonal skills (Geisinger, 2016; NRC, 2011). The most important thing that should be known is how to build these individual skills. Students' conceptions, the extent to which learner believes in knowledge, make meaning, and justify their knowledge, have been known plays a key role in determining their performance in various aspect (Buehl et al., 2002; Buehl & Alexander, 2001; Hidayatullah & Csikos, 2022; Hofer, 2000) such as cognitive, intrapersonal, and interpersonal skill. For instance, in cognitive skills, the ways students solve non-routine tasks are governed by their beliefs about word problems (Garofalo, 1989; Greer et al., 2002; Reusser & Stebler, 1997; Verschaffel et al., 2020). However, the previous investigation regarding personal epistemological beliefs has left one problematic issue that should be clarified: that is the sensitivity of these beliefs in other domains or field studies.

In the literature review, there has been controversy among researchers on whether beliefs system are more general or specific domains. One group of researchers perceive personal epistemological beliefs across domains or more general domains. Whereas other researchers viewed that personal epistemological beliefs are sensitive to field study or more specific domain (Limón (2006). The concept of beliefs as a domain-general was driven by Schommer's epistemological beliefs that consisted of four dimensions; fixed ability, simple knowledge, quick learning, and specific knowledge (Clarebout et al., 2001; Schommer-Aikins, 2004). The authors also proved that individual general beliefs are linked with beliefs about problems solving, reading ability, problem-solving ability, and grade point average (GPA). In other words, the authors successfully showed that general beliefs mirror students' cognition and specific beliefs, such as problem-solving beliefs.

Other empirical research suggested that beliefs about knowledge are more specific domain. Through empirical study, Hofer & Pintrich (1997) investigated and compared students' epistemological beliefs based on the different domains. The researchers proposed discipline-focused epistemological beliefs (DFEQ) as the theoretical framework of personal epistemological beliefs to prove the specificity of domain beliefs. DFEQ consists of four dimensions: beliefs about the certainty of knowledge, beliefs about the justification of knowledge, beliefs about the Source of knowledge, and beliefs about the attainment of the truth. This empirical study compared two groups of students: psychology and science. This study also examined whether their beliefs relate to Schommer's epistemological beliefs (Hart, 2005; Hofer, 2000; Muis et al., 2006). The author found that the influence of disciplinary differences was very significant, indicating that students in different domains hold different beliefs about knowledge. Students in science hold stronger beliefs that knowledge is unchanging than students in psychology (Hofer & Pintrich, 1997).

Although prior studies (Hofer, 2000; Hofer & Pintrich, 1997; Op 't Eynde et al., 2006) have shown that beliefs about knowledge are related to academic performance, and Hofer (2000) has shown that personal epistemological beliefs are more sensitive to field study, the dimensionality of these beliefs in the different field is still unexplored questions. A clearer understanding of whether the sensitivity of personal epistemology also exists in other domains is necessary to provide a new explanation of the role of these beliefs on academic performance and other aspects. Little is known whether personal epistemological beliefs based on the field are associated with attitudes and academic performances.

This investigation aims to explore whether personal epistemological beliefs are more specific domains or more general domains. This study also explores whether these personal epistemological beliefs are associated with attitudes and influence academic performance in the field study. Pehkonen & Pietilä (2003) suggested that beliefs in mathematics could pertain to subjective knowledge, while attitudes can pertain to an emotional aspect. Caprara et al. (2003) showed through their empirical investigation that beliefs determine personal attitudes. The stronger students hold their beliefs, their attitudes toward an object are more positive. Moreover, we investigated another factor (e.g., gender and parents' educational level) relevant to exploring students' epistemological beliefs in the Indonesian context. Therefore, the research questions below guided our investigations:

1. Through the empirical investigation of personal epistemological beliefs in the different field studies, are the students' beliefs more specific or general domains?
2. Do personal epistemological beliefs influence students' academic performance?
3. Do personal epistemological beliefs correlate with students' attitudes toward the academic context?
4. Were there any differences between male and female students in personal epistemological beliefs?
5. Do parents' educational backgrounds generate different personal epistemological beliefs?

2. Theoretical framework

2.1 Beliefs definitions.

Beliefs are very difficult to define precisely. Because the differences in the academic background sometimes generate different definitions and conceptualizations. In the literature review, the term beliefs time was written with other words such as ideology, religion, attitudes, ideas, thinking, value, and perceptions. There are wide definitions of beliefs based on the domain of field study. The most confusing thing is that sometimes authors do not differentiate between self-efficacy beliefs and beliefs about a certain object. However, Pajares (1992), research about beliefs is merit in various domains, such as mathematics, anthropology, education, physiology, science, medicine, law, sociology, and business. Although there is no consensus among researchers regarding the definitions of beliefs, some definitions can be used to conceptualize the structure.

Some researchers, such as Goldin (2002), said that beliefs as part of the cooperative or affective configuration that constitute some attributes such as value. The consequence of these definitions may affect the inclusion of some values as part of belief constructions in certain domains. Besides, based on these definitions, perceive beliefs as an affective domain. While other researchers, such as Di Martino & Zan (2011), perceive those beliefs as not having an affective or cognitive aspect. But, belief positions between the two may also consist of affective and cognitive aspects. Hestener & Sumpter (2018) define belief as a person's understanding that influences how they conceptualize and involve mathematics in all behavior, actions, and thoughts. Thus, beliefs are the roots of activities and ideas involving mathematics. In other words, what anyone does daily reflects their beliefs about an object or something. For example, we can trace one's beliefs based on behavior patterns during problem-solving learning. We also can identify teacher beliefs based on their style and strategies during teaching and learning in the class.

Other researchers, such as Rokeach (1968) and Grootenboer & Marshman (2016), defined beliefs as personal assumptions of truth that act as a predisposition to action. This definition is also in line with the previous definitions by Hestener & Sumpter (2018). Therefore, in the educational context, what a person perceives about an object would generate the consequence of the activity, although it does need justification. Because they believe that what they do in their activity is true. Bobis et al.(2016) define beliefs as conceptions about an object, ideology of personal, a world of view, and values about their purposes and their daily practices. What people perceive about themselves in environmental situations imply to the extent to which they read and evaluate a phenomenon. An important definition of beliefs is proposed by Dewey (1993), who said that beliefs as something outside the individual that be tested according to their perceptions. One's beliefs generate statements about facts and legal principles. These definitions indicate that beliefs definitions depend on the current domains and mention that there is no single definition of beliefs correct or fit. All of them rely on the situation and domains.

2.3 Personal epistemological beliefs

According to Hofer (2000), the core of the personal beliefs system is the nature of knowledge (how someone deals with beliefs and knowledge) and the nature of process knowing (how someone comes to know). The beliefs of the nature of knowledge may consist of certainty and simplicity of knowledge, and the nature of process knowing consists of the source of knowledge and justification of knowledge (Watson, 2020). Using exploratory factor analysis, Hofer (2000) generated four dimensions, beliefs about the certainty of knowledge, beliefs about the justification of knowledge, beliefs about the Source of knowledge, and beliefs about the attainment of the truth.

Ernest (2016) postulated that certainty has two meanings; the first is those whose adherents admit no uncertainties and are aware that they can endure any tests and skeptical inquiry. In modern epistemological frameworks, such views are viewed as indisputable. Another definition of certainty is an assessment of knowledge's actual objects or propositions that reflect beliefs. They can also be said to be certain or to have certainty if they are thought to be objectively justified and now able to withstand any doubts, inquiries, or challenges to their veracity. Certainty of knowledge is the dimension of the belief system that elaborated to the extent to which students perceive knowledge as fixed or fluid (Chen et al., 2019). These beliefs were adapted from Perry and Schommer's work to explore whether students perceive knowledge as tentative or fixed. Perry investigated how students in higher education deal with knowledge and knowledge attainment (Trautwein & Lüdtke, 2007). The finding of Perry's investigation exerted the tendency of first-year university students to perceive that knowledge was certain. In the last year's study, students recognized that knowledge was tentative (Schommer, 1990). In the present study, certain absolute truth exists at lower levels. At more advanced levels, knowledge is provisional and in constant evolution (Hofer, 2000)

The simple of knowledge is the person's belief whether knowledge is simple or complex. Simple knowledge relates to the perception of isolated facts (Schommer, 1990, 1993). Knowledge is considered as a collection of information or as correlating with one another on a continuum. At the lower-level beliefs, someone will perceive knowledge as concrete facts, but at the high level, someone will acknowledge that knowledge is more contextual (Hofer, 2000). Regarding the Source of knowledge, Hofer (2000) argued that the Source of knowledge is how a person perceives the Source of knowledge from the outside person and resides in an external authority. In lower models, knowledge derives outside the self and exists in the external authority from whom it may be transferred.

Justification of knowledge relates to how people perceive how to gain knowledge and clarify their claims. Justification of knowledge is a way for people to prove their knowledge, such as following the information from the experts or doing research to discover the answer (Chen et al., 2019). In her empirical research, Hofer (2000) proposed a new dimension, namely, the attainment of the truth. Chen et al.(2019) interpreted the attainment of the truth as a concern with how someone believes that the ultimate truth can be obtained or unobtainable. The items in this dimension are closer to the justification of knowledge but emphasize the justification of experts, such as the statement that "experts in this field can ultimately get the truth" and "if the scholars try hard enough, they can find the answers to almost anything."

2.5 The relation of personal epistemological beliefs and attitudes

Attitudes are defined as the evaluation dimension of a concept, such as whether the concept is good or bad. They are described as mediating evaluative responses, including liking, enjoyment, and interest, or the opposite side dislikes concepts or objects (Ernest, 1989; Fishbein, 1963). Attitudes relate to affective responses that involve moderately intense and reasonably stable positive or negative feelings. For example, attitudes toward mathematics include liking geometry, disliking word problems, or disliking analysis-real mathematics (McLeod, 1992). If students tend to dislike a certain topic, it will imply their behavior during the learning process.

The relationship between attitudes and performance has been extensively researched. Particularly, the empirical study examines the contribution of a positive attitude to students' performance. Attitude has also been conceptually linked to students' engagement in class, homework completion, and abstinence (Green et al., 2012; Pitsia et al., 2017). The history of attitudes research also attracted attention to the critical issue in affect study, particularly on beliefs, because attitudes and beliefs have rarely been differentiated (Di Martino & Zan, 2011). Sometimes, attitudes and beliefs are used interchangeably with each other. Pehkonen & Pietilä (2003) bunched beliefs as subjective knowledge or cognitive aspect while attitudes are emotions. See figure 1. Then, the authors explained that the two sub-domains interconnect since someone can imagine statements that can be comprehended simultaneously as beliefs and attitudes. For instance," *I am not good at mental calculations*" can be understood as a belief and attitude toward mathematics. In this study, we assumed that attitudes are more emotions and beliefs are more cognition, both of which strongly correlate. However, empirical study that connects attitudes to students' beliefs is still rare.

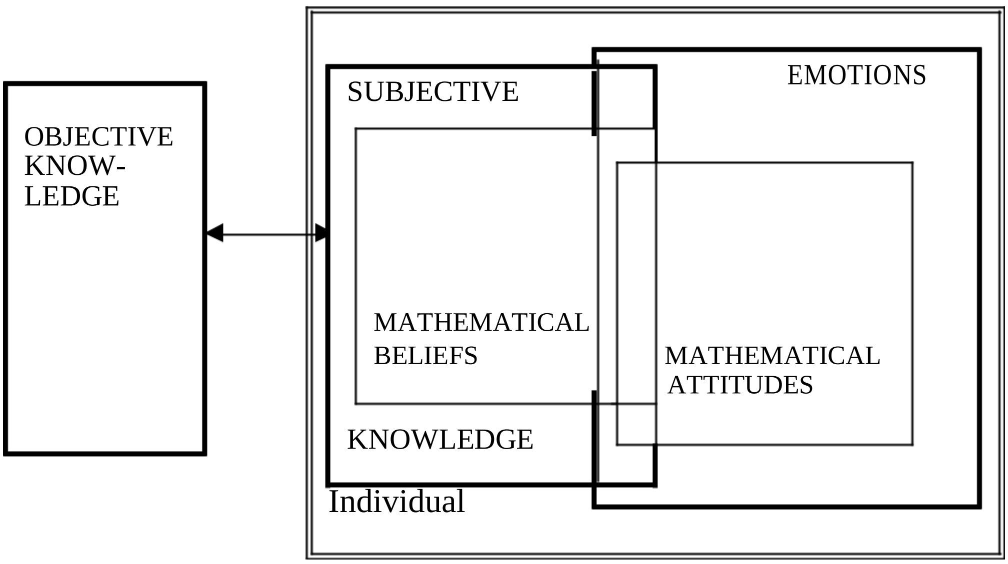

Figure 1. the relationship between beliefs, attitude, and knowledge (Pehkonen & Pietilä, 2003).

2.6 Gender and personal epistemological beliefs

Gender is also questioned in the Indonesian educational context as the most prominent Muslim country. Religion is one of the issues that cause inequality in gender (Muliah, 2016). There is evidence that gender differences in academic contexts still exist in several Muslim countries. For example, Shafiqs' (2013) investigated the differences in gender in an academic context in some Muslim countries. This research involved students from Turkey, Indonesia, Kyrgyzstan, Jordan, Azerbaijan, Qatar, and Tunisia. The researcher compares students' performance in those countries based on gender differences. The research found that the mathematics performance of girls' students in Indonesia, Tunisia, and Kyrgyzstan is lower than boys' students. The significant differences have also been proved by Martha et al. (2021), who found significant differences in learning competence between male and female students in higher education in Indonesia. Other studies suggested that women are more likely to work in some aspects, such as STEM and social work, than men (Maskur et al., 2022).

Nowadays, males and females have the same chance to access education in Indonesia. However, in Indonesian education, several private Islamic schools segregate male and female students. These divisions were founded on the presumption that putting male and female pupils in the same class or an environment where they may interact would have a negative effect on behaviour (Srimulyani, 2007). In higher education, universities follow a modern education system where there is no segregation between male and female students.

Concerning the relation between gender and beliefs in an academic context, researchers have recorded that gender issue also exists in the context of beliefs study. Li (2004) investigated gender differences and beliefs in mathematics education. The authors found that beliefs about mathematics are really different based on gender differences, where males showed higher beliefs than females. Samuelsson & Samuelsson (2016) also reported that male students perceive themselves can do more in mathematics than females. However, no association between personal beliefs and gender differences study has been conducted in the Indonesian context. Therefore, in the present study, we explained the personal epistemological beliefs based on students' gender differences.

2.4 Parents' educational level and personal epistemological beliefs.

Parents' education as part of social-economic status is another factor that has been recognized to influence students' performance. Parents with a high level of education, such as more than four years of experience in higher education, spend more time with their children than parents with less educational experience (Guryan et al., 2008). Parents' education may affect how they interact and send messages to their children. Some of their messages to their children provide information regarding the values and importance of education, such as in mathematics and science fields (Jacobs & Bleeker, 2004). Research by Azhar et al. (2014) reported that parents' education significantly influences students' performance in the university.

The relationship between personal epistemological beliefs and parents' educational study has rarely been studied. There is little evidence of the relationship between the two. For instance, the study by Davis-Kean (2005) reported that parents' education influences their beliefs and behavior, leading to positive outcomes for children and youth. The role of parents in students' beliefs has also been recorded by Gladstone et al.(2018). In that study, researchers investigated students’ beliefs about mathematics in grades 5-12, students’ abilities towards mathematics, and parents’ beliefs about their children. This study's result showed an association between students' beliefs, students' ability in mathematics, and parents' beliefs about their children in mathematics. Therefore, in the present study, we will examine the relations between parents' educational background and students’ personal epistemological beliefs.

3. Method

3.1 Participants

This study took place in Surabaya city-Indonesia, which is an urban or a metropolitan city. A total of 276 higher education students participated in this research, where 86 % of participants were females and 14 % were males (*Mean* age = 20.65, *SD* = 2.29). The participants in the present study are from the Primary teacher education (PME) department and the mathematics education (MED) department. We used the snowball random sampling method to collect our data using the online system with Google Forms. When we spread our instruments online to students in higher education, various students from different backgrounds also participated in the present study. We decided to focus on the two departments, mathematics teacher education, and primary teacher education. We excluded students from another department since the number of participants from other departments is not enough to be calculated using statistical analysis.

Finally, 146 students in MED and 130 students in PME departments participated in this study (See table 1). Although the students in these two departments have similarities because of the same faculty, the differences lie in the curriculum structure. MED students’ college focused on mathematics for teaching, and they obtained several topics for teaching-learning mathematics in primary-senior high school. Students in MED learned natural mathematics such as calculus, algebra, geometry, theory graph, analysis real and statistics mathematics, etc. Students also study teaching and learning strategies, assessments, and training for teaching methods, etc. PME students’ college, on the other hand, focused on all topics for primary teacher education teaching and learning method pedagogy. Students from these departments learned about mathematics for elementary, teaching and learning strategies, assessments, and instruction training. Based on those subject differences, MED students learn more in the mathematics area, while PME students learn more in teaching and learning strategies for elementary students. The output from these two departments is different, MED students have been trained to be secondary school teachers or junior and senior high schools teacher in the Indonesian context. While PME students have been trained to be a teacher for primary students or elementary students in the Indonesian context.

Table 1

Summarize the demography of participants

Characteristic	Full sample	Percentage
Major		
Mathematics education (MED)	146	53%
Primary teacher education (PME)	130	47%
Gender		
Males	39	14%
Females	237	86%
Father Education		
Elementary Schools	81	29%
Junior High Schools	35	13%
Senior High Schools	109	39%
Higher Education	51	19%
Mother Educations		
Elementary Schools	70	26%
Junior High Schools	56	20%
Senior High Schools	102	37%
Higher Education	48	17%

3.2 Instruments

Personal epistemological beliefs. We adapted the Discipline-focused epistemological beliefs questionnaire (DFEQ) was used to measure students' beliefs, their perceptions about knowledge, and knowing their discipline study. This questionnaire was developed by Hofer (2000) and consisted of four dimensions with 18 items: *certainty of knowledge* consisted of eight items. For example: "All experts in this field understand the field in the same way, "and "Truth is unchanging in this subject." *Justification for knowing* entails four items: "Firsthand experience is the best way of knowing something in this field," and "I am more likely to accept the ideas of someone with firsthand experience than the ideas of researchers in this field." The *Source of knowledge* consisted of four items. For example: "Sometimes you just have to accept answers from the experts in this field, even if you don't understand them "and "If you read something in a textbook for this subject, you can be sure it's true." *Attainability of truth* entails two items: "Experts in this field can ultimately get to the truth" and "if scholars try hard enough, they can find the answers to almost anything. This instrument was rated with a Likert scale from 1-5 (1 = strongly disagree, 5 = strongly agree).

Attitude for academics. We adapted the instruments of attitude from Kennedy et al. (2016) were adopted in the present study. For example, *I find many interesting and important things in this field.* Both questionnaires were administrated using a Likert scale rate range of 1-5 (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

Parents' educational background. For the personal background data, we obtained from parents' educational level. We asked students what their father and mother's educational level is; 1 = primary school, 2 = Junior high school, 3 = Senior High School/ Vocational school, 4 = Higher education. *Student achievements* were collected by asking students for their grade point average (GPA). In Indonesian, the system GPA range from 1-4.

3.3 Procedure

In the present study, we identified students' personal beliefs about knowledge in their field study. Therefore, we adapted the Discipline-focused epistemological beliefs questionnaire (DFEQ) developed by Hofer (2000). In the first step, we translated the instruments into the Indonesian language. Before we administered this questionnaire, there are three researchers from Indonesia validated the instrument. We tried to communicate with students and colleges from universities in Indonesia. We explained our research aims. Also, we tried to communicate with some lecturers in Indonesia to get information on how to collect data. Then we used snowball random sampling methods. Both the students and the lecturers in Indonesia helped us to spread our online survey. In the present study, most students from two departments (mathematics and Primary teacher education) were asked to respond to this survey package consisting of the instrument discipline-focused epistemological beliefs questionnaire (DFEQ), a student attitude, and a brief demographic questionnaire such as their parents' education. We excluded the participants from another department since the number of participants was insufficient to be accounted for with statistical methods. The measurement of this study took place in Surabaya, the capital city of East Java province, during the pandemic. We collected our data on 1-30 April 2022. It means that the online collection of data was the only possible solution.

3.4 Data analysis

This study uses a quantitative study approach. Several data analyses were performed in the present study: confirmatory factor analysis (CFA) was used to confirm the stability of validity instruments. The model fit for confirmatory factor analysis can be presented by the comparative fit index (CFI), tucker-Lewis index (TLI), and the root means a square error of approximation (RMSEA). According to van de Schoot et al. (2012), the coefficient of CFI $\geq$ .90, TLI $\geq$ .90, and RMSEA $\leq$ .08 are adequate. Cronbach's alpha was used to examine the reliability of DFEQ instruments. Descriptive statistics were used to analyze students' discipline-focused epistemological beliefs, and a t-test was used to compare students' discipline-focused epistemological beliefs for mathematics education students and primary teacher education students. Regression analysis was used to examine the contribution of personal epistemological beliefs to students' achievements. We also performed a t-test to examine the differences in personal epistemological beliefs based on gender differences. Finally, we performed ANOVA to identify the differences in personal epistemological beliefs based on parents' educational backgrounds.

4. Results

4.1 Confirming the validity dan reliability instruments

We performed confirmatory factor analysis (CFA) in this study to confirm the model of discipline-focused epistemological beliefs in the Indonesian context (see table 2). We found the acceptable fit model (Chi-squared = 5024.33, df = 153, p <.001, NFI = .93, RNI = .96, GFI = .97, TLI = .94, CFI = .96, RMSEA = .08). All items had a good factor loading, range .45 - .83. We checked the internal consistency of this model using Cronbach alpha.

Table 2

Construct validity of epistemological beliefs and attitudes toward academic

Variables		CFI	TLI	RMSEA	Alpha
Personal epistemological beliefs	5024.33	.96	.94	.08	.89
Attitudes towards academic	234.43	.98	.96	.04	.73

Regarding the reliability of our instruments, the result of Cronbach alpha analysis showed that all of our instruments are reliable. Overall, the factors of discipline-focused epistemological beliefs had good reliability (*Cronbach alpha = .71 - .80*). Attainability of truth got the highest reliability (= .80) among factors of these beliefs. Certainty of knowledge also gained high reliability (= .78), and the Source of knowledge gained high reliability (= *.71*). Justification for knowing had the lowest reliability among other factors (= *.67*).

Concerning the attitudes instruments, we also examine the construct validity and the reliability of attitudes toward academic performance. The instrument of attitudes also presented a fit model (Chi-squared = 234.43, *df* = 21, *p* <.001, NFI = .93, RNI = .98, GFI = .98, TLI = .96, CFI = .98, RMSEA = .04). The Cronbach alpha coefficient showed that this instrument is reliable (*Alpha =.73).*

4.2. Descriptive statistics

As shown in Table 3, each factor of personal epistemological beliefs is correlated with attitudes toward academics. The highest correlation was shown by the pair of the source of knowledge and attitudes towards academics (*r* = .71). Students who hold beliefs about the source of knowledge, such as believing that the source knowledge (e.g., textbooks and experts) is favorable to have positive attitudes towards academics. The pair of certainty of knowledge and attitudes towards academics obtained a strong correlation (*r* = .67). The more students believe that knowledge is certain, the more favorable students are to have a positive attitude towards academics. The lowest correlation has been shown by the pair of the attainability of truth and justification for knowing (*r* = .39). The correlation between the source of knowledge and justification for knowing has gained moderate correlations (*r* = .55). It means, the level of student's beliefs about the source of knowledge such as textbook is correlated with their beliefs how to make meaning and justify their knowledge. Attainability of the truth has a strong correlation with the certainty of knowledge (*r* = .63) and the source of knowledge (*r* = .61). Justification for knowing was moderately correlated with attitudes towards academics (*r* = .59).

Table 3.

Descriptive statistics and correlation of each variable

Variables	Mean	SD	Max	Min	1	2	3	4
1. Certainty of knowledge	28.87	5.53	40.00	8	1			
2. Justification for knowing	13.73	2.98	20.00	4	.59			
3. Source of knowledge	13.34	2.97	20.00	4	.61	.55		
4. Attainability of truth	7.79	1.72	10.00	2	.63	.39	.61	
5. Attitudes towards academic	24.67	4.18	35.00	7	.67	.59	.71	.62

4.3. RQ1: Through the empirical investigation of personal epistemological beliefs in the different field studies, are the students' beliefs more specific or general domains?

We performed an independent sample t-test (see table 4) to examine whether personal epistemological beliefs are more specific or more general domain, in the context of mathematics education field and primary education fields. As we discussed earlier, students in MED learned a lot of mathematics topics, such as calculus, algebra, geometry, etc. Although PME students also learned mathematics in elementary students, most of the subjects in their field are related to pedagogy teaching and learning. In the Indonesian context, the main output of MED is mathematics teachers in secondary schools. At the same time, the output of PME is to provide elementary teachers. Therefore, the differences between the two will be identified if personal epistemology is more specific to the domain study. In contrast, both studies will have no significant differences if personal epistemological beliefs are more general domains.

The data in table 5 described significant differences between the two in the context of personal epistemological beliefs but not in all dimensions. MED students hold stronger beliefs about the certainty of knowledge than PME students; M = 29.75, SD = 5.01 and M = 27.88, SD = 5.93, respectively, t (274) = 2.84, p < .05. MED students also hold stronger beliefs about the attainability of truth than PME students (M = 8.18, SD = 1.47 and M = 7.35, SD =1.87, respectively, t (274) = 4.13, p < .05). However, MED and PME were equal in the beliefs about the justification for knowing (t (274) = 0.62, p = .54). It means the way students in both field study had the same conception how to justify their knowledge. Both the students were also equal in their beliefs about the Source of knowledge (t (274) = 1.75, p = .08). This data showed that either MED or PME were in the same way in believing about the Source of knowledge in their area. In other words, the certainty of knowledge and attainability of truth were more sensitive to domain study. In contrast, justification for knowing and the Source of knowledge was across domains.

Table 4

Comparison of students' beliefs based on their discipline

Factors	Mathematics education (MED)	Primary teacher education (PME)	*t* (274)	*p*
	M (SD)	M (SD)		
Certainty of knowledge	29.75 (5.01)	27.88 (5.93)	2.84	.005
Justification for knowing	13.62 (2.92)	13.85 (3.04)	0.62	.54
Source of knowledge	13.63 (2.77)	13.00 (3.15)	1.75	.08
Attainability of truth	8.18 (1.47)	7.35 (1.87)	4.13	.005

Note. N_{MED}= 146, N_{PME} = 130, p < .05 indicated significant. Certainty significant, t (274) = 2.84, p = .005, attainability of truth significant, t (274) = 4.13, p = .001 < .05.

We further examine the differences between the two in the level items by performing an independent t-test (See table 5). The first factor is belief in the certainty of knowledge. In general, the differences between the two have been identified based on the mean result, although not in all items. For instance, both students in MED and PME are equal in their beliefs about the answer to the questions in their field study is very dependent on the experts' findings, as indicated by the high mean result of the corresponding items (3.52

and 3.64, from a five-point likers scale, 5= strongly agree). 58% agreed or strongly agreed, while 13% strongly disagreed or disagreed with the item “Answers to questions in this field change as experts gather more information.” However, both students are really different in some beliefs about the certainty of knowledge. MED students were more positive than PME students with respect to the item “all experts in this field understand the field in the same way” (M = 3.49, SD = 1.10 and M = 3.24, SD = 0.94, respectively, p < .05). MED students hold stronger beliefs that the truth was never changing rather than PME students (M = 3.47, SD =1.27, and M = 3.05, SD = 1.23, respectively, $p < .05$). MED students expressed more positive beliefs than PME students that there is only one right answer in their field based on the mean results (M = 3.88, SD = 1.09 and M = 3.28, SD =1.18, respectively, p <.001). MED students (M = 4.05, SD = 0.87) were more positive than PME students (M = 3.76, SD = 0.96, p <.05) in their beliefs that the idea should be questioned in their field study.

Second, justification of knowing. From these beliefs, we noted a few differences in personal epistemological beliefs based on the field study preferences. Both MED (M = 4.08, SD = 0.92) and PME students (M = 4.06, SD = 0.98) expressed strong beliefs that their first experience is the best strategy to know about some things, as indicated by the high mean result of the corresponding item. Both students also viewed that they were more likely to accept the idea from firsthand experience rather than the result of research (M = 3.40, SD = 1.03 and M = 3.49, SD = 1.04, respectively).

Third, Source of authority. The data showed that both students expressed strong beliefs that they had just accepted the answer from experts, although they did not quite understand the problems, as indicated by the mean result (3.71 and 3.51, in five of the point likers scales). Both students had minor differences in their beliefs about the truth in the textbook. MED students (M = 3.52, SD = 0.89) were more positive than PME students (M= 3.25, SD = 1.00, $p < .05$) in their beliefs that they were sure about the truth when they read the textbook resource in their field study. However, both students were equal with respect to the item “If my personal experience conflicts with ideas in the textbook, the book is probably right” (M = 2.73, SD = 1.08 and M = 2.80, SD = 1.07, respectively). MED and PME students were also equal in response to the item “I am most confident that I know something when I know what the experts think “(M = 3.66, SD = 0.97 and M = 3.45, SD = 1.00, respectively)

Table 5

The t-test of students’ personal epistemological beliefs in MED and PME

Variables	MED			PME			sig
	Mean	**Med**	**SD**	**Mean**	**Med**	**SD**	
Certainty of knowledge							
Answers to questions in this field change as experts gather more information.	3.52	4.00	1.11	3.64	4.00	0.99	.66
All experts in this field understand the field in the same way.	3.49	4.00	1.10	3.24	3.00	0.94	.04*
The truth never changes in this field	3.47	4.00	1.27	3.05	3.00	1.23	.006*
There is only one right answer in this field	3.88	4.00	1.09	3.28	3.00	1.18	.00**
Principles in this field are unchanging.	3.42	4.00	1.18	3.22	3.00	1.14	.17

The answers to questions from experts are the same in this area.	3.76	4.00	1.05	3.65	4.00	1.09	.38
The idea should be questioned in this field	4.05	4.00	0.87	3.76	4.00	0.96	.008*
Most of the truth has been known in this field.	4.09	4.00	0.94	4.04	4.00	1.02	.67
Justification for knowing							
Firsthand experience is the best way of knowing something in this field.	4.08	4.00	0.92	4.06	4.00	0.98	.90
I am more likely to accept the ideas of someone with firsthand experience than the ideas of researchers in this field.	3.40	4.00	1.03	3.49	3.00	1.04	.48
Correct answers in this field are more a matter of opinion than fact.	3.24	3.00	1.07	3.09	3.00	1.05	.25
There is really no way to determine whether someone has the right answer in this field.	2.90	3.00	1.18	3.20	3.00	1.04	.03*
Source of knowledge							
Sometimes you just have to accept answers from the experts in this field, even if you don’t understand them.	3.71	4.00	1.06	3.51	4.00	0.99	.100
If you read something in a textbook about this subject, you can be sure it’s true.	3.52	3.00	0.89	3.25	3.00	1.00	.02*
If my personal experience conflicts with ideas in the textbook, the book is probably right.	2.73	3.00	1.08	2.80	3.00	1.07	.60
I am most confident that I know something when I know what the experts think.	3.66	4.00	0.97	3.45	3.00	1.00	.07
Attainment of truth							
Experts in this field can ultimately get to the truth.	3.92	4.00	0.88	3.54	4.00	1.00	.001**
If scholars try hard enough, they can find answers to almost anything.	4.27	4.00	0.77	3.81	4.00	1.01	.001**

Fourth, attainment of the truth. Generally, we found that students in both fields believed that experts in their field can gain the truth and discover the answers if they try hard enough based on the mean results. 61% of students from both fields agreed or strongly agreed, whilst 6% disagreed or strongly disagreed with the item “Experts in this field can ultimately get to the truth.” 73% agreed or strongly agreed, and 5% disagreed or strongly disagreed with the item “If scholars try hard enough, they can find answers to almost anything.” However, we find the differences between students in these beliefs' level item. MED students expressed more positive beliefs than PME students that the expert in their field can obtain the truth (M = 3.92, SD = 0.88 and M = 3.54, SD = 1.00, respectively, $p < .001$). MED students were more positive about the belief that scholars can discover the answer to all things if they try hard enough than PME students (M = 4.27, SD = 0.77 and M = 3.801, SD = 1.01, respectively, $p < .001$).

4.3 RQ2: Do personal epistemological beliefs influence students' academic performance?

Multiple regression analysis was used to answer the fourth question, whether personal epistemological beliefs influence students' performance in both MED and PME. Table 6 shows the contribution of each belief's dimensions to academic performance. The result indicated that in MED, personal epistemological beliefs contribute more to academic performance than PME.

Table 6

The regression of DFEQ on students' academic performances

Factors	r		r. . 100	t (4)	p
Mathematics Ed (MED)					
Certainty of knowledge	.62	.32	19.84	3.99	.001
Justification for knowing	.51	.16	8.16	2.18	.03
Source of knowledge	.60	.31	18.6	4.08	.001
Attainability of truth	.47	.10	4.7	1.38	.17
Total variance explained			51%		
Primary Ed (PME).					
Certainty of knowledge	.47	.22	10.34	1.73	.09
Justification for knowing	.44	.19	8.36	1.73	.09
Source of knowledge	.43	.14	6.02	1.12	.26
Attainability of truth	.39	.05	1.95	.39	.70
Total variance explained			26%		

Note. N = 146; F-statistics MED. = 14.55. *p* < .001. *N* = 130*; F-statistics PME* = 11.09, *p* < .001. Academic performance ranges from 1-4.

In the context of MED, data table 6 showed that all predictors explain students' academic performance, 51% of the total variance academic performance, R^2 = .51, *p* < .001. The model regression of discipline-focused epistemological beliefs were significant, *F (142) = 14.55, p* < .001. All the dimensions, but not the attainability of truth, significantly influence academic performance. Certainty of knowledge positively influences academic performance (= .31, *t* (142) = 3.99, *p* <.001). Justification for knowing was also positively significant in influencing academic performance (= .16, *t* = 2.18, *p* = .03) as well as the Source of knowledge (= .23, *t* = 4.08, *p* < .001). However, we did not find the influent partially of the attainability of truth (= .10, *t* = 1.38, *p* < .001*)* on the academic performance in MED.

Whilst in the PME context, the result indicated personal epistemological beliefs could predict and explain students' academic performance, 26% of the total variance, R^2 = 26, *p* < .001. The regression model also indicated that all the dimensions of the discipline-focused epistemological beliefs influence students' academic performance, *F* (126) = 11.09, *p* < .001. However, in the partial dimensions, none of the discipline-focused epistemological beliefs dimensions partially influence students' academic performance.

4.4 RQ3: Do personal epistemological beliefs correlate with students' attitudes toward the academic context?

Table 7 presents the relationship between students' beliefs and attitudes toward their discipline study. We performed a simple correlation to evaluate whether each of these beliefs' dimensions correlates significantly with their attitudes toward academic performances.

Table 7

The correlation between epistemological beliefs and students' attitudes

Dimensions	MED	PME
Certainty of knowledge	.55**	.73**
Justification for knowing	.56**	.65**
Source of knowledge	.68**	.72**
Attainability of truth	.51**	.68**

Note. * $P < .05$, ** $p < .001$

Table 3 data describes that in MED, the pair of sources of knowledge and attitude has the highest correlation coefficient (r = .68). It means the more students' beliefs about the Source of knowledge, such as the statement "Sometimes you just have to accept answers from the experts in this field, even if you don't understand them, "the more students have high attitudes toward academic context. The other dimensions have shown a moderate correlation with attitude. The correlation between the certainty of knowledge and attitudes is 55(r = .55). Justification for knowing also has a moderate correlation with attitude (r = .56). The more students' beliefs about the certainty of knowledge, such as believing that knowledge in mathematics unchanging or the principle in this field is unchanging, the stronger positive attitude students towards mathematics. Attainability of truth showed moderate relation with attitude toward academic context (r = .51).

In PME, the correlation between personal epistemological beliefs dimension and attitude is stronger than in mathematics education. Certainty of knowledge gained the highest correlation coefficient to attitude (r =.73). It means the more students perceive that knowledge in their field is stagnant, the more students have positive attitudes toward academic context. Justification of knowing is the lowest correlation among other dimensions. However, the correlations between these beliefs and attitudes are also strong (r = .65). The correlation between the Source of knowledge and attitude academic performance is strong (r = .72). The moderate correlation has been shown by the attainability of truth (r =.68) and attitude toward academic context.

4.5 RQ4: Were there any differences between male and female students regarding personal epistemological beliefs?

Table 8 below presents the differences in students' epistemological beliefs based on gender differences. We performed an independent sample t-test to measure the role of their gender on beliefs in both MED and PME. Because according to a prior study (Li, 2004), there was an association between beliefs and gender preferences. Males students showed higher beliefs about mathematics education than female students. In this study, generally, we did not find differences in beliefs about mathematics education in terms of gender preferences, either for MED students or PME students.

Table 8

Comparison of students' personal epistemological beliefs based on the gender differences

Factors	Male M(SD)	Female M(SD)	*p*
Certainty of knowledge	29.96 (3.82)	29.70 (5.25)	.81
Justification for knowing	12.85 (2.60)	13.80 (2.98)	.13
Source of knowledge	13.63 (2.87)	13.63 (2.76)	1.0
Attainability of truth	8.26 (1.70)	8.17 (1.42)	.77

Note. Significant if the p < .05

First, the data from table 8 indicated that either males or females hold strong beliefs about the certainty of knowledge (M = 29.96, SD = 3.82 and M = 29.70, SD = 5.25, respectively, t (274) = .97, p = .33). We further investigated by performing a t-test on the level items. For instance, both males and female students perceived that all experts understand the field in the same way according to the mean result (M = 3.46, SD = 1.02, and M =3.36, SD = 1.11, respectively). Males (M = 3.41, SD = 1.12) and females (M= 3.24, SD = 1.29) have the same level of belief that the truth is not unchanging in their study.

Second, for justification for knowing, males (M = 12.85, SD = 2.60) and females (M = 13.80, SD = 2.98) students indicated that they had the same conception of how they justify the knowledge (t (274) = -.14, p = .16). For further investigation in the level items, we also examine students' responses for these beliefs by performing a t-test. For instance, males (mean = 4.05) and females (mean = 4.07, sig = .90) are equal in the belief that firsthand experience is the best way of knowing something.

Third, in Source of knowledge, there was no significant difference between males and females in this belief (M = 13.54, SD = 2.75 and M = 13.30, SD = 3.00, respectively, t (247) = .46, p = .65). In the level items, for instance, both males (M= 3.64, SD = 1.09) and females (M = 3.61, SD = 1.03) students are equal in beliefs that they only have to accept answers from the experts, even if they don't understand them.

Fourth, there were no significant differences between males and females students in beliefs about the attainment of the truth (M = 8.10, SD = 1.70 and M = 7.74, SD = 1.72), respectively, t (274) = 1.21, p = .23). Then, we examine the differences between the two in the items level. Males (M = 3.79, SD = 0.98) and females (M = 3.73, SD = 0.96) are equivalent in perceiving that experts in their field study can ultimately get to the truth. Males (M = 4.31, SD = 0.89) and females (M= 4.01, SD = 0.92) also expressed the same belief that if scholars try hard enough, they can find answers to almost anything.

4.6 RQ5: Do parents' educational backgrounds generate different personal epistemological beliefs?

We performed ANOVA to answer whether parents' education generated significant personal epistemological beliefs for both MED and PME students. We used mothers' and fathers' education as the independent variables (See table 9). In mathematics education departments (MED), we did not find personal epistemological belief differences based on parents' education, either father or mother's education. For instance, students were equal in beliefs about the certainty of knowledge (F (3) = 1.34, p = .27), justification for knowing (F (3) = 0.69, p = .65), Source of knowledge (F (3) = 1.57, p = .20), and attainment of the truth (F (3) = 0.72, p = .54) according to mothers' education. Students' personal epistemological beliefs were also equal according to the father's education level, the certainty of knowledge (F (3) = 0.53, p = .66), justification for knowing (F (3) = 0.14, p = .94), Source of knowledge (F (3) = 0.36, p = .78), and attainment of the truth (F (3) = 0.16, p = .92)

Table 9

Personal epistemological beliefs according to mothers' and fathers' educational level

Variables	Edu Level	Mother education				Father Education			
		M	SD	F	p	M	SD	F	p
Mathematics education department (MED)									
Certainty of knowledge	ED	28.75	6.42	1.34	.27	28.97	5.59	0.53	.66
	JHS	29.33	4.70			29.35	6.16		
	SHS	30.65	4.55			30.08	4.51		
	Univ.	29.75	3.98			30.32	4.45		
Justification for knowing	ED	13.91	3.20	0.69	.65	13.44	2.67	0.14	.94
	JHS	13.44	2.94			13.45	3.98		
	SHS	13.80	2.84			13.68	2.77		
	Univ	12.86	2.78			13.88	2.84		
Source of knowledge	ED	13.42	3.22	1.57	.20	13.22	2.92	0.36	.78
	JHS	13.19	2.86			13.90	3.04		
	SHS	14.15	2.60			13.72	2.74		
	Univ	12.90	2.21			13.76	2.45		
Attainment of the truth	ED	8.27	1.44	0.72	.54	8.22	1.48	0.16	.92
	JHS	8.00	1.69			8.25	1.89		
	SHS	8.23	1.21			8.21	1.27		
	Univ	7.86	1.93			8.00	1.47		
Primary Education Teacher department (PME)									
Certainty of knowledge	ED	26.76	6.75	0.84	.47	27.13	6.67	0.52	.67
	JHS	29.07	5.92			28.67	7.00		
	SHS	28.08	5.86			28.66	4.90		
	Univ.	27.85	4.76			27.62	5.68		
Justification for knowing	ED	13.78	3.73	0.61	.61	13.78	3.35	0.04	.99
	JHS	14.14	2.84			13.73	3.58		
	SHS	13.35	2.71			13.86	2.54		
	Univ.	14.29	2.67			14.00	3.11		
Source of knowledge	ED	12.46	3.97	1.15	.33	12.80	3.68	0.22	.89
	JHS	13.31	2.77			12.73	3.77		
	SHS	12.73	2.61			13.11	2.47		
	Univ.	13.81	2.91			13.35	2.95		
Attainment of the truth	ED	6.95	2.16	1.31	.27	7.13	2.14	0.40	.75
	JHS	7.24	1.92			7.40	2.16		
	SHS	7.78	1.67			7.57	1.52		
	Univ.	7.44	1.58			7.35	1.79		

Note. ED = elementary education level, JHS = Junior high schools level, SHS = senior high schools level, and Univ = University level.

The differences in personal epistemological beliefs according to parents' education in the primary education (PME) department were insignificant. For example, students' personal epistemological beliefs were equally based on the mother's educational level, the certainty of knowledge (F (3) = 0.84, p = .47), justification for knowing (F (3) = 0.61 p = .61), source of knowledge (F (3) = 1.15, p = .33), and attainment of the truth (F (3) = 1.31, p = .27). There were no significant differences of personal epistemological beliefs according to fathers' educational level in PME, the certainty of knowledge (F (3) = 0.52, p = .67), justification for knowing (F (3) = 0.04, p = .99), Source of knowledge (F (3) = 0.22, p = .89), and attainment of the truth (F (3) = 0.40, p = .75)

5. Discussion

The finding of this study contributed to clarifying specificity and generality domain beliefs in mathematics education and primary teacher education. The relation of personal epistemological beliefs with achievements, attitudes, parent education, and gender is also explored. We explore the validity and reliability of each questionnaire by performing confirmatory factor analysis (CFA) and Cronbach alpha before we further analyze the data. Our instruments are valid and reliable for the Indonesian context. Most important, by investigating the role of personal epistemological beliefs as proposed by Hofer (2000), this study found the critical role of these beliefs on academic performance and attitudes.

Surprisingly, our finding not only supports that personal epistemological beliefs are a more specific domain, but our finding also supports that certain beliefs are more general. We found that MED students hold stronger beliefs about the certainty of knowledge than PME students. For instance, MED students more positively viewed that the principles in their field study are not changing than PME students. Also, MED students hold stronger beliefs about the attainability of truth than PME students. This finding partially reveals the same result as the previous study by Hofer (2000), who found the dimensionality of personal epistemological beliefs. In other words, the result showed that the beliefs (certainty of knowledge and attainability of truth) are more specific domains. Our interpretation regarding the differences between the two is that MED students frequently receive subjects more about natural mathematics in their classroom than PME students. They frequently encounter the formula and problem-solving that are more certain than PME students. Bandura (2001) mentioned that students' cognitions and behavior are influenced by their learning experience in the class. Interestingly, we found that MDE and PME students are equal in their beliefs about the justification for knowing and the Source of knowledge. This finding is in line with the study by Schommer et al. (2005), which suggested that beliefs are more general. For instance, MED and PME students are equal in believing that firsthand experience is very important to know something in their field study. Limón (2006) argued that both general and specific beliefs domains are the theoretical framework and method matter. In other words, possibly there may be some differences and some similarities in beliefs about knowledge based on the field study, but it depends on the theoretical framework and the methodological issue.

The second finding of this study explains that personal epistemological beliefs significantly influence students' academic performance. This finding is consistent with the prior research (Csíkos et al., 2011; Hidayatullah & Csíkos, 2022; Hofer, 2000; Schommer-aikins et al., 2005) that suggested the stronger students' beliefs, the higher their achievement in academic performance. Cartagena Beteta et al. (2022) argued that personal beliefs would affect intrinsic and extrinsic behavior and academic performance. In MED, we found all of the factors of personal epistemological beliefs can explain 51% of students' academic performance. This prediction statistically is higher than PME students. Besides, all of the factors of personal epistemological beliefs significantly influence academic performance except the attainability of truth. Although personal epistemological beliefs in PME also determine students' academic performance, the partial influence of each factor is not significant. From this stage, the possible explanation of what students learned during mathematics class contributed to their personal epistemological beliefs, such as certainty of knowledge and justification for knowing, and in turn, affected their academic performance. In comparison, PME students get more general topics about teaching and learning for primary education. So, their personal epistemological beliefs on academic performance are lower than MED students.

The third finding of this study showed the relationship between personal epistemological beliefs and attitudes toward academic performance. As mentioned by McLeod (1992) and Pehkonen & Pietilä (2003), beliefs are cognitions aspect, while attitude is a more emotional aspect. We found a significant correlation between personal epistemological beliefs and attitudes in both MED and PME fields. All of the factors have high correlations with attitudes toward academic performance. Our interpretation for this stage is that if students increase their personal epistemological beliefs about knowledge, it will affect their attitude toward the academic context. The impact of students' beliefs and attitudes toward the academic context in the university may also reduce the possibility of college students dropping out of their studies.

Fourth, we find no significant differences between males and females in their personal epistemological beliefs. Both MED and PME students are equal in all the factors. This finding contradicts the prior research (Samuelsson & Samuelsson, 2016; Li, 2004), which finds significant differences between the two. Our interpretation of this stage is that the Indonesian government provides opportunities for all students to pursue their high education. Higher education also provides equal access for males and females in Indonesia. Although we do not find any significant differences between male and female students, gender equity it remains should be considered because equity is a process. We do not say male and female students are equal in all subjects or field studies. Therefore, further investigations are still needed to investigate gender differences.

Finally, our findings showed no significant differences in personal epistemological beliefs according to the mother and father's educational background. Students with fathers with no educational background or students with parents with high education backgrounds showed equal personal epistemological beliefs. The differences in the mother's educational level also do not show the differences in students' personal epistemological beliefs. This finding contradicts the previous study (Guryan et al., 2008; Jacobs & Bleeker, 2004) that the level of parents' education may affect students' cognition and behavior, as mentioned by Davis-Kean (2005) and Gladstone et al.(2018) that the number of education parents receives may affect how they set the environment at their home. We assume that students in higher education in the Indonesian context are more independent than secondary schools. Therefore, the parental educational level influence is not significant.

However, several limitations in the present study should be noted. The limitation of this study lies in the number of participants, and students' field studies are in the same area, which is education. Therefore, further research may consider the different dimensionality of students based on the different areas, such as the comparison beliefs in social humanities and engineering faculty. Although we found that students in MED show hold stronger certainty of knowledge than PME, we have no information on whether their beliefs change or not at the end of their study. Therefore, a longitudinal study is required to confirm whether the personal epistemological beliefs of students changes or not. In this study, we only measured the association between personal epistemological beliefs and general point academic (GPA). We have no information on how personal epistemological beliefs influence academic performance and its relation to other aspects. Future research also needs to examine the influence of these beliefs on academic performance indirectly and directly.

6. Conclusion and Implication

To summarize this study, the finding of this research is significant because it provides empirical data to clarify the debatable among researchers about the general and specific domain of beliefs in different studies. In the Indonesian context, this finding supports both general and specific domains. Certain beliefs (certainty of knowledge and attainability of the truth) are more specific domains, and other beliefs (justification for knowing and source of knowledge) are more general. We also found that personal epistemological beliefs influence academic performance and correlate with attitudes toward academic performance. We did not find significant differences in personal epistemological beliefs based on gender and parents' educational background preferences.

The wealth result of this study is very important for academic research, teaching, and learning. For academic research, the finding of this study can be used as an analysis discourse in mathematics education and the primary teacher education departments. For the educator in both departments, the improvement of students’ beliefs in justification for knowledge is needed because our data showed that students' response to these beliefs is weak. The educator in primary teacher education should put much effort into improving students’ beliefs about the source of knowledge. Our findings also mention that personal epistemological beliefs are associated with students’ academic performance and attitudes. The educators need to improve and maintain students’ personal epistemological beliefs because these beliefs would affect their attitude and their academic performance. Therefore, educators should design their class environment, so that students can shape their beliefs about knowledge in their area to improve their academic performance.

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Study 2

Exploring students' mathematical beliefs: gender, grade, and culture differences

(Hidayatullah & Csíkos, 2023)

Full research paper

EXPLORING STUDENTS' MATHEMATICAL BELIEFS: GENDER, GRADE, AND CULTURE DIFFERENCES

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ABSTRACT

The investigation of students' conceptions of knowledge of mathematics and the process of knowing mathematics is important to provide an understanding of the phenomena behind students' performance. However, there is a scarcity of empirical investigation of students' beliefs about mathematics knowledge in the Indonesian context. This study aims to assess students' beliefs about mathematics education. The relation of these beliefs with gender, grade, and culture was also examined. Fifteen classes were selected by stratified random sampling methods. 536 students (boys = 217, girls = 319) from 8-9 grades participated in the present study. The result of this study revealed that students tend to perceive their mathematics teachers as having tried to make mathematics lessons interesting and perceived that mathematics knowledge continues to expand. Boys' students hold stronger beliefs that they can understand the most difficult tasks in mathematics than girls' students. Grade eight students have higher beliefs than ninth-grade students. Javanese students hold stronger beliefs in mathematics performance than Madurese students. The finding of this study provided information on how to design teaching and learning mathematics in the Indonesian context.

KEYWORDS

Culture, gender, grade, mathematics, students' beliefs

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Highlights

- *Students' conceptions of the teacher role, the nature of mathematics, mathematics performance, and mathematics learning are explored.*
- *Indonesian students believe that mathematics knowledge is dynamics.*
- *Students' beliefs in mathematics learning are different based on their ethnicity.*
- *Boys' and girls' students are different in certain mathematics beliefs.*

INTRODUCTION

Individual conceptions about mathematics knowledge and how they come to know mathematics are essential factors, containing fruitful information about the individual mental process, which have been addressed in the literature review. The ways students conceptualize mathematics or epistemological beliefs in mathematics are important for research and may provide a wealth of understanding to explain the important phenomena behind students' performance in mathematics learning. Beliefs drive students' behavior toward mathematics and their tendency to solve mathematical tasks (Voica et al., 2020). Beliefs are the engine that navigates students to use certain strategies when solving mathematical tasks (Öztürk, Akkan and Kaplan, 2020). Existing studies have shown epistemological beliefs about mathematics was linked with various aspect such as performance, motivation, and attitudes toward mathematics (Heyder et al, 2020; Perera and John, 2020; Silver et al., 2021). Hidayatullah and Csíkos (2023) reported that epistemological beliefs significantly correlate with attitudes and motivation. The stronger individual beliefs, the higher their motivation and perception about objects. Students with strong beliefs about themselves, like believing that they can solve or understand the most difficult topic in mathematics, may drive to put more effort in order to achieve the best performance in mathematics. Gijsbers et al. (2020) reported that students might have fewer beliefs in the relevance of mathematics unless they get an intervention to strengthen their beliefs. Since the prior research (Öztürk, Akkan and Kaplan, 2020; Voica, Singer and Stan, 2020) suggested that there was a relationship between personal mathematical beliefs and performance in math, there may be a possibility that poor performance in math is affected by individual beliefs. Accordingly, the cognitive test result is not enough to explain the phenomena behind poor performance in mathematics, like the students' mathematics scores in Indonesia (Hidayatullah and Csíkos, 2023). The investigation of individual epistemological beliefs about mathematics education provided fruitful information on how to increase the quality of mathematics education.

In the Indonesian context, research beliefs about mathematics have been conducted by several researchers. Zulkarnain et al. (2021) investigated students' self-efficacy beliefs and problem-solving ability in mathematics learning. The focus of that study describes the differences in students' beliefs about their capability in mathematics learning and their ability to solve mathematical tasks. However, researchers did not explain students' conceptions of nature mathematics and problem-solving in mathematics. Other research by Elizar (2021) investigated the influence of mathematics beliefs on students' achievements. Although this study has proved the influence of beliefs about mathematics on achievements, the theoretical framework of the belief system was not mentioned clearly. The latest study was conducted by Hidayatullah et al. (2022), which investigated students' epistemological beliefs in mathematics using the theoretical framework as suggested by Op 't Eynde et al. (2006). In this study, the researcher emphasizes o the adaptation of these mathematics-related belief system questionnaires and their relationship with the ability to solve word problems. However, the researcher failed to provide an explanation of the level of students' mathematical beliefs. Also, whether their personal background (e.g., gender, grade, and culture) contributed to these beliefs or not was unexplored. Therefore, investigating personal conceptions in mathematics with a more comprehensive understanding, as suggested by Op 't Eynde et al. (2006), is necessary. For that reason, our cross-sectional study attempts to identify students' mathematical beliefs in the Indonesian context. Moreover, relevant factors such as gender, age, and cultural differences were examined in the present study. Because in the previous, education equality in the Indonesian context has always been questioned.

1. How do students believe in mathematics in the Indonesian context?
2. Does gender inequality exist in terms of students' beliefs about mathematics education?
3. How do students believe in mathematics education across levels?
4. Are there significant differences that can be identified through the investigation of epistemological beliefs in mathematics based on culture?

THEORETICAL FRAMEWORK

Mathematical beliefs in the education context

Beliefs in mathematics are defined as implicit or explicit students' beliefs held to be true about mathematics education, the self as a mathematics learner, and mathematics in the class context (De Corte, 2015). Accordingly, the beliefs consisted of three dimensions: beliefs about mathematics education, self-efficacy beliefs in mathematics, and personal beliefs about lesson mathematics in the class. These dimensions determine close interaction with each other and students' prior knowledge of their mathematics learning and problem-solving activities in the class context. However, these beliefs may change alongside the growth of students' interaction and their experience in mathematics lessons. For instance, the research by Gijsbers et al. (2020) showed how mathematical beliefs changed through certain interventions. Students showed stronger beliefs about mathematics's relevance after an intervention. Therefore, mathematical beliefs may be stronger or less after they have many experiences during mathematics lessons, like the teaching style and interaction with students.

Concerning the role of beliefs in mathematics learning, some empirical evidence describes the critical role of beliefs about mathematics in the context of mathematics schools. Csíkos et al. (2011) have reported that students' beliefs about word problems determine the way students solve word problems in mathematics. The researchers found in the context of Hungary, students failed to involve real-world knowledge because students held mistaken beliefs about word problems in mathematics. Öztürk et al. (2020) suggested that when the level of students' mathematical beliefs predicted their skill in mathematic problem-solving. Students with higher beliefs in solving mathematics problems tend to have better skills in problem-solving. Through their investigation, Voica et al. (2020) found that when students believe in their capability to solve mathematics problems, they have stronger motivation, affecting their performance while solving mathematical tasks. The latest research by Hidayatullah and Csíkos (2022) also found the role of beliefs about mathematics on the word problem-solving in mathematics. However, most previous studies emphasise the relation between beliefs and mathematics outcome. At the same time, students' beliefs about mathematics education differences based on their personal is still unexplored.

Gender and mathematics beliefs

Several researchers have recorded the connections between beliefs and gender. However, no single result mentioned consistently boys are overachieved than girls students or vice versa. For example, Vuletich et al. (2020) found that females hold stronger beliefs about mathematics than male students. These findings affirmed that mathematics is boys' domain. While Dustan et al. (2022) reported that boys tend to believe they are overscored than girls, girls also believe that boys overscored than girls. Liou et al. (2021) reported that boys hold stronger beliefs than girls. The latest study by Seo et al. (2019) showed that girls have more negative beliefs than boys among Latina and White adolescents in the united states. In the Indonesian context, the association between mathematics-related beliefs with gender differences has not been studied. At the same time, gender equality questions arise since the segregation of boys' and girls' seats in the field has still been conducted by most schools, particularly in Islamic schools (Srimulyani, 2007). The segregation of boys and girls in several Indonesian schools is based on the assumption unify them in the same place would generate a negative impact. Therefore, the investigation of gender differences in terms of epistemological belief systems in mathematics is important. Through this investigation, students' beliefs and performance were explored.

Beliefs and students' grade

In the historical development of cognition research, Piaget in his work explained that individual cognition develops gradually from sensory motoric to formal operational (Zhan et al., 2022). He also explained that the way individual cognition develops through the spontaneous process is tied to the whole process of embryogenesis. At the same time, embryogenesis is not only about body matter but also about mental process development matter. Since cognition has developed over the years, individual beliefs also develop because it contains cognition aspect. Perry's investigation has noted how individual beliefs developed over the years (Taylor, 2016). A longitudinal study by Caprara et al. (2011) in Rome reported that the level of students' grades contributed to students' beliefs about themselves. However, in this research, authors did not explain whether the differences in the level of study also generated differences in beliefs or not. Mozahem et al. (2021) reported that individual beliefs about their capability decreased after becoming older because they received a negative experience like a repeated failure that affected the level of the judgment of their capability. A study by Liou et al. (2021) investigated the students' motivational beliefs across grade levels and gender differences have found that students' conception of their capability decreased significantly from 4 grade to 8 grade. Passolunghi et al (2014), through their investigation, found that pupils in elementary education have higher levels of beliefs than pupils in middle schools. Therefore, we assumed that in the educational context, students in different grades differ because they have different experiences in mathematics learning. For instance, ninth-grade students have more experience regarding mathematics learning in the classroom than eight grade students. Grade ninth students may hold stronger beliefs in mathematics learning since they have experience with problem-solving much more than eighth-grade students. In the present study, the differences in grade study are examined to explain whether the level of study generated different beliefs about mathematics education.

Beliefs differences and students' culture

According to the social cognitive theory proposed by Bandura (2001), individual social life, including social interaction, contribute to students' cognition. Culture also plays a key role in determining students' cognition as well as their perception of mathematics (Kang and Leung, 2022). However, there was an inconsistency among the previous research concerning students' beliefs and their relation to cultural differences. For example, Kang and Leung (2022), during their comparison study between Dai and Han students in China, did not find any significant differences in the context value of beliefs in mathematics. In contrast, Seo et al. (2019) have proved differences in students' beliefs based on ethnicity, where the researcher found that Latina, Asian, and Black girls hold higher beliefs (e.g., growth mindset) than white girls. In the Indonesian context, there is a diversity of cultures. According to the Bureau of Statistics, there are 1331 ethnics that generated multiculturism. According to the Ministry of Education and Culture data, there are 652 local languages. As we discussed earlier, the social environment may generate differences in students' beliefs about knowledge (Kang and Leung, 2022; Seo et al., 2019). In the present study, our participants can pertain to two regions: Sumenep and Surabaya. The two regions, even if in the same province, they have different cultures. For instance, students in Surabaya are Javanese ethnic and use the Javanese language. In the classroom, students use the Indonesian language as the official language. However, for informal interaction and daily life activities, they use the Javanese language. In comparison, students in Sumenep are Madurese ethnic and use the Madurese language for communicating in daily life. In the classroom, they use the Indonesian language as an official language for interaction. Surabaya is an urban city, the center of business in east java province. Contrary, in the Sumenep, most people are farmers. So, the people in both city has a different culture, which may imply the extent they perceive mathematics knowledge. Therefore, in the present study, the student's beliefs about mathematics education based on cultural differences are examined.

METHOD

Participants

The present study took place in Surabaya and Sumenep, east-java province, Indonesia. In Surabaya, most students are Javanese ethnic, while in Sumenep, the students are mostly Madurese ethnic. Fifteen classes were selected using stratified random sampling from sixth of public and private schools. 536 seventh and eighth-grade (boys = 217, girls = 319) students participated in the present study and completed the questionnaire. Most classes in the present research segregated the groups of boys and girls. All participants were asked to complete the questionnaire in the present study.

Instruments

To measure students' mathematical beliefs, we adapted 28 items from a mathematics-related beliefs system questionnaire (Op 't Eynde, De Corte and Verschaffel, 2006). This questionnaire consisted of four factors. We selected ten items of *beliefs about the role and functioning of the teacher*, for instance: "My teacher wants me to understand the concepts, not only memorize the mathematics formula." Seventh item of *belief about the significance of and competence of mathematics*. For instance: "I am very interested in mathematics learning" and "I can understand even the most difficult material. "Seventh items of *beliefs about mathematics as a social activity*, for example: "Mathematical knowledge continues to expand,
& new things are found all the time" and "Anyone can learn mathematics. " Four items of *beliefs about mathematics as a domain excellent*, for example: "I am only satisfied when
I got good grades in mathematics" and "I want to do well in mathematics to show the teacher and my friends how good I am at it."

Procedure

The procedure of this study is through three steps. In the first steps, we started communicating with principals and mathematics educators. We described the purposes of this study. We send our proposal research to several teachers as well as our instruments. The instruments in the present study have been reviewed by the mathematics educators in the schools. In the second step,

Characteristic	Full sample	Percentage
Gender		
Boys	217	40.5%
Girls	319	59.5%
Grade		
seventh	410	76.5%
eight	126	23.5%
Ethnic		
Javanese	400	74.6%
Madurese	135	25.4%
Age		
12years	6	1.1%
13 years	206	38.4%
14 years	256	47.8%
15 years	63	11.8%
16 years	5	0.9%

Table 1: The demography of the participants

after we got permission from the principals, we administered our instruments to the schools. Mathematics educators helped with the collecting data process. MRBQ and mathematics tests were administrated to students using online systems. For the MRBQ, we used the Likert scale rate from 1 to 5; 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree. The data collection process has taken place at the end of the semester. The collecting data process took place for two weeks. This means the teachers gave enough time to the students to complete our instruments. In the third step, we analyze our data.

Data analysis

This research used a quantitative approach which performed several statistical data analyses to answer the research questions. Several data analysis was used during the data analysis process. In the first step, we confirmed the validity and reliability of the questionnaire. Confirmatory factor analysis (CFA) was used to examine the construct validity of the questionnaire. The combination of CFI, TLI above 0.9, and RMSEA below 0.05 indicated the model of the construct validity fit (Hu and Bentler, 1999). Descriptive statistics were performed to answer the first questions. Finally, an independent sample *t*-test was performed to examine the beliefs about mathematics differences based on students' gender, level of study, and culture. According to Cohen (1992) the effect size is low if the value of r varies around 0.1, medium if r varies around 0.3, and large if r varies more than 0.5.

RESULTS

Confirming the validity and reliability

In this study, we performed exploratory factor analyses (EFA) to confirm the variance of students' mathematics beliefs. The coefficient of KMO and Barlet test sphericity = 0.95, Chi-square (df = 272) = 648.26, $p < .001$, indicated that the sample in the present study is adequate. Maximum likelihood was used as a parameter estimate, with varimax rotation and an absolute value of 0.3. Four factors have been identified: beliefs about the teacher, the nature of mathematics, mathematics learning, and mathematics performance.

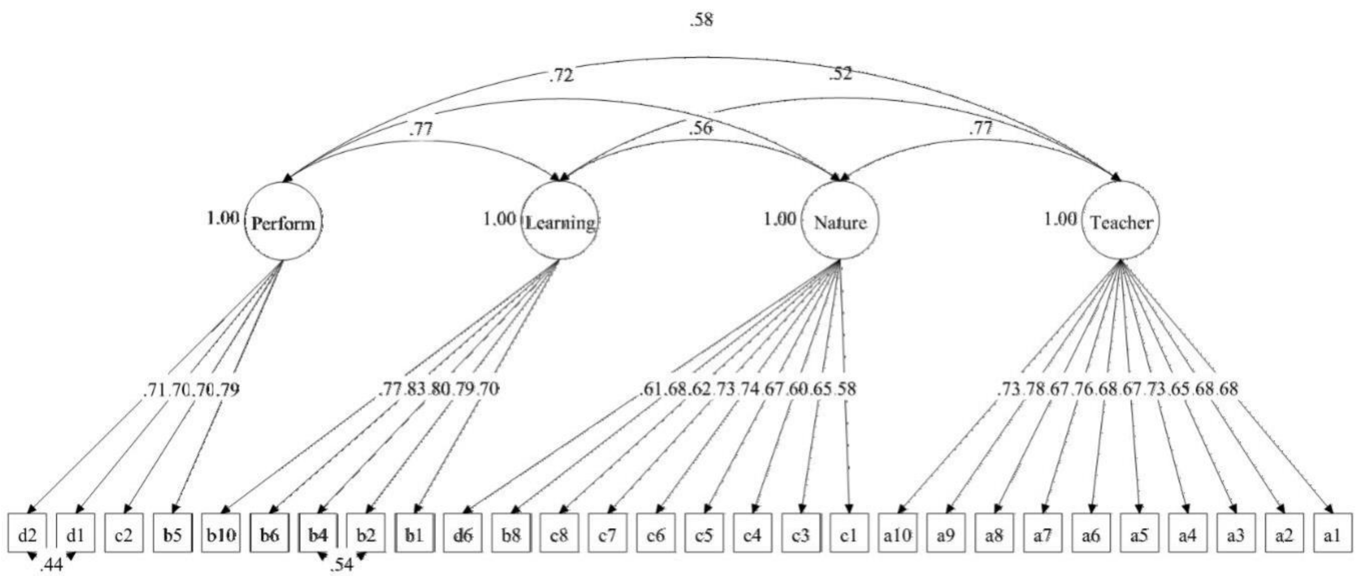

Figure 1: Confirmatory factor analysis of students' mathematical beliefs

We found the fit model of this questionnaire (See figure 1), Chi-square = 808.70, *df* = 342, CFI =0.94, TLI = 0.94, RMSEA= .05, SRMR = 0.04, $p < .001$ (Hu and Bentler, 1999; van de Schoot et al, 2012). All items have good factor loading, ranging from 0.58–0.82 (Appendix 1). We confirmed the reliability of the questionnaire by performing Cronbach alpha. The result showed that all of the factors have good reliability, beliefs of the teacher consisted of 10 items (alpha = .90), the nature of mathematics consisted of 9 items (alpha = .87), mathematics learning consisted of 5 items (alpha = .89), and mathematics performance consisted of 4 items (alpha = .89). Beliefs in the teacher consisted of the item which related to the statement of students' beliefs about the role of their mathematics teacher in the classroom context. Beliefs in the nature of mathematics entailed students' judgment about the nature of mathematics, such as the statement "mathematical knowledge continues to expand." Beliefs in mathematics learning related to students' intrinsic and extrinsic orientation beliefs in mathematics learning. In comparison, beliefs in mathematics performance deal with students' judgment about their capability in mathematics learning.

Preliminary analysis

Table 2 describes the descriptive statistics and the correlation beliefs about mathematics education factors. The result showed that beliefs about nature strongly correlated with beliefs about the teacher and moderately correlated with mathematics learning and performance. It means that those who believed in the role of their mathematics teachers tended to be more confident and more interested in mathematics.

Variables	Mean	SD	1	2	3	4	5	6
Beliefs about teacher	4.23	0.75						
Nature mathematics	4.38	0.68	.68**					
Mathematics learning	3.33	1.05	.47**	.48**				
Mathematics performance	3.76	0.95	.47**	.60**	.64**			
Gender	-	-	-.01	-.08	.10*	.00		
Grade	-	-	-.11*	-.08	.01	-.06	-.06	
Ethnic	-	-	-.09	-.03	.14*	-.06	.19**	.30**

*Note: * significant p < .05, ** significant p < .001*

Table 2: Correlation between each belief about mathematics factors and the achievement of mathematic

Beliefs about mathematics learning were moderately correlated with the conception of nature mathematics. Students who viewed mathematics as dynamic knowledge tended to be more interested in mathematics learning. Beliefs about mathematics learning were strongly correlated with beliefs in mathematics performance.

RQ1: How do students believe in mathematics in the Indonesian context?

In the first factor (See Appendix), students expressed strong beliefs in the role of mathematics teachers as indicated by the highly mean result of the "beliefs in the role of the teacher" factor (3.40-4.40, on a 5-point Likert scale). Students viewed that their teacher was really friendly in mathematics learning (M = 4.16, SD = .99). Students strongly expressed that their mathematics teacher listens to them carefully if they have any questions (M= 4.38, SD = 0.91) and understand their students if the students face some difficulties in mathematics learning (M = 4.02, SD = 1.10). Students believe that their teachers have tried to make mathematics lesson to be not bored learning (M= 4.24, SD = 1.04) and give students time to explore new things (M = 4.23, SD = 1.04)

Second, beliefs in nature mathematics. Students hold strong beliefs about nature mathematics as indicated by the mean result of the items in this factor (4.11-4.68, on a 5-point Likert scale). For further analysis, we found that students perceived that mathematics evolved, dynamics, and the new this still can be discovered (M = 4.28, SD = 0.93). Students viewed problem-solving in mathematics requires smart thinking (M = 4.44, SD = 1.01), and there are many ways to find the right solution in mathematics problems (M = 4.37, SD = 0.91). Students also expressed that all people could study mathematics (M = 4.40, SD = 0.93), and mathematics has been used by many people in daily life (M = 4.41, SD = 0.93).

The third is the belief in mathematics learning. Generally, students expressed moderate beliefs in mathematics learning according to the mean result of the corresponding items in this factor (3.20–3.44 on a 5-point Likert scale). In mathematics learning, students expressed the belief that they could understand mathematics content, even if it was very difficult (M = 3.30, SD = 1.24). Students expressed that they like mathematics (M = 3.20, SD = 1.32) and are interested in mathematics learning (M = 3.25, SD = 1.32). However, the mean result for neutral in these beliefs was also high, as indicated by the median results (median = 3.00) of the items.

The fourth is beliefs about mathematics performance. Students showed moderate beliefs, as indicated by the mean result of the items (M = 3.64 to 3.94). Students expressed that they were quite confident about getting good grades in mathematics learning (M = 3.94, SD = 1.09), and they wanted to show other people that they are good at mathematics (M = 3.76, SD = 1.25). Students want to show others that they are better than other students in mathematics learning (M = 3.69, SD = 1.25). Students also viewed that with mathematics, someone can use their skills to understand more comprehensive problems in daily life (M = 3.64, SD = 1.07).

RQ2: Do gender inequality exist in term of mathematical beliefs?

Table 3 compares boys' and girls' beliefs about mathematics education factors. An independent sample *t*-test was used to examine whether the gender differences generated different beliefs and performance in mathematics learning.

Independent Variables	Boys (217)		Girls (319)		*F*	*t*(534)	*p*	Cohen's *d*
	M	SD	M	SD				
Beliefs in the teacher	4.24	0.79	4.23	0.72	2.43	0.11	.92	0.01
Nature of mathematics	4.32	0.69	4.42	0.61	3.87	-1.76	.08	-0.16
Mathematics learning	3.46	1.05	3.24	1.05	0.33	2.35	.01*	0.21
Mathematics performance	3.76	0.95	3.76	0.95	0.41	-.03	.97	-.00

*Note: * significant p < .05, ** significant p < .001*

Table 3: Boys' and Girls' mathematical beliefs differences

The independent sample *t*- test result indicated no significant differences between boys' and girls' students' beliefs about the teacher, the nature of mathematics, and mathematics performance. Boys and girls were different in their beliefs about mathematics learning ($p < 0.01$), where the boys (M = 3.46, SD = 1.05) gained higher beliefs than the girls (M = 3.24, SD = 1.05). However, the differences between them were small ($d = 0.21$).

RQ3: How do students believe in mathematics education across levels?

Table 4 describes the result of the *t*-test to identify whether there are differences in students' beliefs about mathematics education across the level. According to the result of the *t*-test, there were no differences in students' beliefs in the nature, learning, and performance of mathematics. Students in grade eight are different from students in grade ninth in their beliefs about the teachers with a small effect size ($d = 0.26$). Students in grade eight hold stronger beliefs about the role of a teacher than students in grade nine; (M = 4.24, SD = 0.73 vs. M = 4.09, SD = 0.79, respectively).

RQ4: Are there significant differences that can be identified through the investigation of beliefs about mathematics education based on ethnicity?

Table 5 describes the result of the *t*-test for the differences in mathematical beliefs based on ethnicity. The result showed that Javanese students and Madurese were equal in believing mathematics teachers, nature, and performance in mathematics. However, the differences between the two were significant in the beliefs in mathematics learning. The differences between the two was medium based on the value of Cohen's *d* ($d = 0.33$). Javanese students have higher beliefs about mathematics learning (M = 3.42, SD = 1.04) than Madurese students (M = 3.07, SD = 1.06).

Independent Variables	Eight (410)		Ninth (126)		*F*	*t*(534)	*p*	Cohen's *d*
	M	SD	M	SD				
Beliefs about the teacher	4.24	0.73	4.09	0.79	3.82	2.44	.01*	0.26
Nature of mathematics	4.41	0.63	4.29	0.68	3.87	2.22	.07	0.19
Mathematics learning	3.32	1.06	3.34	1.05	0.02	-.24	.81	-0.03
Mathematics performance	3.79	0.92	3.66	1.02	2.91	1.37	.17	0.14

*Note: * significant p < .05, ** significant p < .001*

Table 4: The differences in epistemological beliefs about math based on a level of study

Independent Variables	Javanese (400)		Madurese (136)		*F*	*t*(534)	*p*	Cohen's *d*
	M	SD	M	SD				
Beliefs about the teachers	4.28	0.72	4.13	0.80	3.43	1.96	.05	0.19
Nature of mathematics	4.39	0.63	4.35	0.68	0.03	0.69	.49	0.07
Mathematics learning	3.42	1.04	3.07	1.06	0.60	3.35	.001**	0.33
Mathematics performance	3.79	0.94	3.66	0.97	0.41	0.51	.16	0.14

*Note: * significant p < .05, ** significant p < .001*

Table 5: The differences in epistemological beliefs about math based on ethnicity

DISCUSSIONS

This study explores students' beliefs about mathematics in the Indonesian context. We also investigated relevant factors (e.g., gender and region) and their relation to these beliefs. We found explored the students' tendencies toward mathematics. Also, we found differences in students' conceptions of mathematical knowledge based on gender and ethnicity preferences in the Indonesian context. The findings of this study contributed to improving the quality of mathematics education in the Indonesian context.

Firstly, we found that students expressed strong beliefs in the role of the teacher in mathematics learning. Students showed that their mathematics teacher is friendly, cares about students' problems, and try to create an interesting lesson about mathematics. Students also showed that their math teachers had taught them to understand the process of mathematics rather than memorizing. How teachers interact with students may contribute to students' beliefs in the role of teachers, like the appreciation of the students by the mathematics teachers (Li et al., 2021). Therefore, in the mathematics context, mathematics educators emphasize the process rather than memorizing. Also, since this study took place in East Java, all of the schools taught students to highly appreciate the role of teachers because, in this region, the teaching profession is highly valued. The norm guide students were unthinkable for a student to address a teacher by "talking down" or "talking intimately" to the teacher (Quinn, 2011). Consequently, students highly believe that their mathematics educators know everything, as well as students' problems.

We found students expressed a strongly believe in the nature of mathematics. Rather than perceiving mathematics as a statics knowledge, students viewed mathematics is always evolving and that new things still can be discovered. Also, the finding of this study revealed that they believe that there are many ways to solve mathematics problems. Students also highly believe that everyone can learn mathematics. Our interpretation of this stage, the student's daily life activities, such as interaction with digital technology to access mathematics information, may be why students believe in many ways to solve problems in mathematics. Interestingly students also believe that everyone can understand mathematics rather than believing that mathematics competence is genetics matters. Most students believe that hard work can reach the best grade in mathematics.

However, the data on students' beliefs about mathematics learning showed that the number of students who expressed disagreement or strongly agreed with the item "I like mathematics" was very high. Also, students 32% strongly disagree or disagree with the item "I am very interested in mathematics." This data indicated that, in reality, many students don't interest in mathematics. This finding was in contrast with previous beliefs, such as beliefs in the nature of mathematics and mathematics teachers. The possible explanations, the way teachers transform mathematics learning, and the nature of mathematics are not the single factors behind students' motivation to study mathematics. The experience failed repeated also contributed to students' beliefs about mathematics (Usher and Pajares, 2009; Özcan and Kültür, 2021). With respect to students' beliefs in mathematics performance, the finding of this study revealed that students expressed a strong belief they would get a good score in mathematics. They have external orientation beliefs such as the inner desire to show that they have good capability in mathematics to their peers or their mathematics teachers. This finding is in line with the finding by (Wang et al., 2022), which revealed that Asian students tend to have high confidence that they are capable in mathematics. Students also expressed beliefs to show that they are better than other students. This finding is quite surprising since many students expressed did not agree with the previous beliefs. Although they were not like mathematics, they wanted to show they had the capability in mathematics. Indeed, further analysis is necessary to explain more comprehensively the contradiction of these beliefs, they believe that everyone can study mathematics and believe in gaining high scores in mathematics on the one hand, and they don't like mathematics on the other.

Second, we found that boys and girls were equal in the conception of mathematical knowledge except for beliefs in mathematics learning. The finding of this study told us boys had higher beliefs in mathematics learning. For instance, boys hold stronger beliefs that they like mathematics, are interested in mathematics learning, and understand the course material in mathematics even if it was difficult for them than girls. For these beliefs, the data is contrary to Vuletich et al. (2020), but it is in line with Dustan et al. (2022), Liou et al. (2021), and Seo et al. (2019) that found boys hold stronger beliefs in mathematics than girls. Seo et al. (2019) mentioned that girls students tend to perceive mathematics as more difficult for them than boys students. However, further investigation is necessary to confirm the differences between the two in the context of beliefs in mathematics learning.

Third, we found that students in eighth grade hold stronger beliefs about the teacher than in ninth grade. For example, students hold stronger beliefs that their mathematics teachers have tried to make mathematics learning interesting, their teachers care about students' problems, and their teachers really understand students' problems in mathematics learning. This finding is in line with the prior research (Liou et al., 2021; Mozahem et al., 2021; Passolunghi et al., 2014), which mentioned the differences in beliefs about mathematics in different grades, where students in the lower grade level study tend to have stronger beliefs than students in the higher level study. Pupils' experience and interaction with the teachers over the years may contribute to these beliefs. Mozahem et al. (2021) in their study argue that the source of personal beliefs like mastery experience, vicarious experience, social persuasion, and physiological state is the factor behind the decreasing or lower beliefs in different grades. According to the cognitive development theory, the change of beliefs in the form of the development of mental cognition is a process that concerns the totality of the knowledge structure (Zhan et al, 2022).

Fourth, this study's finding revealed differences between students based on their ethnicity in their beliefs about mathematics learning. Javanese students hold stronger beliefs in mathematics learning than Madurese students. Javanese students are much more interested in mathematics learning than Madurese students. Also, they expressed more confidence in understanding the most difficult topic in math than Madurese students. This finding reveals the same result as the previous research (Seo et al., 2019), which reported the differences in beliefs based on cultural differences. Social cognitive theory (Bandura, 2001) suggests that sociocultural factors influence individual behavior through their psychological mechanism. Cultural embeddedness contributed to shaping the ways individual beliefs are developed.

Although the present study provided a wealth of information regarding beliefs about mathematics education, several limitations should be noted. The present study focused on explaining students' beliefs about mathematics education. We did not investigate the extent to which these beliefs influence students' performance in mathematics. Future research and the investigation of these beliefs in the Indonesian context should identify the relation of this belief to other aspects such as performance and motivation achievements. This research examined students' beliefs based on the self-report that failed to explain a deep understanding of students' beliefs personally. Future research should be considered to do a deep interview with students to investigate their beliefs about mathematics education. This study used a small sample and compared the beliefs of students based on two regions. However, the small sample in the present study did not represent all Indonesian contexts. Therefore, future research should consider the generalizability of the sample.

IMPLICATION

This study found that students hold strong beliefs about the teacher, the nature of mathematics, and the performance of mathematics. We found significant differences in students' beliefs in mathematics learning based on gender and grade preferences. Also, we found differences in beliefs in mathematics performance based on cultural differences. The finding of this study has some implications for teaching practices. Since the findings tell us that students hold strong beliefs about the teacher, mathematics educators can increase students' performance by providing a good example of mathematics. Because students will follow the ways teachers deal with mathematics. Mathematics educators should put some effort into increasing girls' beliefs in mathematics learning. Mathematics educators are necessary to maintain students' beliefs in mathematics learning since our data found that students' beliefs in grade ninth lower than students in grade eight, for example, by involving gamification strategy in mathematics learning. For the policy maker, this data can be used how to ensure the equity of education based on the differences in culture and region.

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DECLARATION OF COMPETING INTEREST

No conflict of interest exists.

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APPENDIX

STUDENTS' MATHEMATICS-RELATED BELIEFS SYSTEMS

Variables	Mean	Med	SD	SE
Beliefs about teacher				
My teacher is very friendly	4.16	4.00	0.99	0.04
My teacher listens carefully	4.38	5.00	0.91	0.39
My teacher understands my difficulties	4.02	4.00	1.11	0.04
My teacher cares about me when I have difficulties	3.40	4.00	1.10	0.05
My teacher appreciates me even if my result is not good	4.40	5.00	0.94	0.04
My teacher really wants me to learn new things	4.27	5.00	0.96	0.04
My teacher tries to make mathematics lessons interesting	4.24	5.00	1.04	0.04
My teacher wants me to understand the content, not just memorize it	4.38	5.00	0.96	0.04
My teacher gives me time to find new problems and to try out possible solutions	4.23	5.00	1.04	0.05
My teacher provided me with a thorough step-by-step explanation before handing me an assignment	4.30	5.00	1.03	0.04
Beliefs about nature mathematics				
I think I can use what I learn in mathematics in other courses	4.11	4.00	1.02	0.04
Solving mathematics problems is demanding and requires thinking, even for smart students	4.44	5.00	1.01	0.04
Mathematics is used by many people in their daily life	4.41	5.00	0.93	0.04
Mathematical knowledge continues to expand, & new things are found all the time	4.28	5.00	0.93	0.04
There are several ways to find the correct solution to a mathematics problem	4.37	5.00	0.91	0.04
Anyone can learn mathematics	4.40	5.00	0.93	0.05
I choose mathematical assignments that I can learn from even if I am not at all sure of getting a good grade	4.19	5.00	1.08	0.05
If I try really hard, I will understand very well in math	4.52	5.00	0.84	0.04
I am only satisfied when I get a good grade	4.68	5.00	0.75	0.03
Beliefs about mathematics learning				
I can understand even the most difficult material	3.30	3.00	1.24	0.05
I like to learn mathematics every time	3.20	3.00	1.32	0.06
I am very interested in mathematics learning	3.25	3.00	1.32	0.06
I can understand course materials in mathematics	3.47	4.00	1.15	0.05
I prefer mathematics tasks for which I have to exert myself to find the solution	3.44	4.00	1.27	0.05
Beliefs about mathematics performance				
I am confident that I will get a good grade in mathematics.	3.94	4.00	1.09	0.47
Mathematics enables students to better understand the world he live in	3.64	4.00	1.07	0.05
I want to show the teacher that I am better than most other students	3.69	4.00	1.25	0.05
I want to do well in mathematics to show the teacher and my friends how good I am at it	3.76	4.00	1.19	0.05

Study 3

Beliefs in mathematics learning and utility value as predictors of mathematics engagement among primary education students: the mediating role of self-efficacy

(Hidayatullah et al., 2023)

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Beliefs in mathematics learning and utility value as predictors of mathematics engagement among primary education students: the mediating role of self-efficacy

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Beliefs in mathematics learning and utility value as predictors of mathematics engagement among primary education students: the mediating role of self-efficacy

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ABSTRACT
Students' performance in mathematics learning is closely associated with their engagement. Then, how can students' engagement in mathematics learning be promoted? Social cognitive theory argues that those who engage emotionally and behaviourally hold strong beliefs about their ability. This study investigated the role of beliefs about mathematics learning and utility value in emotional and behavioural engagement through the mediating role of self-efficacy. This study revealed that beliefs about mathematics learning and utility value directly predicted emotional and behavioural engagement in mathematics learning. Self-efficacy positively mediated the relationship between beliefs about mathematics learning and students' engagement.

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KEYWORDS
Beliefs; utility value; self-efficacy; engagement

Introduction

The Indonesian Ministry of Education and Culture introduced the Merdeka curriculum (Independent curriculum) as a measure to respond to the long education crisis (Kemdikbud 2022), such as the low student score in mathematics based on the International Survey (Mullis et al. 2016; OECD 2018). The Merdeka curriculum has also been introduced as a response to the loss of learning during the pan-demic situation (Kemdikbud 2022). This curriculum has been expected to provide flexibility to tea-chers in enforcing the student performance profile. In terms of mathematics learning for grades 5 and 6, mathematics engagement, like interest, attention to the mathematics courses, curiosity, and self-efficacy, have been stated as important objectives for this curriculum (Kemdikbud 2022) besides understanding, reasoning, and problem-solving skills. Therefore, schools and mathematics teachers need to consider students' engagement as intended by the Merdeka curriculum objective for students since they are in the first stage of education.

Students' engagement is the quality of students' participation in learning activities that involve energised, focused, enthusiastic, and emotionally positive interactions (Skinner, Kindermann, and Furrer 2009). Students who engage in mathematics learning are more interested, have good enthu-siasm, pay more attention, and invest more effort to be active in mathematics learning (Dogan 2015; Kong, Wong, and Lam 2003; Skinner, Kindermann, and Furrer 2009). In previous studies, academic engagement has been published to be closely associated with beliefs (Csíkos, Kelemen, and Verschaffel 2011), utility value (Wigfield and Eccles 2000), and self-efficacy (Schunk and Usher 2019). Therefore, students who are more engaged in mathematics learning hold strong beliefs about mathematics (Antunes, Armellini, and Howe 2023; Hidayatullah and Csíkos 2023c, 2023a; Hofer 2000) and perceive mathematics as a useful course (Chong et al. 2018; Lavasani and

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Khandan 2011; Sağkal and Sönmez 2022) and hold strong self-efficacy (Schunk and Pajares 2016). At the same time, numerous studies have shown that self-efficacy is determined by beliefs about math-ematics learning (Op't Eynde, De Corte, and Verschaffel 2003; Yin et al. 2020) and utility value (Bong and Skaalvik 2003; Yurt 2022). Accordingly, there is a chance that the level of beliefs about math-ematics learning and utility value determines self-efficacy and, in turn, increases engagement in mathematics learning. However, adopting research that simultaneously investigated the inter-relation and intermediation between beliefs about mathematics learning, utility value, self-efficacy, and engagement in mathematics learning has received little attention to date. Therefore, the present study tested whether beliefs about mathematics learning and utility value predicted stu-dents' engagement and whether self-efficacy mediated students' engagement.

Theoretical framework

Beliefs about mathematics learning and the utility value of mathematics

The discourse of beliefs in mathematics learning has attracted the interest of researchers several decades later. Op't Eynde, De Corte, and Verschaffel (2003) defined beliefs in mathematics learning as students' conceptions implicitly or explicitly held to be true about mathematics education, about the self as a mathematics learner, and about mathematics class context. Beliefs about mathematics learning in this study refer to students' conception of mathematics as a discipline, learning, and problem-solving (Op't Eynde, De Corte, and Verschaffel 2006). Utility value relates to a student's per-ception of the course material regarding interest, importance, and utility (Pintrich 2015). According to expectancy-value theory (Wigfield and Eccles 2000), individuals' choice, persistence, and perform-ance are determined by their beliefs to do well and the extent to which they value the activity. Op't Eynde and De Corte (2003), in their mathematics-related beliefs system theoretical framework, included the utility value of mathematics as a part of beliefs about the self as a mathematics learner. Therefore, in the present study, beliefs about mathematics learning refer to students' con-ception of mathematics as a discipline in the schools and utility value as students' conception of the usefulness of mathematics for daily life.

In Indonesia, there were some studies exploring students' beliefs about mathematics and its impacts on academic performance. For instance, a study by Hidayatullah and Csíkos (2023c) suggested that beliefs about mathematics learning influence mathematics performance in primary education. Later, Hidayatullah and Csíkos (2023b) investigated the response to problem-solving and their relation to beliefs about mathematics among fifth and 6th-grade students. This study showed that students' beliefs about mathematics determine their performance in mathemat-ical problem-solving. Nonetheless, neither of these studies clearly provides information regarding beliefs about mathematics learning and the utility value of mathematics. Therefore, the present study investigated beliefs about mathematics learning and the utility value of mathematics within the primary education context.

Students' engagement in mathematics learning

Skinner et al. (2009) defined students' engagement as multidimensional activity in the quality of stu-dents' participation in learning activities that involved energised, focused, enthusiastic, and emotion-ally positive interactions. The conceptualisation of academic engagement exhibited considerable variability among scholars and researchers in the field. For instance, Skinner et al. (2009) proposed that the construct of engagement consisted of behaviour and emotion engagement, disaffected behaviour, and emotion. Fredricks et al. (2004) suggested that engagement contained behavioural, emotional, and cognitive engagement. The present study emphasised the dimensions that all concep-tualizations agree on: behavioural engagement and emotional engagement (Fredricks, Blumenfeld, and Paris 2004; Skinner, Kindermann, and Furrer 2009). Behavioural engagement refers to the participation of students in learning activities such as attention, effort, and participation (Sinatra, Heddy, and Lombardi 2015). Emotional engagement refers to students' emotional reactions to academic subject areas (Sinatra, Heddy, and Lombardi 2015), such as mathematics learning. In Indonesia, there were few studies on student engagement, especially in mathematics learning. For instance, Purnomo et al. (2021) pointed out that during the pandemic situation, the students' engagement in mathematics learning has been predicted by parents' involvement. However, further empirical studies are necessary to explain students' engagement in mathematics learning in the Indonesian context. By investigating behavioural and emotional engagements, our study expected to obtain deeper insight into how to promote students' engagement in mathematics learning.

The role of beliefs about mathematics learning in mathematical engagement

Although previous studies have shown the significant role of beliefs about mathematics learning in mathematics achievement (Csíkos 2003; Garofalo 1989; Hidayatullah and Csíkos 2023b; Verschaffel, De Corte, and Lasure 1994), the association between beliefs about mathematics learning and engage-ment has received little attention. Chouinard, Karsenti, and Roy (2007) suggested that students' com-petence beliefs in mathematics learning positively predicted students' engagement. The researchers explained that when students believe in their competence in mathematics, they put more effort and work hard in mathematics. If students' beliefs about their ability in mathematics learning affect their engagement, there is a chance that beliefs about mathematics conception also predict mathematics engagement. Garofalo (1989) pointed out that beliefs about mathematics learning, such as beliefs that mathematics is a collection of facts, rules, and formulas, predict 'students' engagement. Under the control of these beliefs, students pay more attention (emotions) and work as hard as they want (behav-iour) to memorise mathematical concepts. Meanwhile, research has shown that under controlled beliefs about the speed of knowledge in problem-solving mathematics, students tended to cease to try to solve some tasks, apply less effort, and have less engagement (Schommer et al. 2005). There-fore, this study assumed that beliefs about mathematics learning predict students' engagement.

H1: Beliefs about mathematics learning positively predict students' engagement.

Utility value and academic engagement

Students typically engage in activities that they believe will result in positive outcomes and avoid actions that may generate negative outcomes (Schunk and Pajares 2016). It means that there is an association between students' engagement and their utility value. However, there were inconsistent results regarding the relationship between the utility value of mathematics and students' engagement in mathematics learning from previous studies. Greene et al. (1999) pointed out that students' beliefs and utility values in mathematics significantly predicted students' involvement in mathematics learning. The researchers found that the increase in students' beliefs and the conception of the usefulness of mathematics learning increased students' efforts to study mathematics. Metallidou and Vlachou (2007), through their investigation, showed that higher students perceive the usefulness of studying mathematics related to their engagement level. In the same vein, Chang (2015) pointed out that students' utility value significantly influences their engagement. Chouinard, Karsenti, and Roy (2007) elucidated in their empirical study that students' conception of the usefulness of mathematics learning for their lives also prompted their involvement in math-ematics learning. On the contrary, a later study by Metzger et al. (2019) found that students' con-ception of the usefulness of mathematics was not significantly related to students' engagement. Therefore, in light of the contradiction in the previous studies, more empirical studies are necessary to clarify the relationship between the two. This study assumed that utility value significantly pre-dicted students' engagement.

H2: The utility value of mathematics positively predicted students' engagement.

Self-efficacy as a mediator for students' engagement

Bandura defined self-efficacy as people's judgment of their ability to manage and execute the courses of action required to attain designated types of performance (Bandura 1997). Self-efficacy theory is concerned not with the number of skills one has but with what one believes one can do with what one has under certain circumstances (Bandura 1997). In the education context, students who feel more efficacious about learning should be more apt in learning engagement. Self-efficacy affects the courses of action people choose to pursue, the level of effort, how long people can survive in difficult times, and the level of achievement they realise (Bandura 1997). In the context of the belief system in math-ematics learning, Op't Eynde and De Corte (2003) posed that self-efficacy, utility value, and beliefs about mathematics learning determine close interaction with each other. Empirical evidence has shown that the level of beliefs about mathematics learning was closely related to self-efficacy (Briley 2012). More-over, the study by Bong et al. (2012) and Yurt (2022) suggested that utility value in mathematics is posi-tively associated with self-efficacy in mathematics learning. At the same time, numerous studies have shown that self-efficacy influences student engagement, such as behaviour, effort, persistence, achieve-ments, and interest (Schunk and Pajares 2016). The study by Chong et al. (2018) suggested that behav-ioural engagement has been found to be the result of students' self-efficacy. Sağkal and Sönmez (2022) reported that self-efficacy in mathematics positively predicted students' engagement in mathematics learning. Accordingly, there is the possibility that self-efficacy mediates student engagement. It can be assumed that when students hold strong beliefs about mathematics learning and utility values, they will have stronger self-judgment about their abilities, which, in turn, affect their engagement during mathematics learning, either emotionally or behaviourally.

H3: self-efficacy is expected to mediate the relationship between beliefs about mathematics learning and stu-dents' engagement.

H4: Self-efficacy is expected to mediate the relationship between utility value and students' engagement.

Following the literature review and hypotheses, a research model was proposed, as presented in Figure 1.

Methods

Participants

This cross-sectional study involved 500 participants, 5–6 grade students from five schools in Surabaya, Indonesia. The participants were 11–12 years old. They were 46.6% boys and 53.4% girls

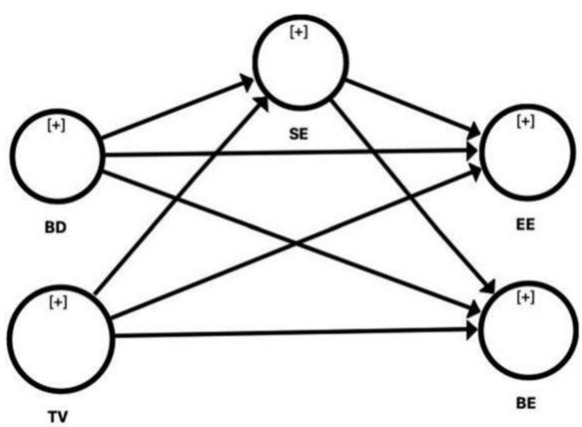

Figure 1. Mediating Effect of self-efficacy (SE) on the relationship between beliefs about mathematics learning (BD), utility value (TV), emotional engagement (EE), and behavioural engagement (BE).

students. Participation in this study was voluntary. Since the Indonesian Ministry of Education and Culture introduced the zonation system in 2017, the students in the schools varied in terms of socio-economic status. The zonation system is the school enrolment system for students in accordance with the provisions of the domicile zoning area determined by the local government. This system has been employed to ensure the equality of education. Consequently, students in each school come from a variety of social and economic statuses.

Procedures and ethical approval

Before this study started, the research proposal was reviewed ethically by the research and empow-erment unit (LPPM) of Universitas Muhammadiyah Surabaya. After the ethical approval, the letter of permission and the proposal have been sent to each school. The communication has also been con-ducted directly by the researcher to the school's principals in Surabaya. After the schools approved the letter of permission, the appointment for collecting data was scheduled. The students were informed about the purpose of this study and given instructions on how to complete the items of our questionnaire. The participants were informed that the data in this study was confidential. The participants were also allowed to withdraw from this project without needing to provide a reason. Finally, the questionnaires were administered through a paper-pencil test. Mathematics tea-chers in each school actively helped the researcher collect the data. The data collection had been conducted in one month, May 2023.

Instruments

Beliefs about mathematics learning

In the present study, students' epistemological beliefs were measured by assessing their perception of mathematics education. Four items of belief about mathematics education were adapted from Grootenboer and Marshman (2016). These items were translated into Indonesian version. For example, 'mathematics is a collection of rules, facts', and 'the only goal of doing mathematics is to get the correct answer'. This scale was rated using a 4-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree).

Utility value

Utility value refers to students' perception of the usefulness of mathematics in real life. Four items of utilitarian belief items were selected to measure students' utility value of beliefs (Grootenboer and Marshman 2016). The original items of this questionnaire are in English. The items were translated into the Indonesian version. For instance, 'Maths is important' and 'Maths is useful'. Participants responded to the items on this scale on a 4-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree).

Self-efficacy

Five items of mathematics self-efficacy scale items (Nielsen and Moore 2003) were adopted. In the present study, students were asked the degree of their ability in terms of mathematics. For example: 'How confident are you that you can perform the decimal fraction task?' and 'How confident are you that you can perform the geometry task?' This scale was rated using a 4-point Likert scale (1 = Not confident at all, 2 = not confident, 3 = confident, 4 = very confident).

Students' engagement in mathematics learning

Four items of emotional engagement were adapted from a study by Skinner, Kindermann, and Furrer (2009) to measure the level of students' engagement. In this study, the items were modified for the mathematics learning context. For example: 'In mathematics class, I am enthusiastic', and 'When I do something in the mathematics class, I am interested'. Also, four items of behavioural engagement were adapted to measure the level of students' engagement in the mathematics learning context. The items were modified for specific mathematics learning, for example, 'I try hard to do well in mathematics class', 'I pay attention in mathematics class', and 'I work as hard as I want in mathemat-ics class'. All items were rated using a 4-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree).

Data analysis

The present study used a quantitative approach. The partial least square structural equation model-ling (PLS-SEM) was employed to evaluate the proposed hypotheses through the smartPLS 3.3 version. According to Hair et al. (2019), there are several steps to evaluate SEM. First is the reflective evaluation, which involves the loading factor, reliability, convergent validity, and discriminant val-idity. Kwong-Kay Wong (2013) suggested that loading factor higher than 0.7, but 0.4 is acceptable. This study used composite reliability (CR) to evaluate the internal reliability of each latent variable. Convergent validities were evaluated by assessing the average variance extracted (AVE). Hair et al. (2019) proposed that AVE should be > 0.5. Discriminant validities were evaluated using the Fornell-Larcker test. Fornell and Larcker (1981) suggested that the criteria for discriminant validity, the root of AVE, should be higher than the correlation between factors. Second, the hypothesis model was evaluated by performing coefficient determination (R^2), blindfolding-based cross-vali-dated redundancy (Q^2), and the significance and relevance of path coefficients (Hair et al. 2019).

Result

Descriptive statistics

Table 1 describes the descriptive statistics constructs of latent variables in the present study. All the mean results showed were above 2.00 on the 4-point Likert scale. It means that students expressed they have participated emotionally and behaviourally. The standard deviations range from 0.657 to 0.839, indicating a narrow spread around the mean result.

Evaluation of the measurement model

A reflective measurement model was conducted for the first. This involved evaluating the indicators of loading factors, internal consistency of the items, convergent validity, and discriminant validity (Hair et al. 2019; Ramayah et al. 2018). Hair et al. (2019) recommend the loading factor should be >0.70. Table 2 shows the loading factors of the items matching the requirements; the loading factors range from 0.715 to 0.916. Composted reliability (CR) was performed to examine internal reliability. The composite reliability ranges from 0.802 to 0.938. Hair et al. (2019) stated that the coefficient value for composite reliability between 0.60 and 0.70 is considered acceptable, and between 0.70 and 0.90 indicates satisfactory. Convergent validity refers to the extent to which the measures or constructs converge with other constructs (Hair et al. 2019). Convergent validity appears when the cut-off value of Average Variance Extracted (AVE) is equal to or higher than 0.5 (Hair et al. 2019). As presented in Table 2, the coefficient value of AVE for all the latent variables was higher than 0.5, which met the recommendation of the guidelines.

Table 1. Descriptive statistics of the study construct.

Variables	Mean	SD
Behavioural engagement	2.769	0.769
Emotional engagement	2.282	0.839
Beliefs about mathematics learning	2.387	0.657
Utility value	3.106	0.846
Self-efficacy	2.568	0.775

Table 2. Convergent validity of the construct.

Latent variables	Item	Factor loading	Average variance extracted	Composite reliability
Beliefs about mathematics learning			0.577	0.803
	BD1	0.824		
	BD2	0.735		
	BD3	0.715		
Utility value			0.774	0.932
	TV1	0.891		
	TV2	0.916		
	TV3	0.901		
	TV4	0.807		
Self-efficacy			0.691	0.918
	SF1	0.822		
	SF2	0.844		
	SF3	0.826		
	SF4	0.831		
	SF5	0.833		
Behaviour engagement			0.627	0.871
	BE1	0.801		
	BE2	0.802		
	BE3	0.763		
	BE4	0.797		
Emotional engagement			0.791	0.938
	EE1	0.905		
	EE2	0.905		
	EE3	0.905		
	EE4	0.840		

Furthermore, the extent to which each latent variable is distinct from each other was evaluated by performing the discriminant validity. In this study, Fornell Larcker method was performed to examine the discriminant validity. Fornell and Larcker (1981) suggested that discriminant validity can be eval-uated by comparing the correlations between factors and the root of average variance extracted (AVE). If the correlation between factors is higher than the root of the average variance extracted, there is a possibility of multicollinearity within the constructs (Hair et al. 2019; Teo 2010). Table 3 indi-cated that the root of the average variance extracted was higher than the correlation between factors. Therefore, the result of discriminant validity appears satisfactory for all factors.

Hypothesis testing

The evaluation of the hypothesis model involves coefficient determination (R^2), blindfolding-based cross-validated redundancy measure Q^2, and the statistical significance and relevance of the path coefficient. The results See Figure 2 showed that behavioural engagement was explained by beliefs about mathematics learning, utility value, and mathematics self-efficacy in the amount of 51.9% ($R^2 = 0.519$). Self-efficacy and emotional engagement were explained by their determinations in the amounts of 10.9% ($R^2 = 0.109$) and 44.2% ($R^2 = 0.442$), respectively. With respect to the

Table 3. Discriminant validity.

Variables	BE	EE	BD	SF	TV
BE	(0.792)				
EE	0.657**	(0.889)			
BD	0.623**	0.545**	(0.759)		
SF	0.402**	0.419**	0.322**	(0.831)	
TV	0.651**	0.591**	0.682**	0.274**	(0.880)

Note: *p < 0.05, **p < 0.001, BD = beliefs about mathematics learning.
TV = utility value of mathematics, SE = self-efficacy, EE = emotional engagement.
BE = behavioural engagement; diagonal in parentheses is the square root of average variance extracted; off-diagonal correlations between constructs.

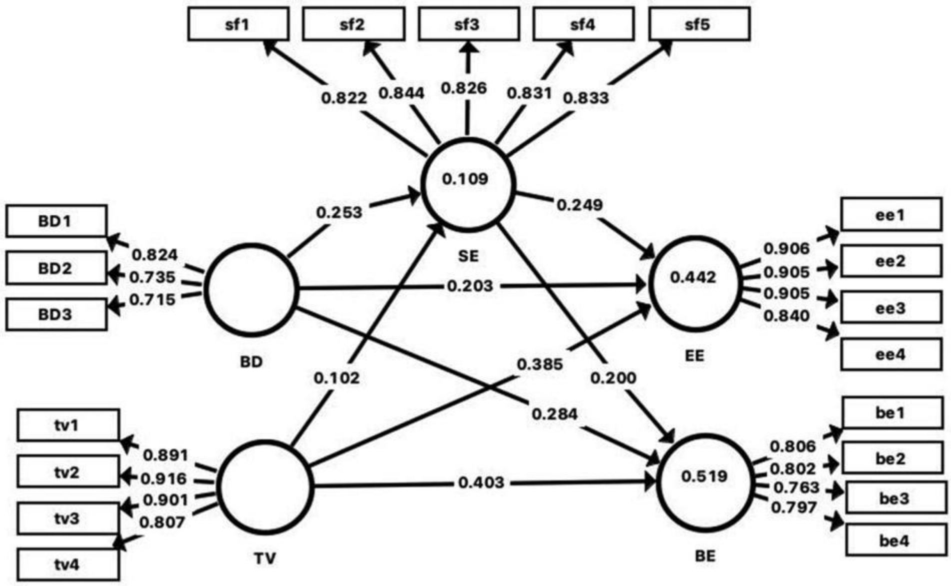

Figure 2. The standardised relationship between factors. BD = beliefs about mathematics learning, TV = utility value of math-ematics, SE = self-efficacy, EE = emotional engagement, BE = behavioural engagement.

blindfolding-based cross-validated redundancy, Hair et al. (2019) stated that the value of Q^2 should be larger than zero for a specific endogen construct to indicate predictive accuracy. The coefficient values of Q^2 between 0, 0.25, and 0.5 indicated small, medium, and large predictive accuracy. The predictive accuracy of beliefs about mathematics learning and utility value on mathematics self-efficacy was small (Q^2 = 0.072). Meanwhile, the prediction of beliefs about mathematics learning, utility value, and mathematics self-efficacy was a medium for either emotional engagement (Q^2 = 0.343) or behavioural engagement (Q^2 = 0.320) in mathematics learning.

Finally, the statistical significance and relevance of the path coefficient were examined. Figure 1 describes the research model with the standardised path coefficient depicting the relationship among the factors. Beliefs about mathematics learning positively predicted mathematics self-efficacy (*b* = 0.253, p < .000), emotional engagement (*b* = 0.203, p < 0.000), and behavioural engage-ment (*b* = 0.284, p < 0.000). Utility values significantly predicted behavioural engagement (*b* = 0.403, p < 0.000) and emotional engagement (*b* = 0.385, p < .000). Surprisingly, the utility value did not predict self-efficacy in mathematics (*b* = 0.102, p < 0.095). With respect to the indirect prediction, beliefs about mathematics learning indirectly predicted behavioural engagement (*b* = 0.051, p = 0.005) and emotional engagement (*b* = 0.063, p = 0.001) through the mediation of self-efficacy beliefs in mathematics learning. Surprisingly, the mediation of self-efficacy for the prediction utility value on behavioural engagement and emotional engagement was insignificant (*b* = 0.020, p < 0.117) and (*b* = 0.025, p < 0.106), respectively. Table 4 summarises the results of the evaluation of our hypotheses.

Discussion

This paper examined the effect of beliefs about mathematics learning, utility value, and self-efficacy on student engagement among primary students in Surabaya, Indonesia. This study found: (1) beliefs about mathematics learning positively predicted behavioural engagement and emotional engagement in mathematics learning, (2) utility value significantly influenced behavioural engage-ment and emotional engagement, (3) self-efficacy acts as a mediator for the relationship between

Table 4. The results from the hypothesis test.

Path	Estimate	t-value	p-value	Result
Beliefs about mathematics learning → behavioural engagement	0.284	5.786	0.000	Supported
Beliefs about mathematics learning → emotional engagement	0.203	4.113	0.000	Supported
Beliefs about mathematics learning → Self-efficacy	0.253	3.905	0.000	Supported
Self-efficacy → behavioural engagement	0.200	5.141	0.000	Supported
Self-efficacy → emotional engagement	0.249	7.232	0.000	Supported
Utility value behavioural engagement	0.403	8.143	0.000	Supported
Utility value emotional engagement	0.385	7.361	0.000	Supported
Utility value→ self-efficacy	0.102	1.672	0.095	Not supported
Beliefs about mathematics learning → self-efficacy → behavioural engagement	0.051	2.189	0.005	Supported
Beliefs about mathematics learning → self-efficacy → emotional engagement	0.063	3.301	0.001	Supported
Utility value→ self-efficacy → behavioural engagement	0.020	1.571	0.117	Not supported
Utility value→ self-efficacy → emotional engagement	0.025	1.620	0.106	Not supported

beliefs about mathematics learning, emotional, and behavioural engagement, (4) Self -efficacy did not mediate the relationship between utility value, emotional, and behavioural engagement.

This study revealed that beliefs about mathematics learning significantly influenced behavioural and emotional engagement. This study revealed the same result as the studies by Hidayatullah and Csíkos (2023b) and Csíkos, Kelemen, and Verschaffel (2011), which also found a link between epis-temological beliefs and academic outcomes. Interestingly, this finding contrasts with the findings by Hofer (2000) and Schommer-Aikins (2004), who found a negative association between beliefs about the nature of knowledge and achievements. Instead, this study suggests a positive link between beliefs about mathematics and engagement in the subject. It could be that students with strong beliefs about mathematics learning tended to engage more in mathematics learning, such as paying more enthusiasm and interest to study mathematics. Students with strong beliefs about mathematics learning are more likely to do well in mathematics, work hard, and pay more attention to mathematics courses. For instance, when students perceive that the goal of mathematics learning is to get the correct answer, these beliefs may encourage students to understand problems in real life, affecting their interest and enthusiasm, as well as their participation in mathematics learning. Accordingly, schools and math teachers must focus more on how to shape students' perceptions of mathematical education. By providing an environment that supports this belief, the behavioural and emotional engagement of students will increase. This finding is valu-able in light of the Indonesian policy on the freedom of learning curriculum or Merdeka curriculum, which states that one of the purposes of mathematics learning for 5-and 6-grade students is to promote mathematical disposition, such as confidence and curiosity in mathematics learning (Kem-dikbud 2022) which involves emotional and behavioural engagement.

The current study found that utility values significantly predict behavioural engagement and emotional engagement. Rather than supporting the study by Metzger, Sonnenschein, and Galindo (2019), the finding of this study was consistent with Metallidou and Vlachou (2007), who found that the level of student's perception of the value of mathematics has been found to run a greater engagement. Students were more willing to engage if they perceived what they learned in the class was related to their future and daily life (Fredricks et al. 2018). This finding also supports the expectancy-value theory (Wigfield and Eccles 2000), which argues that the level of one's value about the task would increase one's performance, including behavioural and emotional engagement in this study. Thus, it could be that to promote greater enthusiasm and hard work in mathematics learning, awareness, and perception of the function of mathematics must be strengthened. In line with the tenet theory and this finding, schools and mathematics teachers need to embed students' conceptions about the usefulness of mathematics in mathematics learning. Mathematics teachers in Indonesia can help students build their beliefs about the usefulness of mathematics by explaining simple examples of mathematics in daily life. Furthermore, mathematics textbooks in primary edu-cation have provided thematic issues and many examples of realistic mathematics. They can help teachers to strengthen students' beliefs about the function of mathematics. Through increasing the greater utility value, students' emotional and behavioural engagement increased.

Our study showed that self-efficacy mediated the relationship between beliefs about mathematics learning and students' engagement. It implies that there are indirect pathways from beliefs about mathematics learning to students' engagement. It means that beliefs predict students' engagement by increasing their self-efficacy. This finding is in line with the study by Yin et al. (2020), who found the significant influence of epistemological beliefs on self-efficacy and, in turn, increases academic performance. Drawing from self-efficacy theory (Bandura 1997), students' outcomes, either emotional or behavioural, are governed by their efficacy. Accordingly, students are more willing to pay attention and to do hard work in mathematics learning because they have self-judgment (Bandura 1997; Schunk and Pajares 2016), and they can understand mathematics which has been determined by their beliefs about mathematics learning (Op't Eynde and De Corte 2003; Op't Eynde, De Corte, and Verschaffel 2003; Yin et al. 2020). Thus, this relationship may provide insight for mathematics teachers to set a strategy to promote students' engagement by considering the mediating role of self-efficacy. By considering students' self-efficacy, the objective of mathematics courses in primary education, as intended by the Merdeka curriculum (independent curriculum), can be achieved.

Unexpectedly, in this study, self-efficacy did not significantly mediate the relationship between utility value and students' engagement either emotionally or behaviourally. It is reasonable since the direct prediction of beliefs in utility value on self-efficacy was insignificant in this study. This finding contradicted Azar et al. (2010), who found a direct association between the perceived use-fulness of mathematics and self-efficacy. This finding also contradicted Yin et al. (2020), who found the mediation of self-efficacy for mathematical beliefs and academic performance. It can be inter-preted that the utility value of mathematics may not be the single factor of students' judgment about their ability. Accordingly, this study told us that the utility value was more favourable to directly predicting students' engagement. It is reasonable, since the prediction of utility value on self-efficacy was insignificant, generated the insignificant prediction of utility value of on stu-dents' engagement indirectly through the mediating role of self-efficacy. Although self-efficacy did not mediate the relationship between utility value and mathematics engagement, this finding showed that self-efficacy directly predicted mathematics engagement. At the same time, as discussed earlier, utility value directly predicted engagement. Therefore, both self-efficacy and utility value are still important to be considered as a factor in building students' engagement in mathematics learning.

Limitations and directions for future research

Although our study provides important information, several limitations should be carefully con-sidered when readers interpret the results of this study. The limitations also can be considered for future research. Our participants were 5–6 grade students in primary education from 5 schools in Surabaya. Consequently, the findings of this study cannot be generalised to other stages and all Indonesian situations. Future research needs to extend the study in different stages to a more repre-sentative sample. For a long time, the equity of education in this country is questionable. Although the Indonesian Ministry of Education and Culture has employed the zonation system to ensure the equity of education in different regions of Indonesia, equality in students' mathematics engagement has rarely been studied. Therefore, future research needs to consider the comparison of students' engagement in mathematics learning based on the students' region. In this study, our study did not include students' achievements, such as reasoning, understanding concepts, problem-solving skills, and creativity in mathematics learning. Future research needs to incorporate mathematics ability variables and their relationship with students' beliefs, self-efficacy, utility value, and students' engagement. Lastly, this study uses a quantitative approach. Next research should consider a quali-tative approach to obtain deeper insight into students' engagement in mathematics learning.

Conclusions and implications

The current study told us that beliefs about mathematics learning, utility value, and self-efficacy have been found to matter for behavioural and emotional engagement in mathematics learning. When students hold strong beliefs about mathematics learning, they are more motivated to engage emotionally and behaviourally. Students are more enthusiastic, pay more attention, and work harder in mathematics learning when they hold beliefs about mathematics learning and utility value. This study showed that self-efficacy mediated the relationship between beliefs about math-ematics learning and students' engagement. Although the mediating role of self-efficacy on the relationship between utility value and students' engagement was insignificant, the finding is still valuable since the direct prediction of utility value and self-efficacy on students' engagement was significant.

The findings of this study provided theoretical contributions. The finding of this study provides new insight and a literature review in terms of students' engagement in mathematics learning invol-ving the role of beliefs about mathematics learning, utility value, and self-efficacy. This finding enriched the literature review about the mediation of self-efficacy in the relationship between beliefs and students' engagement. An interesting result of this study was the insignificant prediction of utility value on self-efficacy beliefs in mathematics learning. Therefore, this finding may contribute to the need for more academic discussion about the belief theory in mathematics regarding the relationship between the two.

The findings of this study also contributed to the teaching practices, especially for a mathematics teacher in Surabaya, Indonesia. Since this study showed that beliefs about mathematics learning and utility value directly influenced students' engagement, mathematics teachers need to pay more attention to student's beliefs about mathematics learning, utility value, and self-efficacy to promote students' engagement. Mathematics teachers are suggested to provide a mathematics environment that supports beliefs about mathematics learning and utility values. For example, math-ematics teachers can help students increase their beliefs about the usefulness of mathematics by showing some examples of each topic in a real-life activity. Mathematics teachers need to encourage students to find mathematical activity in their real life. Teachers can also develop some realistic mathematics work for students based on the mathematics textbook in the Merdeka curriculum that was provided by the Ministry of Education of Indonesia. Considering the significant mediating role of self-efficacy, teachers are suggested to provide experiences that help students build their self-efficacy in mathematics learning. For instance, teachers can help students to build their self-efficacy by demonstrating how to observe other people and making social comparisons regarding math-ematics ability.

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Study 4

The role of students' beliefs, parents' educational level, and the mediating role of attitude and motivation in students' mathematics achievement

(Hidayatullah & Csíkos, 2023)

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REGULAR ARTICLE

The Role of Students' Beliefs, Parents' Educational Level, and The Mediating Role of Attitude and Motivation in Students' Mathematics Achievement

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Abstract Investigating factors affecting students' aca-demic performance seems a hard job for researchers on the empirical front. Beliefs, parents' educational background, motivation, and attitudes have been proven significantly influence achievement. However, concurrent research on the relationship among these variables seems scarce. There-fore, to contribute to this gap in knowledge, the purpose of this study is to examine the structural relationships among beliefs, parents' educational level, attitude, motivation, and achievement in mathematics learning. We selected 30 classes randomly from six schools in Surabaya, Indonesia. This study involved 894 fifth- and sixth-grade students (448 boys and 446 girls). Structural equation modeling results showed that this model predicts students' achievement in mathematics (R^2 = 0.49). Beliefs are positively associated with students' achievement (β = 0.20, $p < 0.001$), attitude (β = 0.82, $p < 0.001$), and motivation (β = 0.68, $p < 0.001$). Parents' educational level is positively associated with achievements (β = 0.17, $p < 0.001$) and motivation (β = 0.07, $p = 0.04$). Beliefs were indirectly associated with achieve-ments through attitude (β = 0.31, $p < 0.001$) and motivation (β = 0.08, $p = 0.01$). The indirect association between par-ents' educational level and achievement through motivation was insignificant. This study is valuable because it helps unpack the relationship between beliefs, parents' educational level, attitudes, motivation, and achievement.

Keywords Belief · Parents' Education · Attitude · Motivation · Achievement

Introduction

Although researchers and mathematics educators have been attempting to identify the most influential factors behind mathematics research for many years, the role of the factors behind students' mathematics performance remains unclear. Obviously, cognitive factors solely are not enough to explain the phenomena behind academic performance. Therefore, investigations that combine cognitive, metacognitive, and non -cognitive factors may fill this research gap. Accord-ing to the metacognition knowledge theory (Csíkos et al., 2011; Veenman et al., 2006), those who can regulate and judge beliefs about mathematics will succeed in academic performance. Those who succeed in academics have good motivation (Middleton & Spans, 1999; Habók et al., 2020), and a positive attitude toward mathematics (Casty et al, 2021; Kiwanuka et al., 2022). While the social cognitive theory suggested that students' success in academic learn-ing is determined by learning experience and environmental stimuli (Bandura, 2001). Driven by both theories, research-ers have suggested that students' beliefs (Hidayatullah & Csíkos, 2022; Hofer, 2000; Schommer-Aikins et al., 2005), motivation (Habók et al., 2020; Pajares & Graham, 1999), attitude (Kiwanuka et al., 2022; Mazana et al., 2018), and parents' educational level (PED; Dixson et al., 2018), play a critical role in students' mathematics performance.

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In the literature review, empirical studies proved that beliefs as part of metacognition were consistently asso-ciated with mathematics achievements (Hidayatullah & Csíkos, 2022; Hofer, 2000; Schommer-Aikins et al., 2005). For instance, a study by Schommer-Aikins et al. (2005) suggested that what students perceive about the nature of mathematics affects their achievement. Students tend to fail academically when they think that mathematical tasks can be solved very quickly. Moreover, research also indicated that beliefs are not only associated with achievements but also it is associated with attitudes and motivation (Hofer, 2000; Rarujanai et al., 2022). Fishbein (1963) pointed out that attitude is a function of personal beliefs. In other words, personal beliefs are a source of information that generates individual motivation attitudes toward mathematics and in turn, influences mathematics achievements.

At the same time, academic performance and motivation were also closely associated with a personal background like parents' educational background (PED) . According to prior research (Cascella, 2020; Davis- Kean, 2005), PED is consistently associated with students' mathematics perfor-mance. Students with a higher level of PED tend to have bet-ter achievements (Dixson et al., 2018) because parents with high educational backgrounds tend to be more involved in their children's studies. Besides, research indicated that PED determines students' academic motivation. For instance, a study by Acharya and Joshi (2009) suggested that students who come from high PED levels are more motivated than those students whose PED levels are less.

Although there was evidence indicating achievements are associated with beliefs and PED, little is known whether beliefs and PED can also predict and control attitudes and motivation, especially in mathematics learning. Moreover, less attention has been directed to the mediation of attitudes and motivation for the relationship between beliefs, PED, and achievements in mathematics learning. Therefore, inves-tigating the interrelation among these variables in the math-ematics learning context is imperative.

To respond to the gap in the previous studies, the aim of this study is to examine how beliefs and PED are associated with attitudes and motivation and predict students' achieve-ments in mathematics learning. We develop a model that examines the structural association among beliefs, PED, atti-tudes, motivation, and achievement in mathematics learning. We study whether attitude and motivation mediate beliefs and achievement and whether motivation mediates the rela-tionship between PED and achievement.

Theoretical Framework

Role of Beliefs About Mathematics in Achievement, Attitudes, and Motivation Towards Mathematics

Schoenfeld (1985) defines beliefs about mathematics as someone's worldview about mathematics. Based on this def-inition, beliefs about mathematics may constitute the percep-tion of the nature of mathematics, problem-solving, teaching mathematics, etc. Empirical study has proved that beliefs influence mathematics achievement. Csíkos et al. (2011) suggested that students tend to follow their beliefs about the nature of mathematics when solving mathematical tasks, such as the perception that all word problems can be solved by applying arithmetic operations. Students who believe that all word problems can be solved using text information tend to solve such problems using superficial approaches. In their empirical study, Hidayatullah and Csíkos (2022) found that students' beliefs about their competence in mathematics sig-nificantly influence their achievement.

Empirical studies suggested that beliefs play a key role in shaping individual attitudes. Personal beliefs have been recognized as informational bases that determine attitude and form individual behavior (Rarujanai et al., 2022). Savol-ainen et al. (2022) reported that beliefs had a strong effect on individuals' attitudes. Fishbein (1963) emphasized that an individual's attitude toward an object is a function of their beliefs about the object. Prior research (Muis & Foy, 2010; Muis et al., 2006) also indicated the links between beliefs and motivation. Kim and Keller (2010) empirically identified a significant influence of students' beliefs on their motivation toward mathematics. Habók et al. (2020) sug-gested that when students hold strong beliefs about their capability, they have good motivation to achieve the best performance. Therefore, the influence of beliefs on achieve-ment, attitude, and motivation is investigated in the present study.

Role of Parents' Educational Background in Mathematics Achievements and Motivation

An increase in the SES of students, such as parents' educa-tion level (PED) and working status, family income, and home opportunities, induces a positive change in their edu-cational outcomes (Suna, 2020). Students with Low-PED levels tend to show poorer academic performance than stu-dents whose high-PED level (Acharya & Joshi, 2009). Par-ents with a high level of education tend to be more active to support their children's studies (Tan et al., 2020), and in turn, it would affect their children's performance in math-ematics. In the previous studies, the PED level was also associated closely with students' motivation. Ruedas-Gra-cia et al. (2020) pointed out that PED influences motivation indirectly through the mediation of school belonging. Students who come from high PED levels tend to have more motivation since their parents support their children academically. Therefore, students were more motivated to study. However, a further empirical study is needed for clarity due to the scarcity of literature resources describing the relation-ship between PED, motivation, and achievement.

Attitude as a Mediator of the Relationship Between Beliefs and Achievements

Attitude is an individual disposition or tendency to respond positively or negatively to an object, situation, or another person (Segarra & Juliá, 2021; Harun, 2021; Di Martion & Zan, 2011; Hannula et al., 2016; Kiwanuka et al., 2022). Attitude toward mathematics is also perceived as the liking and enjoyment of and interest in mathematics; it can also mean the opposite of these feelings, which in extreme cases include "math phobia" (Ernest, 1989; Grootenboer & Marshman, 2016) and a combination of affective feelings and cognitive beliefs.

As we discussed earlier, there is a link between attitudes and beliefs. Fishbein (1963) emphasized that one's attitude toward any object is a function of his/her beliefs about the object. If students hold strong beliefs about mathematics, they will hold positive feelings toward mathematics. Sev-eral studies have recorded the association between attitudes and beliefs. Chan and Lay (2021) pointed out that students' behavior in the classroom contexts was influenced by their personal judgment about their capability. Another study by Ünlü et al. (2010) suggested that the more positive individuals' attitudes toward mathematics, the stronger their beliefs. Furthermore, previous studies suggested attitude plays a significant role in the mathematics learning (Kiwanuka et al., 2022; Palacios et al., 2014). Ma (1997) and Mazana et al. (2018) reported the critical role of attitudes on mathematics achievement. The researchers stated that students' feelings about mathematics learning, such as enjoyment influent, directly affect their achievement; in particular, feelings of difficulty influence their achievement. As a result, we proposed that attitudes may serve as a mediator in the relationship between beliefs and achievements.

Motivation as a Mediator of the Relationship Between Beliefs and Achievements

Motivation is the factors and the process that drive and govern the interest, intensity, and quality of goal-directed behavior (Paulsen & Feldman, 1999). Motivation deals with interest, engagement, and attention, which directly and indi-rectly influence students' cognitive process, learning pro-cess, construction of tasks, and problem-solving (Hardré, 2011). Based on this definition, motivation plays a key role in driving students' learning activities.

The role of motivation in mathematics learning has been extensively researched. An international survey by PISA showed an association between students' motivation and performance. Students with higher motivation achieve higher scores (Mo, 2019) . Herges et al. (2017) suggested the positive influence of motivation on students' achieve-ment. When students are motivated, they will put effort into doing well in academic performance. According to prior research, motivation is also associated with beliefs about an object. Paulsen and Feldman (1999) pointed out that motivation correlates positively with students' beliefs. The more students hold sophisticated beliefs about knowledge, the higher their intrinsic motivation. Voica et al. (2020) sug-gested that the level of students' motivation in mathematics is determined by their individual beliefs. Students' beliefs strengthen and stimulate their motivation in mathematics. Therefore, there is the possibility that motivation may medi-ate the association between beliefs and achievements.

Motivation as a Mediator of the Relationship Between PED and Achievements

As we discussed earlier, some research suggested motivation was associated with achievements. Herges et al. (2017) reported that students with high motivation tend to have better achievements in mathematics. Mo (2019) suggested that when students become motivated, their anxiety in math decreased. Then, students will enjoy mathematics learning and put effort into studying, affecting their performance. At the same time, there were pieces of evidence that showed motivation is also associated with PED. Acharya and Joshi (2009) suggested that students with parents with post - grad-uate education levels have more motivation compared to stu-dents with high school education parents. Iwaniec (2020) found students whose parents have a lower level of education tend to be less motivated in academic learning. Therefore, in the present study, we proposed that motivation can mediate PED and achievements.

Research Aims and Hypothesis Model

As mentioned above, previous studies suggested that beliefs, PED, attitudes, and motivation play a key role in mathemat-ics achievements. Our focus is to investigate the prediction of beliefs and PED on achievements. Also, we examine the mediation of attitudes and motivation for the relation-ship between beliefs, PED, and achievements. Figure 1 described our proposed model. Our investigation follows the hypothesis:

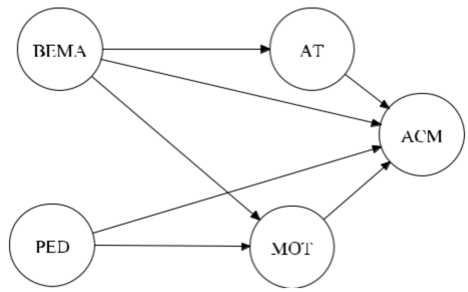

Fig. 1 Hypothesis model of the association between beliefs (BEMA), PED, attitude (ATM), motivation (MOT), and achievement (ACM)

H1: Beliefs are expected to be positively associated with attitudes, motivation, and mathematics achievements.
H2: PED is expected to be positively associated with motivation and mathematics achievements.
H3: Attitude mediated the association between beliefs and mathematics achievements.
H4: Motivation mediated the association between beliefs and mathematics achievements.
H5: Motivation mediated the association between PED and achievement.

Method

Participants

This study was conducted in Surabaya, an urban area and the capital city of the province of East Java, Indonesia. A total of 894 students aged 9–12 years participated in this study. We selected 30 classes randomly from five schools in Surabaya. They were from the fifth grade (449) and the sixth grade (445) and consisted of 448 boys and 446 girls (Table 1). Data were collected via a survey study based on the paper–pencil test system. The students in this study come from various socio-economic status backgrounds because Indonesian schools use a zoning system that ensures a short distance between each school and its students' homes. Table 1 describes the demographics of our participants.

Table 1 Demographics of participants

Characteristic	Full sample	Percentage
Gender		
Boys	448	50.1
Girls	446	49.9
Grade		
Fifth	449	50.2
Sixth	445	49.8
Age		
9 years	15	1.7
10 years	316	35.3
11 years	417	46.6
12 years	146	16.3

Instruments

Beliefs about mathematics education. We selected 9 items from the mathematics-related beliefs system questionnaire developed by Eynde and De Corte (2003) to measure students' beliefs about mathematics, such as "I can understand the difficult topic presented in mathematic" and "My teacher tries to make learning mathematics interesting." These items were rated using a 5-point Likert scale (1 = strongly disa-gree, 5 = Strongly agree). We confirmed the validity by performing CFA with a maximum likelihood parameter esti-mate (Table 2). The result showed that the model of beliefs about mathematics education instrument is fit, CFI= 0.94, TLI = 0.91, RMSEA = 0.06, and SRMR = 0.04. The Cron-bach's alpha values (α = 0.86) showed that our instruments had good internal consistency.

Attitudes towards mathematics. We adapted four items of attitudes toward mathematics questionnaire (Al-Mutawah & Fateel, 2018). For instance, "I learn many interesting things in mathematics" and "Mathematics is harder for me than any other subject". These items were rated using a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). We found a fit model for attitude toward mathematics instruments, CFI = 0.99, TLI = 0.97, RMSEA = 0.06, SRMR = 0.02. The corresponding questionnaire was reliable (α = 0.75).

Motivation towards mathematics. We measured students' motivation with five items, such as "I want top grades in mathematics learning" and "Whatever I do, I want to be the best in mathematics learning." We rated these items with a 5-point Likert scale (1 = strongly agree, 5 = strongly disa-gree). Each item in this questionnaire had a high coefficient alpha. The model of motivation toward mathematics had a good fit model (CFI = 0.99, TLI = 0.97, RMSEA = 0.06, SRMR = 0.02) and a reliability value of 0.082 (α = 0.82).

Parents' education level (PED). The data were collected by asking students what their fathers' and mothers' highest education level were. We calculated the PED by the sum of the father and mother's educational levels. The range of

Table 2 Validity and reliability of beliefs, attitudes, and motivation

Variable	CFI	TLI	RMSEA	SRMR	Alpha
Beliefs about mathematics	0.97	0.95	0.06	0.03	0.86
Attitude toward mathematics	0.99	0.97	0.06	0.02	0.77
Motivation toward mathematics	0.99	0.97	0.06	0.02	0.80

the father and mother's educational level from 1–7 (1 = no experience education, 2 = primary education, 3 = secondary education, 4 = senior high school, 5 = higher education (bachelor), 6 = Higher education (Master), 7 = Higher education (doctoral)) following the education systems in the Indonesian context. *Mathematics achievement* data were col-lected based on students' self-reports about their last score test. The score ranges from 1–100.

Procedure

Since schools in Indonesia have reopened and started conducting offline classes, we collected our data using paper–pencil tests to obtain good responses from the students. Data gathering was completed in the middle of an academic semester. In the first step, we prepared our instruments, which were then checked by experts. We communicated with the schools' principals and sent letters to obtain permission. We also consulted the mathematics teachers in all the schools regarding the ethics of our data collection (the data-gathering process involved these teachers). They helped further enhance our method and complete the questionnaires. The students were asked to complete the survey within at least two weeks to avoid fatigue.

Data Analysis

In the first step, we examined the construct validity and reliability of each questionnaire. We used SPSS and MPlus8 software versions. Confirmatory factor analysis (CFA) was used to examine construct validity. The Tucker–Lewis index (TLI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) were used to assess the model fit. Hu and Bentler (1999) suggested cutoff criteria of close to 0.095 for TLI and CFI and <0.05 or 0.6 for RMSEA.
According to van de Schoot et al. (2012), TLI and CFI ≥ 0.9 and RMSEA ≤0.08 are acceptable. Maximum likelihood (ML) parameter estimates and an absolute value of 0.4 were used in this study. Afterward, we examined the internal con-sistency, or reliability, of each questionnaire. In the second step, we studied the direct influence of all noncognitive factors on achievement and the former's prediction of the latter. In the third step, we performed descriptive statistical analysis to describe our data (mean and standard deviation [SD]) and the correlation between factors. Hemphill (2003) said that coefficient correlation values below 0.2, between 0.2 and 0.03, and more than 0.3 indicate low, medium, and high correlation, respectively. We examined our hypothesis model via full structural equation modeling (SEM) in the third step. The model fit criteria were the same as those for the CFA (TLI and CFI ~ 0.95, RMSEA ≤ 0.08).

Result

Descriptive Statistics and Correlation of Latent Variables and Achievement

Table 3 describes the descriptive statistics and correla-tion between the latent variables and achievement, along with their statistical means and SDs. Most of the partici-pants came from high parent educational backgrounds as shown by the mean result (M = 4.67, SD = 1.00). The data also showed that most of the students hold strong beliefs (M = 3.76, SD = 0.57), have positive attitudes (M = 3.82, SD = 0.68), have a good motivation (M = 3.67, SD = 0.67), and have good score in math (M = 86.17, SD = 6.21).

With respect to the correlation among latent variables, the results showed that all the correlations among variables were significant. The correlations between parents' educational background, achievement, and other latent vari-ables were significant. Beliefs about mathematics education and motivation had the highest peer correlation (r = 0.68). Attitudes were significantly correlated with PED (r= 0.30) and beliefs about mathematics (r = 0.64). Motivation was strongly correlated with attitude (r = 0.67). Motivation was also correlated with PED (r = 0.30). Overall, achievement and all noncognitive factors had a strong correlation with each other (Hemphill, 2003).

SEM Analysis

The association between the latent variables was analyzed by covariance-based structural equation modeling (CB-SEM) using the software *Mplus version 8*. First, we examined the

Table 3 Descriptive statistics and correlations of beliefs, attitude, motivation, PED, and achievement

Variable	Mean	SD	Min	Max	1	2	3	4
1. Parents education (PED)	4.67	1.00	1.00	7.00				
2. Beliefs in math	3.76	0.57	1.00	5.00	0.27**			
3. Attitude towards math	3.82	0.68	1.00	5.00	0.30**	0.64**		
4. Motivation in math	3.67	0.67	1.00	5.00	0.30**	0.68**	0.67**	
5. Achievement	86.17	6.21	39.00	100.00	0.45**	0.57**	0.58**	0.60**

**Correlation is significant at the level 0.001 ($p < .001$)

model hypotheses (Fig. 1). We found the model fit of the first hypothesis, Chi-square = 573.87 *df* = 182, $p < 0.00$, CFI = 0.95, TLI = 0.94, RMSEA = 0.04, SRMR = 0.04 (Hu & Bentler, 1999; van de Schoot et al., 2012), but not all relations were significant ($p > 0$; Fig. 2). Overall, this model could explain the students' mathematics achievement 49% ($R^2 = 0.49$).

The path analysis coefficient values showed that all model variables significantly influenced students' achievement. Beliefs about mathematics were positively associated with students' achievement (β = 0.20, $p < 0.001$), attitude (β = 0.82, $p < 0.001$), and motivation (β = 0.68, $p < 0.001$). The achievement was positively and directly related to attitude (β = 0.38, $p < 0.001$) and motivation (β = 0.11, $p = 0.01$). Beliefs were positively and indirectly related to students' achievement (β = 0.31, $p < 0.001$) through attitude toward mathematics. In other words, attitude partially mediated the relationship between beliefs about mathematics and achieve-ment. Beliefs were also indirectly associated with achieve-ment (β = 0.08, $p = 0.01$) through motivation. PED was positively associated with achievement (β = 0.17, $p < 0.001$). The direct association between PED and motivation was sig-nificant but weak (β = 0.07, $p = 0.04$). However, the indirect association between PED and achievement through motiva-tion was insignificant (β = 0.01, $p = 0.11$).

We further examined the model in Fig. 3 for the fifth and sixth grades. The models for both grades had a good fit (fifth grade: CFI = 0.94, TLI = 0.932, chi-square = 404.96, df = 182, $p < 0.00$, RMSEA = 0.05, SRMR = 0.05; sixth grade: CFI = 0.95, TLI = 0.94, chi-square = 388.28, df = 182, $p < 0.00$, RMSEA = 0.05, SRMR = 0.04) . Although both models had a good fit, some associations were not signifi-cant. The direct effect of beliefs on achievement was only significant for the fifth grade. Nonetheless, for both models, beliefs significantly influenced achievement via attitude.

Beliefs were positively associated with motivation and attitude in both grades. The association between beliefs and achievements was stronger in fifth grade than in sixth grade. PED was also associated with achievement in both grades. A stronger association between PED and motivation was shown in the sixth grade. The links between PED and moti-vation were only significant in sixth grade. The mediation of attitude for beliefs and attitudes was significant in both grades. However, the mediation of motivation for the rela-tionship between the two was only significant in sixth grade. While the mediation motivation for the relations of PED and achievements in both grades was not significant.

Discussion

The novelty of this research lies in the proposed structural model consisting of students' beliefs, PED, attitudes, motiva-tion, and achievement, which have been rarely investigated.

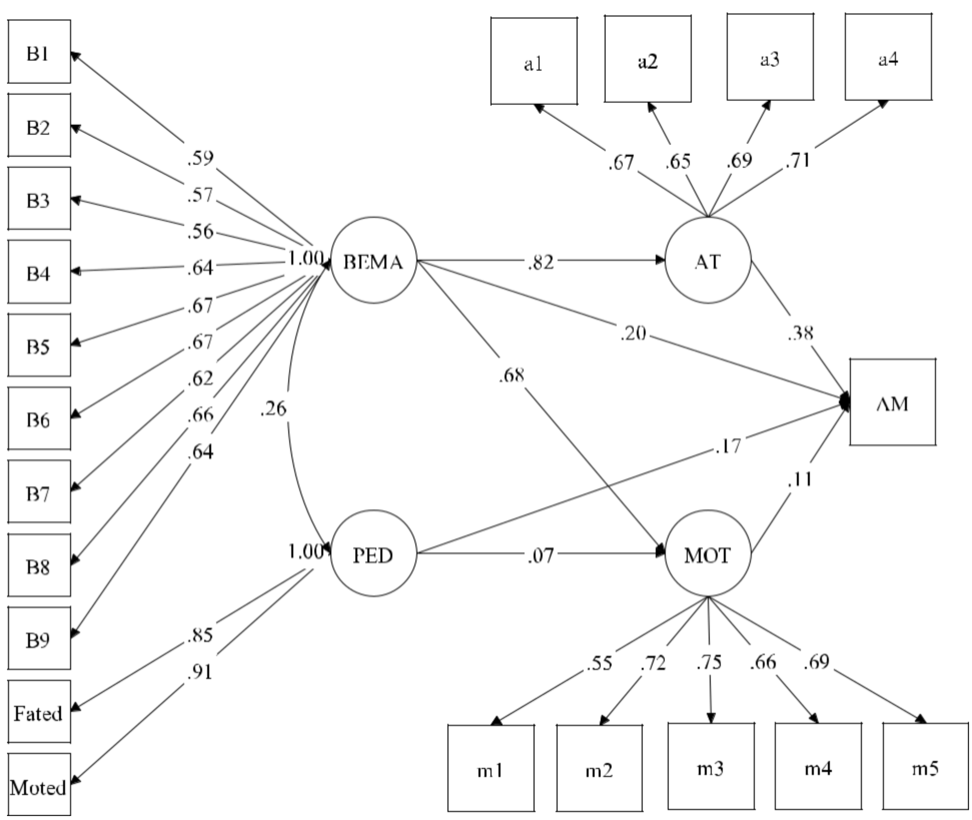

Fig. 2 Standardized path coefficient of the relationship between beliefs (BEMA), PED, attitude (AT), motivation (MOT), and achievement (AM)

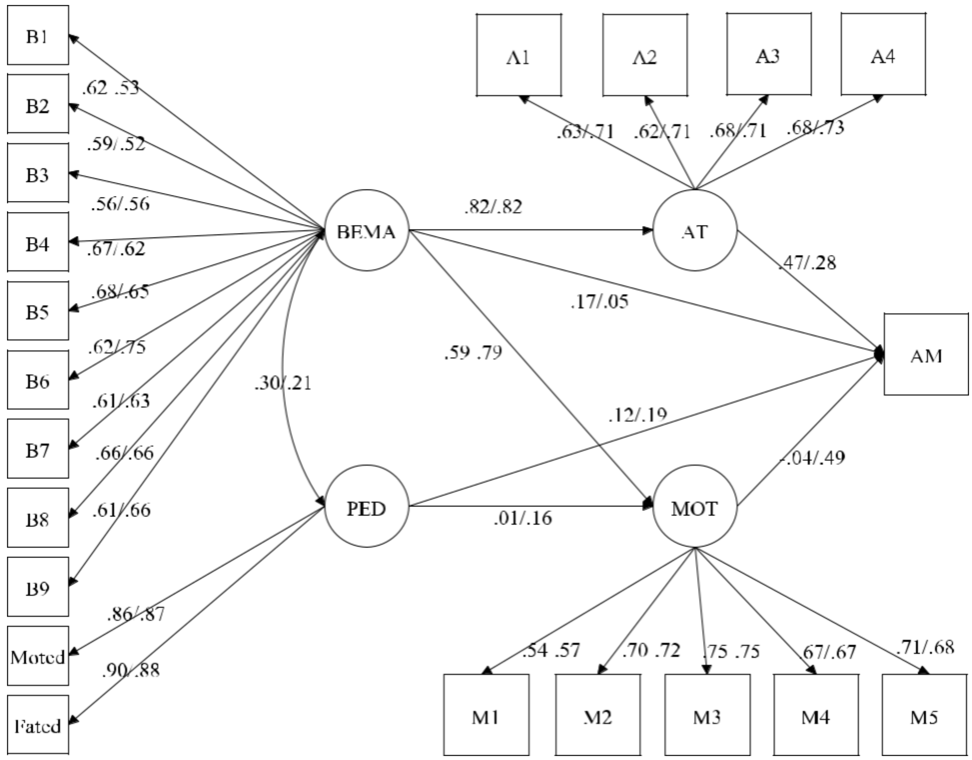

Fig. 3 Standardized path coefficient of relationships between beliefs (BEMA), PED, attitude (AT), motivation (MOT), and achievement (AM) for fifth and sixth grades

Remarkably, the simultaneous contribution of all the variables (beliefs, attitude, motivation, and PED) explains math-ematics achievements by 49%. Also, we find the mediation of attitudes and motivation for the association of beliefs, and achievements. Hence, these variables are important in determining students' performance.

First, our research confirmed that beliefs about mathematics are associated with mathematics achievement, attitude, and motivation. This finding supports Hypothesis 1, which holds that beliefs are associated with achievements, attitudes, and motivation.Interestingly, the direct associa-tion between beliefs and attitudes is the strongest relation among other variables (motivation and achievements). It means that students' beliefs about mathematics would drive their attitudes toward an object (Kim & Keller, 2010), which may affect their achievements (Csíkos, 2011; Verschaffel et al., 1994). This finding is in line with the prior research (Caprara et al., 2003; Rarujanai et al., 2022), which con-sistently indicated the association between the two. Those who have lower-level beliefs tend to have negative attitudes and low achievements. Moreover, we found that motivation toward mathematics is also determined by students' beliefs about mathematics. This finding confirmed the prior stud-ies (Kim and Keller (2010); Muis & Foy, 2010; Muis et al., 2006) which indicated that the conception of mathematics, like perceiving that the most difficult mathematical tasks can be understood, will increase students' motivation to gain the best score in math. Among latent variables, attitudes toward mathematics are the strongest factors directly associ-ated with achievements in mathematics.

Secondly, the data showed that PED predicts achievement and motivation. This finding supports Hypothesis 2, which stated that PED is expected to be positively associated with achievements and motivation. This result is consistent with previous studies (Acharya & Joshi, 2009) that PED predicted achievement. The level of PED background may relate to their involvement in mathematics learning, like providing support for students. Although this finding is also consistent with the previous study (Acharya & Joshi, 2009; Iwaniec, 2020) that suggested PED determines individual motivation, the association between the two was weak. A possible explanation of the weak association between PED and motivation is that PED is just one of the several factors that influence students' motivation. Other factors probably affect students' motivation, such as parents' involvement in students' learning.

Thirdly, we found an indirect association between beliefs and achievements through the mediation of attitudes toward mathematics. This result supports Hypothesis 3, which stated that attitude mediated the association between beliefs and achievements. This finding is in line with the prior research (Chan & Lay, 2021; Ünlü et al., 2010) that consistently stated that beliefs are associated with attitudes. This finding also supports the thesis proposed by Fishbein (1963), who explained that students' attitude toward an object (mathematics education in this study) is a function of their beliefs about the object. We assume that student's achievements are affected by their attitudes such as enjoyment which is controlled by their beliefs about mathematics.

Fourthly, we found an indirect association between beliefs and achievements through motivation toward mathematics. This finding supports Hypothesis 4, which holds that motivation mediates the association between beliefs and achievements. It means that when students perceive that they are capable of mathematics, it would control their motivation (Muis & Foy, 2010; Muis et al., 2006) and then affect achievements (Herges et al., 2017; Mo, 2019). According to House (2006), the extent to which students believe in math would drive their effort, such as hard work, which helps them achieve high scores in mathematics.

Fifthly, according to Hypothesis 5, motivation will be expected to mediate the relationship between PED and achievements. In the present study, the mediation of motivation for the two variables was not significant. The data in the present study showed that PED does not associate with motivation, which is contrary to prior studies (Ruedas-Gracia et al., 2020; Steinmayr et al., 2012). Also, motivation does not mediate the relationship between PED and achievements. A possible explanation is that previous studies did not control other variables when investigating the relationship between PED and motivation. Another explanation may be that PED only has a marginal influence in this model.

Unexpected differences emerge between the fifth and sixth grades. The influence of beliefs on motivation and attitude is significant for both grades. By contrast, beliefs only significantly influence fifth-grade students' achievement. A possible reason is that sixth- grade students may become more rational in their beliefs about mathematics because their mental process is more mature than those of younger students. Therefore, the responses of the sixth-grade students to the questionnaire about the belief systems imply a low significance of the influence of beliefs on achievement. However, we cannot generate any conclu-sion because of the cross- sectional nature of this study. A longitudinal study would affirm these factors' prediction of students' achievement.

To summarize, the finding of this study pointed out that the direct relation of beliefs on attitudes towards mathematics was the strongest direction among other associations. Attitudes are the strongest predictor for students' achievements among other variables latent (beliefs, motivation, and PED). While motivation is the weakest predictor of achievements in the present study. This finding told us that the direct association between PED and achievements was significant. Also, our study told us that attitudes and motivation can mediate the relationship between beliefs and achievement. However, motivation did not mediate the relationship between PED and achievements.

Limitations and Suggestions for Future Research

Although this finding provided a wealth piece of informa-tion, several limitations should be noted. In the present study, we only use cross-sectional surveys. This means the regression coefficients in our path models cannot be inter-preted as the causal relationship among beliefs, PED, atti-tudes, motivation, and achievements. A longitudinal study is required for future research to prove the predictive power of the aforementioned variables for achievement. Further-more, we only used the PED variable as an external factor to explain achievements. At present, parents' education is not the sole factor that influences students' achievement and motivation. Family income and learning support tools, such as appliances, mathematics, and digital devices, may also affect students' perception of mathematics. Therefore, future works should expand student backgrounds, such as SES, that incorporated family income. Other variables, such as self-regulated learning and students' attitude toward digital technology in mathematics, should likewise be investigated in future research.

Implications

This study has significant findings for mathematics education. For practice, considering the mediation of attitudes and motivation for the relationship between beliefs and achievements, mathematics educators should consider how to shape students' beliefs, because these beliefs would control students' attitudes as well as motivation, in that way their achievements will increase. Mathematics educators should train students on how to regulate their motivation as well as their attitudes toward mathematics. Additional support services can be provided by mathematics educators to improve students' achievements by communicating with par-ents on how to encourage parents to increase their involve-ment. Mathematics educators should pay attention more to students with low parents' educational levels. Preservice teachers can use this finding as an academic discourse to be analyzed from a different perspective.

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Declarations

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Availability of Data and Material Applicable.

Code Availability Applicable.

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Study 5

Students' responses to the realistic word problems and their mathematics-related beliefs in primary education

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Students' Responses to the Realistic Word Problems and Their Mathematics-Related Beliefs in Primary Education

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Annotation. The main purpose of this study is to investigate students' reactions when doing realistic word problems based on their implicit beliefs and based on their personal factors. Our study revealed that students tended to choose non-realistic responses by ignoring real-world knowledge and excluding realistic considerations when doing realistic mathematics tasks. There were no significant differences in students' reactions to word problems according to their attitude, grade, and gender.

Keywords: *realistic word problem, beliefs, mathematics, students.*

Introduction

Word problems (WPs) in mathematics have long been recognized as an essential technique for bridging the gap between real-life problems and classroom mathematics (Depaepe et al., 2010; Selter, 2000). Through WPs, students are expected to apply their mathematical knowledge in realistic contexts (Dewolf et al., 2015; Piel & Schuchart, 2014). WPs not only provide students the chance to learn the relationships among mathematics, language, and reasoning processes but also provide basic experiences in mathematical modeling (Reusser & Stebler, 1997). Mastering mathematics WPS would benefit students because they can solve real-life problems easier with mathematics.

In the last decade, mathematics education research addressed critics when discussing the gap between classroom WPs and real-life problems (Csíkos, 2011). Today, WPs have been thought not to promote a genuine interest in mathematical modeling where the text describes a real-world event that may be mathematically represented (Lave, 1992; Corte et al., 2000; Verschaffel, 2010; Verschaffel et al., 2020). Researchers and mathematics educators have attempted to promote a new concept of WPs more analogous to real-life problems. Problematic WP (P-item) is an example of a new conception of WPs, developed by Greer (1993) and Verschaffel et al. (1994), comprising actual situations and is more analogous to real-life problems. Rather than performing a routine operation, solving P-items requires realistic consideration and real-world knowledge. Using P-items for investigating students' performance, researchers revealed the hidden phenomenon of students' tendency to exclude real-world knowledge and realistic consideration.

According to prior research (Habók et al., 2020; Hidayatullah & Csíkos, 2022; 2023; Pongsakdi et al., 2020), students' tendency to solve the WPs in mathematics was closely associated with their beliefs. Beliefs influence how students learn mathematics and employ strategies in solving mathematics problems (Csíkos, 2016; Garofalo, 1989; Hidayatullah et al., 2023; Lave, 1992; Yin et al., 2020). An empirical study by Csíkos (2011) confirmed the association between students' tendency toward P-items and their implicit beliefs regarding mathematics. Researchers also assumed that students possibly hold implicit beliefs such as all.

WPs could be solved by applying routine procedures based on several numbers in the text information. However, most of the unrealistic WPs studies, such as a P-items study conducted in Western countries, implicated the lack of information on whether students in other cultures have a different tendency or not.

It is rare to find empirical studies that have addressed the students' implicit beliefs about unrealistic WPs in South Asian countries, such as Indonesia. There is no study about students' tendency to unrealistic mathematic WPs could lead to an uncompre-hensive conclusion about students' performance in mathematics. Although the ministry has made many changes to education to improve the quality of education in Indonesia, the investigation by international surveys such as PISA (OECD, 2019) and TIMMS (Fenanlampir et al., 2019; Hidayatullah & Csíkos, 2022) showed students' performance in mathematics is very poor compared to other countries. Therefore, the investigation of students' responses to WPs would provide new insight to improve the quality of math-ematics education in the Indonesian context.

To contribute to the existing gap, the purpose of this study is to explore students' responses to the realistic WPs that come from their implicit beliefs about WPs in math-ematics learning, in the Indonesian context. Relevant factors such as students' gender, grade, and feelings about mathematics were also investigated. According to the prior studies (Oakley, 2004; Shafiq, 2013), students' demographic characteristics (e.g., gender, grade) were associated with students' performance in mathematics learning. For instance, a study by Shafiq (2013) found that there was a gap in mathematics performance based on gender differences in several Muslim countries, including Indonesia. As a result, this investigation described students' performance and their tendency on WPS in math with included the aforementioned variables.

Theoretical Framework

The Types of WPs and Students' Implicit Beliefs

WPs are verbal explanations of questions that can be answered using mathematical operations based on data or information in the text problems (Greer et al., 2003; Boonen et al., 2016). Verschaffel et al. (2020) stated that WPs have always been an integral feature of mathematics education globally. WPs always exist in elementary and secondary school textbooks and enable students to develop their mathematical abilities and equip them with tools for solving life problems (Csíkos et al., 2011).

In the literature review, students' reactions to WPs have been found to be the result of their implicit beliefs about mathematics (Greer et al., 2003; Hidayatullah & Csíkos, 2022; 2023; Kloosterman, 2003; Schommer-Aikins et al., 2005). According to Greer et al. (2003) and Garofalo (1989), there are several specific beliefs in WPs were held by students, for example:

1. The task can be solved by performing the familiar mathematical procedure.
2. Any word problem presented by the teacher and textbook is solvable and makes sense.
3. Almost all mathematical tasks can be solved by directly applying the facts, formulas, rules, and procedures as shown by the teacher and textbooks.

The implications of these beliefs for students' mathematics learning were significant. When students hold these beliefs, they tend to spend their time memorizing facts and various formulae and practicing routine procedures of the most applicable methods (Garofalo, 1989). On the basis of solvability, there are two types of WPs in a mathematics classroom. The first type may be solved using only arithmetic operations, and it does not comprise real-life problems. The second type comprises more complicated WPs closer to real-life WPs, and solving such WPs requires employing imageries and considering different aspects of situations described in the WPs rather than superficial operations (Csíkos, 2011; Csíkos et al., 2011).

Seminal studies have been conducted by Greer (1993), and Verschaffel et al. (1994) confirmed these beliefs. Through their empirical studies, the researchers proposed standard word problem-solving (S-items) and the problematic word problem-solving (P-items) to investigate students' responses to WPs. S-items are the first type of task, or solvable task with routine operation. P-items are the second type of WPs or unsolvable mathematics tasks (Csíkos et al., 2011).

Surprisingly, their study found that students tend to solve the P-items using numerical operations, even if the tasks are unsolvable. In comparison, students performed very well in S-items. Greer et al. (2003) argued that the ways students solved P-items or unrealistic WPs were governed by their beliefs in WPs. Therefore, in the present study, S-items and P-items were performed to investigate students' implicit beliefs about WPs. We assumed that students performed very well on S-items and they had poor performance on P-items because they held mistaken beliefs about the solvability of WPs in mathematics learning.

The Pattern of Students' Reactions to WPs

According to the metacognition theory (Veenman et al., 2006), those who can regulate their cognition process will succeed in academic performance. When students hold the belief that all WPs can be solved based on the information in the text, they solve all mathematical tasks based on these beliefs (Garofalo, 1989). The strategy to solve the mathematical task needs to involve the metacognitive process (Csikos, 2011). In fact, people sometimes use the metacognitive process only the first time when they encounter a certain task. They then use an automated approach to solve the problem. Logically, when students find the same or repeated task, they will perform better. However, a serious problem arises if students encounter different tasks at the same time, but they leave the metacognition knowledge. Their performance becomes poorer if they use the same strategy for different consecutive tasks. Lemaire & Lecacheur (2010) suggested that students tend to switch their strategies to solve different mathematical tasks at the consecutive time. The authors also called this phenomenon a switch-cost strategy, where students tend to use the same strategy over two consecutive problems. Therefore, the pattern of students' responses to P and S-items in the present is explored. Our study assumed that students use the same strategy for P and S-items, which come from their implicit beliefs about WPs.

Personal Background Factors

Students' personal background factors, such as attitudes toward mathematics, grade, and gender issues, have been found to influence their performance when solving WPs. Attitude toward mathematics is the like or dislike of mathematics as a subject, respond-ing favorably or unfavorably to an object, a tendency to participate in or avoid mathe-matics tasks, etc. (Ajisuksmo & Saputri, 2017; Al-Mutawah & Fateel, 2018; Di Martino & Zan, 2011). Students with a high interest in mathematics would put effort into learning and solving mathematical tasks (Hidayatullah & Csíkos, 2023). We assumed that stu-dents who love mathematics would have higher marks in mathematics due to less pres-sure when solving P-items compared with other students.

The classroom grade is associated with students' age and cognition development. Cognition development is a mentally active process integrating rational thinking and logical reasoning (Taylor, 2016). Students develop their cognition through interaction in social life with themselves and mature individuals (Oakley, 2004). Older students have more school experience, and students' efficacy is influenced by their well-defined perceptions of their strengths and weaknesses (Pantziara, 2016), implying their understanding of WPs. Therefore, our study hypothesized that students with higher-level grades would perform better than lower-level grades (e.g., sixth grade and fifth grade) on WPs.

Gender differences are rooted in the social structure, inadequate educational opportunities, material shapes, and biased instructional methods (Leder, 2019) that imply on mathematics gap between boys and girls (Hyde & Mertz, 2009). Girls appear to have more negative attitudes toward mathematics than boys do, although these disparities can be narrow (Fennema, 2000). Shafiq (2013) proved that disparities in mathematics per-formance based on gender differences exist in several Muslim countries, such as Indo-nesia. The investigation of students' performance on WPs based on gender in this study would clarify whether the gap between boys and girls exists in the context of solving P-items in mathematics.

Research Hypotheses

The research objective in this study is based on several hypotheses as follows:

1. Students will have poor performance on P-items and perform very well on S-items. They will apply routine operations using the numbers elicited in a task (option *a*) for P-items.
2. Students who chose mathematics as their favorite subject outperform those who dislike mathematics in solving P-items.
3. There are significant differences between fifth- and sixth-grade students' performance on WPs.
4. There are significant differences in students' performance on WPs based on their gender.
5. Students tend to operate consistently and use the same strategies for different WPs.

Method

Participants

This study used a cross-sectional approach. Twenty-five classes were selected randomly from 9 elementary schools in Surabaya, Indonesia. 757 students (379 and 378 fifth- and sixth-grade students, respectively) participated in the present study. The data collection was conducted in the first semester. According to curriculum K13, fifth- and sixth-grade students spend 40 hours each semester. The model approach of the mathematics textbook of curriculum K13 emphasizes that students should use their reasoning for tasks typi-cally based on real-life experience. The introduction of every chapter of the mathematics textbook always begins with problems relevant to students' daily lives. Therefore, students are familiar with WP solving in mathematics.

Instruments

Our study adapted 5 items of WPs from a list of 10 P-items from Verschaffel et al. (1994). The number of P-items was increased to 13 items, in line with the mathemat-ics curriculum for the first semester in the Indonesian education context. For example: *"Runner" = John's optimal time to run 100 m is 17 s. How long will it take him to run 1 km?* And "*Mr. Aiman went sailing to catch some fish in the sea because the weather was good. In a day, he caught 10.5 kg of fish. So, how many kilograms did he catch in one week?".*

4 the S-items were also administered to enable comparison. For example, "*Sailing" = Mr. Aiman went sailing to catch some fish in the sea. On a day, he catches approximately 5.5 kg of fish. How many kg of fish will Mr. Aiman catch for five days if he gets the same volume every day?"* As a result, our study administered 13 P-items (items 1–13) and 4 S-items (items 14–17). Each item has good reliability, the coefficient alpha ranges from .82 to .83 (for the P-items, and the coefficient alpha range from .63 to .67 (for S-items. Our study adopted a multiple-choice format following the previous study in the Hungarian context (Csíkos et al., 2011). In other words, the answers are similar to the strategy that asked students how they would have solved the 17 WPs. Both P-items and S-items in this study have three options as follows.

a) Option *a* is a routine-based, non-realistic, precise, numerical response accompanied by a statement saying that this is unambiguously the correct answer.
b) Option *b* is a numerical response that considers realistic elements and considerations.
c) Option *c* is a realistic response that considers the situational complications of the problem but concludes that the problem is unsolvable.

Options *b* and option *c* were the correct answer for P-items. While option *a* was the correct answer only for S-items. Before these instruments were administered, the items of these instruments were reviewed by six experts (3 researchers and 3 mathematics teachers). Regarding students' attitudes, we asked two questions for students: *what your favorite subject is*, and *what is your unfavorite subject in school*? Then, we compared stu-dents who said mathematics was the most liked and mathematics was the most disliked subject on their performance over WPs. This test was administered to students using the Google form. Mathematics teachers and principals actively helped in collecting data. The collecting data process has taken place at the end of the semester in Indonesia.

Data Analysis

This study used a quantitative approach. Several methods were used to analysis of the data and to answer the hypotheses. The descriptive statistics of the data were used to analyze the first hypothesis. Both P-score and S-score are cumulative performance measures calculated from individual P- and S-item scores. We code the correct answer

1 and incorrect answer 0 for P- and S-item. To answer the second to fourth hypotheses, Mann Whitney test was performed. A coefficient contingency was performed to answer the fifth hypothesis.

Results

Students' reactions to WPs

The results presented in Table 1 supported the first hypothesis; students tended to employ a non-realistic approach for P-items. The frequency of the non-realistic approach in P-item 1 "Runner" was the highest; 86%, 12%, and 2% of students chose options *a*, *b*, and *c*, respectively. Meanwhile, the non-realistic approach was least prevalent in P-item 4, "Water"; 49%, 42%, and 9% of students chose options *a*, *b*, and *c*, respectively.

Table 1

Frequencies of P-Items and S-Items Response

No	Word Problem	Response options (%)		
		a	b	c
	P-Items			
1	Runner	86	12	2
2	Rope	70	26	4
3	School	77	16	7
4	Water	49	42	9
5	Friend	73	24	3
6	Cycling	63	30	7
7	Walk	75	21	4
8	Sailing	52	36	12
9	Doll	77	19	4
10	Ship	73	24	3
11	Run Park	72	25	4
12	Shoes	70	15	15
13	Playing	68	21	10
	S-items			
14	Cycling 2	72	22	6
15	Sailing 2	77	19	4
16	Shoes 2	82	15	3
17	Driving	75	21	4

Note: The names of tasks 1–5 was adapted from Verschaffel et al. (1994).

The number of students who chose option *b* was higher than the number of students who chose option *c*. A substantial numerical consideration influenced students' choice of option *b* over option *c*. However, the data also illustrated a significant difference from previous research, revealing that most students chose option *b* in several P-items. In this study, no numerical data indicated a majority response for options *b* or *c*. The data showed that most students chose option *a* for P-items (70% for option *a* and 30% for the combination of options *b* and *c*). The realistic answer of Indonesian students is lower than in previous studies, such as in the Hungarian context. In Hungary, 33.33% students chose options *b* and *c*. (Csaba, 2011),

The data in Table 1 also confirmed that students performed very well on S-items. As shown in the S-items data in Table 1, most students chose option *a* (77% for option *a*, and 23% for the combination of options *b* and *c*). The highest frequency of option *a* was 82%, i.e., S-item 16 "Shoes 2" S-item 14 "Cycling 2" had the lowest frequency of option *a*, i.e., 72%.

Students' Favorite Subject and Their Reactions on P-items

Students were asked about their favorite and least favorite subjects. 16.4% of students chose mathematics as their favorite subject, indicating that a small percentage of stu-dents like mathematics. In addition, mathematics is the least favorite subject, with 41.9% of 757 students. Table 2 compares students' responses based on their choice of mathe-matics as their favorite and least favorite subjects. Overall, the data showed that 70.38% of option *a* and 29.62% of option *b* - *c* had been chosen by students with mathematics as a favorite subject. While 70.86% of option *a* and 29.14 option *b* - *c* have been selected by students with mathematics as an unfavorite subject.

Table 2

Response on P-items Based on Students Feeling About Mathematics (%)

P-Items	Mathematics favorite (N = 124)			Mathematics least favorite (N = 317)		
	a	**b**	**c**	**a**	**b**	**c**
Runner	94	6	0	86	11	3
Rope	73	24	3	69	27	4
School	78	13	9	80	13	7
Water	46	45	9	54	37	9
Friend	73	25	2	75	22	4
Cycling	59	33	8	64	30	6
Walk	79	16	5	76	20	4
Sailing	52	33	15	55	35	10
Doll	79	17	4	75	22	3
Ship	78	20	2	74	22	4
Run Park	73	22	5	69	26	5
Shoes	64	14	22	75	13	12
Playing	67	19	14	70	22	8

For P-item 1, "Runner", almost 100% of students who like mathematics chose option *a*; almost 90% of students who dislike mathematics also chose option *a* . Meanwhile, for P-item 4, "Water", option *b* was the most frequently chosen by students who like mathe- matics (46% for option *a* and 54% for options *b* and *c*). The percentage of option *c* in both groups was almost identical for all P-items.

Grade, Gender, and Students' Reaction on WPs

In Table 3, using descriptive statistics, the data compare fifth- and sixth-grade students' responses to P-items to evaluate the fourth hypothesis: there are no significant differences between fifth- and sixth-grade students when solving P- and S-items. Overall, the data showed that the total percentages of fifth-grade students' responses for P-items are 70% for option *a* and 30% for options *b* and *c*. Meanwhile, the total percentages of sixth-grade students' responses for P-items are 61% for option *a* and 31% for options *b* and *c*.

Table 3

The Percentage of WPs Response Based on Students' Grade

Word Problems	Fifth-grade students' response			Sixth-grade students' response		
	a	b	c	a	b	c
P-items						
Runner	86	11	3	85	13	2
Rope	72	25	3	69	27	4
School	78	15	7	76	16	8
Water	48	44	8	51	40	9
Friend	77	20	3	67	29	4
Cycled	60	31	9	66	28	6
Walk	77	20	3	73	22	5
Sailing	51	36	13	52	36	11
Doll	79	17	3	74	22	4
Ship	75	21	4	72	26	2
Run Park	71	25	4	72	24	4
Shoes	69	13	18	70	17	13
Playing	68	20	12	68	23	9
S-items						
Cycled 2	71	23	6	73	21	6
Sailing 2	80	16	4	75	22	3
Shoes 2	82	14	4	82	16	2
Drive	75	20	5	76	21	3

Interestingly, sixth-grade students chose much more option *a* (51%) compared with fifth-grade students (44%) for P-item 4, “Water.” Meanwhile, the frequencies of fifth-grade students who chose option *b* (44%) and option *c* (8%) were higher than those of sixth-grade students [option *b* (40%) and option *c* (9%)] for the same P-items.

We further examined whether or not there were significant differences in students’ responses on P-items and S-items based on grades level and gender differences (See table 4). Since our study measures students’ performance, our data can be considered as being ordinal scale. According to Mann Whitney test, no significant difference was found between fifth and sixth graders on P-items and S-items. We also didn’t find significant differences between male and female students in P-items and S-items.

Table 4

T-test of WPS Based on Grades and Gender

Variables	P-score				S-score			
	Mean Rank	***Sum of ranks***	***U***	***p***	**Mean Rank**	***Sum of ranks***	***U***	***p***
Grade								
Fifth	374.16	141060.00	69807.00	.67	376.82	142059.50	70806.50	.67
Sixth	380.84	143575.00			378.18	142575.50		
Gender								
Boys	373.19	138081.50	69446. 50	.59	379.39	140375.50	70339.50	.79
Girls	381.65	146553.50			375.68	144259.50		

Note. *Significant p < 0.05, **significant p < .001.

The Pattern of Students’ Reactions on WPs

Frequency, chi-square included coefficient contingency was employed to evaluate the fifth hypothesis; Students tend to operate consistently and use the same strategies for different WPs. Table 5 shows the percentage of association between responses on P-items and S-items.

Table 5 showed that students who failed on P-items, 96.8% of them had correct answers on all S-items. For students with at least 1 correct answer for P-items, 83.3% of them had correct answers for all S-items. Meanwhile, 70% of students who were correct for all of the P-items had no correct answer on S-items. The result from the contingency table indicated the association between P-items and S-items, *Chi-square (df* = 52*)* = 500.08, *p* < .001 (*CI* = .65, *p* < .001).

Table 5

The Pattern of Response Over P and S-items

Students' correct answers on P-items		Students' response on S-items (%)				
		0	1	2	3	4
Total P-items	0	0	0.0	0.0	3.2	96.8
	1	0	2.2	1.1	13.3	83.3
	2	0	1.5	9.0	22.4	67.2
	3	0	6.5	14.5	29.0	50.0
	4	5.5	5.5	12.3	28.8	47.9
	5	3.0	11.9	20.9	35.8	28.4
	6	3.4	10.3	22.4	27.6	36.2
	7	5.2	29.3	29.3	15.5	20.7
	8	9.8	24.4	34.1	19.5	12.2
	9	11.8	35.3	29.4	5.9	17.6
	10	23.8	9.5	23.8	19.0	23.8
	11	23.1	15.4	38.5	23.1	0.0
	12	42.9	14.3	28.6	0.0	14.3
	13	70	10.0	0.0	10.0	10.0

Note. Coefficient Contingency (N =757) = .63, p < .001, Chi-square (df=52) = 500.08, p < .001.

This means the data showed students are good at P-items, but they will be bad at S-items because they switch or repeat the same strategy to a different task. Students who chose *options b* (realistic consideration) and *c* (realistic reaction) for the P-item were more favorable to repeating this option on S-items. Spearman correlation was performed to confirm the correlation of students' performance on P-and S-items. The total correla-tion between P- and S -score (r = -.65, p < .001) confirmed that students who succeed in P-items tend to fail in S-items.

Discussions

Our findings demonstrated that Indonesian students employ non-realistic approaches when solving WPs in mathematics, which is consistent with a similar study conducted in Hungary by Csíkos (2011), who found that most of the students ignore realistic considerations when answering P-items. This study revealed a similar phenomenon to the *"how old the Captain*" study by French and German researchers, where students solved this problem using arithmetical skills based on routine operations, although this task is irrational and unsolvable (Greer, 1997). The findings of this study revealed that Indonesian students tend to exclude real-world knowledge when they encounter unrealistic

WPs (Garofalo, 1989; Greer et al., 2003). This study also described Indonesian students' implicit beliefs regarding the solvability of WPs, demonstrating that they believe that they can solve all WPs using routine operations.

This study showed that almost half of the Indonesian students did not like mathematics as a subject. This phenomenon should alarm mathematics educators to be rethinking how to establish a comfortable and joyful mathematics learning environment since the teaching method has been recognized to influence students' attitudes (Tahar et al., 2010). Concerning students' attitudes and their relation to WP solving, this study revealed that students who like mathematics tend to use non-realistic approaches when solving P-items. P-items can be categorized according to whether they are understood and handled by students whose favorite school subject is mathematics.

Moreover, there was no significant difference between fifth- and sixth-grade students in relation to their performance on P- and S-items. Theoretically, sixth graders should outperform fifth graders on the same tasks because of the content of P-items in this study. Meanwhile, our findings elucidated that higher grades do not guarantee the use of realistic approaches for P-items. In this instance, we assume that the school mathematics WP has not served the aim of the WP, which is to develop thinking and practical mathematics in everyday life (Greer et al., 2003). According to Lampert (1990), students' beliefs regarding WPs are formed by their experience in school; doing mathematics was following the technique used by a teacher in solving mathematics tasks, whereas knowing mathematics was memorizing, remembering, and using correct rules for solving a given question.

Concerning the gender issue, our findings showed no significant differences in students' performance on P- and S-items. Boys' and girls' Indonesian students have had equal performance in WPs mathematics. This finding clarifies the previous study by Shafiq (2013), which revealed that male students outperformed female students in mathematics. Our discovery is also different from an earlier study that found male students solved WPs better than female students (Lailiyah, 2017). This could be because the educational system in Indonesia has changed from a traditional to a modern system, where there is the same opportunity to access education.

According to Fitzpatrick et al. (2020), students who are better at realistic consideration may have a higher ability to prevent an automatic or non-realistic approach. However, the findings of this study have shown the tendency for students who succeed in P-items are more favorable to fail in S-items. Maybe students involved the realistic consideration or real-world knowledge when they first-time encounter P-items. Afterward, they didn't involve realistic consideration for the next tasks (S-items), but they used the automa- tics mentality. In other words, students tend to repeat and switch the same strategy for different tasks. According to Lemaire and Lecacheur (2010), when switching strategies, students switch the same strategy from one task to another. The data in our findings revealed that students who had the highest score in P-items tended to fail in S-items because they repeated the same strategy on different tasks.

Limitation

Although this study provides a wealth of information, several limitations of this study should be noted. First, we used data from the East Java Province and fifth and sixth grades. Research with a larger sample and another grade should be conducted to validate our findings. Second, this study did not describe the relation of students' performance on P and S-item with other non-cognitive factors such as motivation, parents' education level, and their attitudes. For the next research, other non-cognitive factors should be investigated in further studies to provide more comprehensive data on students' perfor-mance on WPs in mathematics. Third, since this study used a cross-sectional approach, experimental research is necessary to find a solution to change the mistaken beliefs about the solvability of WPs in mathematics learning.

Conclusion and Implication

Our finding suggests that Indonesian students use a more non-realistic approach toward P-items in mathematics. Our study found no significant differences in the P-item context based on students' personal backgrounds, such as gender and grades. In the In-donesian context, students must change their beliefs regarding the solvability of WPs. This study also indicated that the role of WPs in schools did not encourage students to use their reasoning when solving mathematics problems.

The implication for education is mathematics educators need to design appropriate means to change students' beliefs. Mathematics educators should be reflecting on whether their concept of mathematical tasks supports the goal of WPs – to develop students' reasoning regarding mathematical structures through imaginative but frequently unreal narratives. Students' skills on WPs, particularly P-items, are significant parts of mathematics education that go beyond regular teaching. The learning process that encourages students to discuss and elaborate on their idea may change their beliefs regarding the solvability of WPs. Mathematics teachers also need to demonstrate how to involve the metacognition strategy skill in solving each WPs in mathematics learning.

Declaration of Competing Interest

No conflict of interest exists.

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Mokinių atsakymai sprendžiant tekstinius uždavinius ir su matematika susiję įsitikinimai pradinio ugdymo etape

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Santrauka

Šio tyrimo tikslas – atsižvelgiant į netiesioginius mokinių įsitikinimus ir asmeninius veiksnius ištirti mokinių atsakymus sprendžiant tekstinius uždavinius. Šiame tyrime dalyvavo 757 Indonezijos mokyklų penktos ir šeštos klasės mokiniai (373 berniukai, 378 mergaitės). Penki probleminių tekstinių uždavinių elementai (P-elementai) buvo adaptuoti iš Verschaffel ir kt. (1994). Aštuoni P elementai ir 4 standartiniai tekstiniai uždaviniai (S elementai) buvo sukurti pagal Indonezijos mokymo programą. Žodiniuose uždaviniuose buvo pateikti uždaro klausimo formato atsakymai su keliais atsakymų variantais: a variantas (netinkamas atsakymas), b variantas (tinkamas atsakymas) ir c variantas (teiginys „neišsprendžiama“). Teisingi probleminio žodinio uždavinio atsakymai buvo b ir c variantai, o a variantas buvo teisingas standartinio žodinio uždavinio atsakymas. Tyrimo rezultatai atskleidė, kad mokiniai buvo linkę rinktis netinkamus atsakymus, ignoruodami realias žinias ir atmesdami realias aplinkybes. Mokiniai netiesiogiai laikosi klaidingų įsitikinimų, kad visus žodinius uždavinius galima išspręsti naudojant įprastinius veiksmus. Reikšmingų skirtumų tarp mokinių, sprendžiančių šiuos uždavinius, pagal jų lytį ir mokymosi klasę nenustatyta. Indonezijos mokiniai linkę naudoti ir primygtinai taikyti tą pačią strategiją spręsdami skirtingus uždavinius, todėl matematikos rezultatai yra prasti. Šio tyrimo išvados prisideda prie pradinio ugdymo matematikos mokymo praktikos Indonezijoje.

Esminiai žodžiai: *tekstinis uždavinys, įsitikinimai, matematika, mokiniai.*

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CHAPTER III. GENERAL DISCUSSION

3.1. Insights from empirical studies

This dissertation set out with the aim of assessing the importance of mathematics-related beliefs in mathematics learning that composed the issue of generality and specificity of epistemological beliefs, mathematics-related beliefs, and the significance of mathematics-related beliefs in promoting academic outcomes. This dissertation combines five empirical studies related to the aforementioned issues.

It has been discussed earlier, in the historical epistemological beliefs studies, Limón (2006) pointed out that the epistemological beliefs studies generally can be grouped into developmental epistemological beliefs, structure of epistemological beliefs, and source of epistemological beliefs. Among this form of epistemological beliefs, there was debate among the researchers about the structure of epistemological beliefs. The main concern was whether the feature of epistemological beliefs across a domain or a specific domain. The initial revelation in Study 1 confirms the universality and particularity of personal beliefs concerning knowledge. Interestingly, rather than support the argumentation that epistemological beliefs are more general solely (Schommer-Aikins et al., 2005; Schommer et al., 1992), the finding of study 1 also supports the argumentation that epistemological beliefs are more specific domains (Buehl & Alexander, 2001; Hofer, 2000; Hofer & Pintrich, 1997). In study 1, students from different departments hold equal beliefs about the justification of knowing and beliefs about the source of knowledge. As we discussed earlier, justification of knowing relates to the ways students justify their beliefs. Both students from different departments believe more in the one who has first-hand experience rather than an expert in their field study. Nevertheless, students in mathematics education hold stronger beliefs about certainty of knowledge (e.g., "The truth never changes in this field" and "there is only one right answer in this field") than students in primary teacher education. Also, mathematics education students hold stronger beliefs in attainability of the truth (e.g., "Experts in this field can ultimately get to the truth" and "If scholars try hard enough, they can find answers to almost anything") than students from primary teacher education. The explanation for this finding is that social structure and environments in the mathematics department may contribute to such beliefs. Interactions with mathematicians, mathematics teachers, and formulas more frequently affect their perception of the certainty of knowledge and attainability of the truth in their field study. Since study 1 indicated that domain study significantly determines the way one conceptualizes knowledge, the more specific beliefs instruments with specific purposes would be more valuable to explain students' conception, such as mathematics-related beliefs questionnaire to measure students' beliefs in mathematics. Accordingly, I decided to adopt a more specific instrument to measure students’ beliefs about mathematics.

In Study 2, I found that Indonesian students in secondary schools hold strong beliefs about the teachers, beliefs about the nature of mathematics, moderate beliefs about mathematics learning, and moderate beliefs about mathematics performance. For instance, most of the students believe that their mathematics teacher is friendly, their teacher tries to make mathematics interesting, their teacher listens carefully to students' problems, and their teacher understands the difficulties of students. The possible explanation for this case is that Indonesia's social norm determines how students perceive their teachers. For instance, there is a general awareness among Indonesian people that a teacher is someone who should be appreciated. Accordingly, all the students should show good behavior and be polite to their teacher. Moreover, students highly believe in the usefulness of mathematics, such as the functioning of mathematics courses for other courses and daily life.

In this current dissertation, discrepancies have emerged regarding the connection between epistemological beliefs and gender within the research findings. While significant differences in beliefs were identified in secondary schools (Study 2) and primary education (Study 4), there were no significant differences found in higher education (Study 1) or primary education (Study 5). Study 2 pointed out that boys hold stronger beliefs about mathematics learning and perceive that they understand the most challenging tasks in mathematics better than girls. However, the differences in beliefs were insignificant in higher education (Study 1) and primary education (Study 5). The possible explanation for these inconsistencies is that several factors, including teaching methods in the classroom, influence gender differences. As the samples of empirical studies were not the same, there were probably differences in teaching methods and social culture in the classroom. Further investigations are necessary to confirm this finding.

Furthermore, In Study 2, it was found that students' beliefs about mathematics learning vary based on personal factors such as their level of study and ethnicity. Eighth-grade students have stronger beliefs about the role of their teacher than seventh-grade students. Additionally, students' beliefs differ based on their ethnicity, with Javanese students having higher beliefs in mathematics learning than Madurese students. According to social cognitive theory (Bandura, 2002), beliefs are determined by social structure and environment. It is possible that the way mathematics is taught in the Madura context influences students' beliefs. However, further research is needed to confirm this finding.

The findings of this dissertation indicated that mathematics-related beliefs significantly predict emotional engagement and behavioral engagement, as shown by Study 3. Specifically, students who hold a strong belief about the nature of mathematics, such as considering it to be a collection of rules and facts, exhibit greater engagement in mathematics learning (Csíkos et al., 2011; Schommer et al., 2005). It means that in elementary schools, the less sophisticated students' beliefs about the nature of mathematics, the higher their emotional and behavioral engagement. This finding contradicted other investigations of epistemological beliefs construct. For instance, Schommer et al. (2005) reported that the higher students' beliefs about the speed of knowledge, the lower their achievements. The study also highlights that students who recognize the utility of mathematics in their daily lives are more likely to engage in the subject. Students' self-judgment about their ability has been found to slightly mediate the relationship between beliefs about the nature of mathematics and behavioral and emotional engagements. It could be that when students perceive that mathematics is more memorizing and the collection of facts, rules, and numbers, such a situation increases their efficacy in understanding mathematics learning and, in turn, increases behavioral and emotional engagement.

This dissertation found that there is a direct correlation between students' mathematics-related beliefs and their attitudes (Study 1 and Study 2), motivation (Study 3 and Study 4), and achievements in the subject. The research findings indicate that stronger perceptions regarding the role of mathematics teachers in the classroom, self-efficacy, and the nature of mathematics lead to higher levels of motivation, positive attitudes, and better mathematics achievements. This finding is consistent with prior research (Greer et al., 2002; Hofer, 2000; Op 't Eynde & De Corte, 2003; Schommer et al., 2005) that has established epistemological beliefs in mathematics as associated with various aspects. Interesting result from Study 4 is that attitudes and motivation mediate the relationship between students' mathematics-related belief systems and their achievements in mathematics. This implies that students' belief systems regarding the nature of mathematics, their ability, and the role of their teacher indirectly affect their achievements in mathematics by influencing their attitude and motivation towards the subject.

If Study 4 found a positive relationship between mathematics-related beliefs and mathematics achievements, Study 5 revealed the same result but in a more specific context that students' mathematics-related beliefs are associated with students' responses to realistic word problems in mathematics learning. Indonesian students in primary education tend to believe that all word problems can be solved by performing routine operations. This belief implies that students tended to exclude real-world knowledge and realistic considerations when solving word problems in mathematics. Study 5 is consistent with Verschaffel et al.(1994) and Greer (1997), which showed the tendency of students to avoid realistic estimation when doing word problems in mathematics. At the same time, their performance on standard word problem-solving tests is sophisticated. Interestingly, when students involved the realistic consideration in problematics word problems, they should have performed well in standard word problems in mathematics learning. Otherwise, those who performed well on p-items they performed poorly in s-items. At the same time, those who perform poorly on p-items tend to perform well on s-items. It can be interpreted that in consecutive and different tests, students tend to switch their strategies even if they do different tests. This phenomenon can be called a switch-cost strategy (Lemaire & Lecacheur, 2010).

To summarize, the findings of this dissertation revealed that different background field studies affect the differences in personal epistemological beliefs. In the mathematics learning context, this dissertation found that mathematics-related beliefs were significantly associated with personal factors, such as gender and ethnicity. Furthermore, this dissertation pointed out that mathematics-related beliefs predict various aspects, such as motivation, attitudes, engagement, strategy, and achievement. This dissertation also revealed an indirect association between mathematics-related beliefs and achievement through the mediating role of attitude and motivation. There were indirect associations between mathematical beliefs, behavior, and emotional engagement through the mediating role of self-efficacy. Last but not least, students hold mistaken beliefs about the solvability of word problems that affect their strategy to respond to realistic word problems. Students tend to solve every realistic word problem and exclude the realistic consideration.

3.2. Implications

Drawing from the insight of our empirical studies, the findings of this dissertation provided some theoretical contributions. These empirical studies enrich the literature review about the contribution of students' mathematics-related belief systems or epistemological beliefs about mathematics-on-mathematics learning, particularly in the Indonesian context. In light of the controversy of generality-specificity of epistemological beliefs, the finding of study 1 showed that generality and specificity domain beliefs have their own space. The result showed that some beliefs are general domains, and others are sensitive to domain studies. Consequently, a more specific instrument is needed to measure personal epistemological beliefs in certain field studies, such as mathematics, science, engineering, etc. Study 2 provided a literature review on the extent to which students in Indonesia hold beliefs about mathematics. An important result is that I find evidence personal factors, such as gender, level of study, and ethnicity, may influence mathematics-related beliefs, which have rarely been studied. This result aligns with the social cognitive theory that the social structure where individuals live may contribute to shaping beliefs, cognition, and behavior (Bandura, 2001; Schunk & Usher, 2019). The findings of Study 3, study 4, and Study 5 provide a literature review about the significant role of mathematics-related beliefs in promoting behavior engagement, emotional engagement, attitudes toward mathematics, intrinsic motivation, problem-solving strategy, and achievements. The poor performance of Indonesian students in mathematics, according to international surveys such as PISA and TIMSS, is probably associated with the level of students' mathematics-related belief systems. For instance, the way students solve realistic word problems while excluding the realistic consideration indicates that students hold mistaken beliefs. Therefore, the finding of this dissertation aligns with the results of PISA and TIMSS, where Indonesian students suffer from mathematics achievements.

The findings of this dissertation also contribute to teaching practices in mathematics learning. According to Study 1 and Study 2, most students believe that their knowledge of mathematics continues to expand and that mathematics is useful in other courses and in real-life situations. Mathematics teachers can help students reinforce this belief by showcasing examples of new discoveries in society that relate to mathematics. Since studies 3 and 4 showed that students' mathematics-related belief systems in mathematics learning are positively associated with engagement, mathematics achievement, motivation, and attitudes, it is important for mathematics teachers in the Indonesian context to pay more attention to students' beliefs. Beliefs about self-ability or self-efficacy should be strengthened. Teachers can persuade students that they have the ability to learn mathematics. Teachers can help students improve their beliefs by providing them opportunities to show their ability in mathematics learning. Teachers are also suggested to improve students' beliefs about the role of the teacher by teaching mathematics well and showing how caring they are for their students. Concerning the findings of Study 5, direct instruction and reminders would also help students involve their metacognition knowledge when doing word problem-solving in mathematics. It is suggested that the mathematics teacher provide a new concept of mathematical tasks by considering realistic word problems. Mathematics teachers must help students change their beliefs about the solvability of word problems in mathematics. As this dissertation showed, students hold mistaken beliefs about mathematics word problems. Organizing students into group discussions to solve realistic word problems would be valuable in changing students' mistakes and beliefs.

3.3. Limitations and directions of the future research

Although the result of the present dissertation provided wealth and important information, several limitations should be noted for future research. All the investigations in this dissertation were cross-sectional. Each research was conducted through a survey at one time. It happens because of the limitation of the resource and distance. At the same time, with the limited resources, it was challenging to do experiments and longitudinal studies in Indonesia. During the period 2020-2021, the pandemic made the situation more complicated. The longitudinal study and experiment were difficult to conduct.

Consequently, the connection between factors in each of these studies cannot be claimed as a causal relationship (e.g., empirical study I, empirical study 3, and empirical study 5). Therefore, future research is needed to confirm this finding by conducting a longitudinal study. Second, Indonesia, as an archipelago country, becomes a problematic issue in terms of equity. However, most of the empirical studies in the present dissertation were conducted in Surabaya, except for I and Study 2. Consequently, the generalizability issue should be considered in future research. Many psychological and policy issues were not covered in this dissertation. For instance, although study 4 showed the structural model to explain students' performance, this dissertation did not provide an explanation of how Indonesian students in primary education obtain their beliefs about mathematics. Therefore, the investigation of the source of self-efficacy and the source of epistemological beliefs is necessary for future research. Also, self-regulated learning, self-determination theory, metacognition awareness, mastery motivation, and students' behavior are important issues not yet covered in this study. Lastly, the new controversy in Indonesia related to equity is the new policy of the zonation system. Every year, there is a debate among researchers, practitioners, and policymakers about the zonation system, which still has many problematic issues. Besides investigating psychological matters, future research needs to consider policy matters and economic status.

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APPENDIX A
ETHICAL APPROVAL

University of Szeged

Institutional Review Board
Doctoral School of Education

6722 Szeged, 30-34 Petőfi S. Av., Hungary
Phone/fax: +36 62 544-032

Achmad Hidayatullah
PhD Student: Doctoral School of Education
Reference number: 3/2021
Subject: Ethical evaluation of a research project

Date: 16 February, 2021

E T H I C A L A P P R O V A L

The Insitutional Review Board (IRB) of the Doctoral School of Education, University of Szeged has recently reviewed your application for an ethical approval (Title of the Research Project: "**Design Instruments and analyses of a Questionnaire Students Mathematics-related beliefs system**", senior researcher: Dr. Csaba Csikos Antal). This proposal is deemed to meet the requirements of the ethical conducts on social research with human subjects of the Doctoral School of Education, University of Szeged.

IRB decision: approved

In this study, I will conduct an investigation into the structure and nature of students' mathematics related beliefs system in Indonesian students.

Justification: The research project meets the requirements of the professional-ethical criteria of the social research including human subjects within the field of education science. Main goal of the study is to investigate the structure and nature of students' mathematics related beliefs system in Indonesian students using a questionnaire created by Eric De Corte. The participants will be students of 13-15 years old (N = 150), males and females from state, in West Java and East Java. Data are collected by using online questionnaire and online problem-solving test. Participation is voluntary. The data collection will ask the participants' name, age, gender, school type; however, the data collection is registered by code. Written consent given by the participants and their parents will be asked (informed consent). Procedure of the data collection does not harm their privacy law, it does not have an impact on the participants' mental or physical health. Data cannot be handled by persons to whom they are not concerned.

In a summary, full ethical approval has been granted.

We wish you all the best for the conduct of the project.

Prof. Dr. Bettina Pikó
IRB coordinator

APPENDIX B
Letter permission for elementary education

um surabaya
UNIVERSITAS MUHAMMADIYAH SURABAYA

Nomor : 170/II.3.AU/FKIP/F/VII/2021

Lamp : -

Perihal : Izin Penelitian

Yang terhormat

Kepala SD Muhammadiyah 18 Surabaya

Jl. Mulyorejo Tengah No.5, Mulyorejo, Kec. Mulyorejo, Kota SBY, Jawa Timur 60115

Assalamualaikum Wr. Wb.

Dengan ini kami Dekan Fakultas Keguruan dan Ilmu Pendidikan Universitas Muhammadiyah Surabaya menerangkan bahwa :

Nama : Achmad Hidayatullah, M.Pd

NIDN : 0705089002

Jabatan : Dosen Tetap Program Studi Pendidikan Matematika (S1)

Pada kesempatan ini kami mohon Bapak/Ibu berkenan memberikan izin kepada dosen tersebut untuk mengadakan penelitian secara online pada tanggal 20 Juli 2021 sampai 30 Agustus 2021 di sekolah Bapak/Ibu. Adapun judul penelitian adalah :

”BELIEFS SISWA TERHADAP MATEMATIKA DALAM PEMECAHAN MASALAH”

Atas bantuan dan kerja samanya kami ucapkan terima kasih.

Wassalamualaikum Wr. Wb.

Surabaya, 09 Juli 2021

Dekan

Ratno Abidin, S.Pd., M.Pd.

APPENDIX C

Discipline-Focused Epistemological Beliefs Questionnaire

Certainty of knowledge	**1**	**2**	**3**	**4**	**5**
Answers to questions in this field change as experts gather more information.					
All experts in this field understand the field in the same way.					
The truth never changes in this field					
There is only one right answer in this field					
Principles in this field are unchanging.					
The answers to questions from experts are the same in this area.					
The idea should be questioned in this field					
Most of the truth has been known in this field.					
Justification for knowing					
First-hand experience is the best way of knowing something in this field.					
I am more likely to accept the ideas of someone with first-hand experience than the ideas of researchers in this field.					
Correct answers in this field are more a matter of opinion than fact.					
There is really no way to determine whether someone has the right answer in this field.					
Source of knowledge					
Sometimes, you just have to accept answers from the experts in this field, even if you don't understand them.					
If you read something in a textbook about this subject, you can be sure it's true.					
If my personal experience conflicts with ideas in the textbook, the book is probably right.					

I am most confident that I know something when I know what the experts think.					
Attainment of truth					
Experts in this field can ultimately get to the truth.					
If scholars try hard enough, they can find answers to almost anything.					

Note: *1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree*

APPENDIX D. DSBQ (INDONESIAN)
Survey terhadap personal epistemologi keyakinan (pengetahuan)

Nama :
Usia :
Jenis kelamin :
Program studi :
Fakultas :
Domisili asal :
Etnik :
Madura :
Jawa :
Sunda :
Batak :
Lainnya :
IPK :
Pendidikan orang tua :

Bacalah pernyataan di bawah ini!
Berilah tanda cecklist pada pernyataan di bawah ini pada kolom yang disediakan. Saya sangat tertarik terhadap respons Anda mengenai pernyataan-pernyataan tersebut. Terima kasih telah berkontribusi dalam mengisi Survey ini.
(1= sangat tidak setuju, 2 = tidak setuju, 3 = netral, 4 = setuju, 5 = sangat setuju)

No	Pernyataan	1	2	3	4	5
Certainty of knowledge						
1	Jawaban terhadap permasalahan dalam bidang studi yang saya pelajari bisa berubah sesuai dengan temuan terbaru dari ilmuan					
2	Semua pakar dalam bidang studi yang saya pelajari memiliki pemahaman yang seragam					
3	Kebenaran dalam bidang ini bisa berubah					
4	Semua permasalahan dalam bidang ini hanya memiliki satu jawaban yang benar.					
5	Tidak ada perubahan prinsip dalam bidang study saya					
6	Seluruh pakar memiliki jawaban yang sama terhadap permasalahan dalam bidang ini					
7	Ide atau gagasan dalam bidang ini perlu diragukan					
8	Sebagian besar jawaban terhadap permasalahan dalam bidang ini telah ditemukan					
Justification for knowing						
9	Langkah terbaik untuk mengungkap kebenaran dalam bidang ini adalah melalui pengalaman langsung					
10	Saya lebih percaya gagasan atau ide dari seseorang yang memiliki pengalaman langsung dari pada ide atau gagasan pakar di bidang ini					
11	Jawaban dalam bidang lebih pada persoalan opini ketimbang fakta					

12	Tidak ada cara yang pasti untuk menentukan apakah jawaban seseorang dalam bidang ini benar.					
Source of knowledge						
13	Terkadang kamu hanya perlu menerima saran atau jawaban dari pakar dalam bidang ini, meskipun kamu tidak memahaminya					
14	Jika kamu membaca sebuah buku teks dalam Bidang ini, kamu yakin itu pasti benar.					
15	Jika saya memiliki pengalaman yang berbeda dengan yang ada di buku, berati apa yang tertulis di dalam buku lebih benar					
16	Saya sangat yakin bisa mengetahui sesuatu jika saya mengetahui apa yang dipikirkan oleh para ahli dalam bidang ini					
Attainability of the truth						
17	Para pakar di bidang ini dapat mengungkap kebenaran yang pasti					
18	Jika para ahli bidang ini meneliti dengan sungguh-sungguh, mereka akan menemukan jawaban seluruh permasalahan					

APPENDIX E. MRBQ (ENGLISH)

Mathematics-Related Beliefs System (MRB) Questionnaire in The Indonesian Context

Name :
Gender: boy/ girl
Age :
Grade :
School :
City/Province :

Read this scale carefully!
For each of the prompts below, tick the response that best represents what you think. I am really interested in what you think, so please give your honest views. Thank you for taking part.
(1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

Beliefs about the role and the functioning of their teacher	**1**	**2**	**3**	**4**	**5**
My math teacher is very friendly when teaching mathematics in class					
My math teacher listens carefully when I ask or say something					
My teacher understands my problems and difficulties					
My math teacher does not really care how we feel in class. They are soared with the content of this mathematics course					
My math teacher cares about students when we have difficulties					
My teacher appreciates my work.					
My math teacher really wants us to enjoy learning new things					
My math teacher wants me to understand the content of this mathematics course, not just memorize it.					
My math teacher tries to make the mathematics lessons interesting					
My math teacher gives me time to explore new problems and to try out possible solution strategies					
My math teacher thinks mistakes are okay as long as we are learning					
My math teacher thinks I know everything about mathematics					

My teacher provided me with a thorough step-by-step explanation before handing me an assignment					
My math teacher explains why mathematics is important					
My teacher does not allow me to ask fellow students to help me during classwork.					
We do a lot of group work in this mathematics class					
Beliefs about the significance of and their own competence in mathematics,					
I can understand even the most difficult material presented in a mathematics course					
I like to learn mathematics every time					
I believe that I will receive this year an excellent grade for mathematics					
I'm very interested in mathematics					
Taking into account the level of difficulty of our mathematics course, the teacher, and my knowledge and skills, I'm confident that I will get a good grade in mathematics.					
I can understand the course material in mathematics					
I expect to get good grades on assignments and tests in mathematics					
To me, mathematics is an important subject					
I prefer mathematics tasks for which I have to exert myself to find the solution					
Mathematics learning is mainly memorizing					
It is a waste of time when the teacher makes us think on our own about how to solve a new mathematical problem					
If I try hard enough, then I will understand the course material of the mathematics class.					
Group work facilitates the learning of mathematics					
Mathematics as a social activity					
I think I will be able to use what I learn in mathematics also in other courses					
Mathematics enables men to understand better the world they live in					
Solving a mathematics problem is demanding and requires thinking from smart students					
Mathematics is used by a lot of people in their daily life					
Mathematics is continuously evolving. New things are still discovered.					
There are several ways to find the correct solution of a mathematics problem					

Anyone can learn mathematics					
When I have the opportunity, I choose mathematical assignments that I can learn from even if I'm not at all sure of getting a good grade.					
Making mistakes is part of learning mathematics					
Mathematics as a domain of excellence					
By doing the best I can in mathematics, I want to show the teacher that I'm better than most of the other students.					
I want to do well in mathematics to show the teacher and my fellow students how good I am at it.					
My major concern when learning mathematics is to get a good grade					
There is only one way to find the correct solution to a mathematics problem					
Those who are good at mathematics can solve any problem in a few minutes					
I'm only satisfied when I get a good grade in mathematics.					

APPENDIX F. MRBQ (INDONESIAN)
Sistem Keyakinan Siswa Terhadap Pendidikan Matematika

Nama :
Usia :
Jenis kelamin :
Kelas :
Nama sekolah :
Kota :
Pendidikan terakhir ibu :
Pendidikan terakhir bapak :

Bacalah pernyataan di bawah ini!
Berilah tanda cecklist pada pernyataan di bawah ini pada kolom yang disediakan. Saya sangat tertarik terhadap respons Anda mengenai pernyataan-pernyataan tersebut. Terima kasih telah berkontribusi dalam mengisi Survey ini.
(1= sangat tidak setuju, 2 = tidak setuju, 3 = netral, 4 = setuju, 5 = sangat setuju)

Pernyataan	1	2	3	4	5
Keyakinan terhadap peran dan fungsi guru					
Guru matematika saya sangat bersahabat					
Guru matematika saya memberikan saya waktu cukup untuk memahami permasalahan baru					
Guru matematika saya memperhatikan dengan baik saat kami bertanya tentang suatu hal					
Guru matematika saya memahami masalah dan kesulitan yang saya alami					
Guru matematika saya peduli bagaimana perasaan saya dalam pelajaran matematika					
Guru matematika saya peduli terhadap siswa					
Guru matematika saya mengapresiasi usaha keras saya meskipun hasil saya tidak maksimal					
Guru matematika saya sangat ingin saya menikmati mempelajari hal-hal baru					
Guru matematika saya sangat ingin saya memahami konten pembelajaran matematika, tidak hanya menghafalkannya					
Guru matematika saya berusaha membuat pelajaran menarik					
Guru matematika saya memberi saya waktu yang cukup untuk mempelajari permasalahan baru					
Guru saya berpikir kesalahan tidak menjadi masalah selama kita belajar					
Guru matematika saya menunjukkan secara bertahap bagaimana seharusnya menyelesaikan permasalahan matematika, sebelum memberikan saya tugas					

Guru matematika saya menjelaskan mengapa matematika sangat penting					
Guru matematika saya tidak mengizinkan saya untuk bertanya pada teman					
Kita banyak melakukan kerja kelompok dalam pelajaran matematika					
Keyakinan matematika dan kompetensi diri dalam matematika					
Saya dapat memahami bahkan materi tersulit dalam pembelajaran matematika					
Saya suka matematika					
Saya sangat tertarik dengan matematika					
Saya yakin saya akan mendapatkan nilai yang bagus untuk matematika					
Saya bisa mengerti materi pelajaran matematika					
Jika saya berusaha dengan sungguh-sungguh, saya akan memahami materi pelajaran matematika dengan baik					
Matematika merupakan pelajaran penting bagi saya					
Saya lebih suka tugas matematika yang harus saya lakukan sendiri untuk menemukan solusinya					
Pembelajaran matematika mengutamakan hafalan					
ketika guru membuat kita berpikir sendiri tentang bagaimana memecahkan masalah matematika baru, itu sia-sia					
Jika saya berusaha dengan baik, saya pasti bisa matematika					
Kerja kelompok memfasilitasi pembelajaran matematika					
Matematika sebagai aktivitas sosial					
Saya pikir saya akan dapat menggunakan apa yang saya pelajari dalam matematika pada matapelajaran lainnya					
Saya pikir matematika memungkinkan seseorang untuk lebih memahami dunia tempat dia tinggal					
Memecahkan masalah matematika menuntut dan membutuhkan pemikiran, juga kecerdasan siswa					
Matematika digunakan oleh banyak orang dalam kehidupan sehari					
Matematika terus berkembang, hal-hal baru masih bisa ditemukan					
Ada beberapa cara untuk menemukan solusi yang tepat dari suatu masalah matematika					
Seseorang dapat mempelajari matematika					

Ketika saya memiliki kesempatan, saya memilih tugas matematika yang dapat saya pelajari meskipun saya sama sekali tidak yakin akan mendapatkan nilai yang baik					
Membuat kesalahan adalah bagian dari belajar matematika					
Keyakinan terhadap matematika sebagai domain yang unggul					
Saya ingin menunjukkan kepada guru bahwa saya lebih baik daripada kebanyakan siswa lain					
Saya ingin berbuat yang terbaik dalam matematika untuk menunjukkan kepada guru dan sesama siswa betapa baiknya saya di dalamnya.					
Ketika guru membuat kita berpikir sendiri tentang bagaimana memecahkan masalah matematika baru, itu hanya buang-buang waktu					
Perhatian utama saya saat belajar matematika adalah mendapatkan nilai yang bagus					
Hanya ada satu cara untuk menemukan solusi yang benar dari sebuah masalah matematika					
Mereka yang pandai matematika dapat menyelesaikan masalah apa pun dalam beberapa menit					
Saya hanya puas ketika saya mendapat nilai bagus dalam matematika.					

APPENDIX G

Problematics word problem (P-items) and standard word problem (S-items) in mathematics

1. *"Runner" = John's optimal time to run 100 m is 17 s. How long will it take him to run 1 km?*
2. *"Rope" = A man wants to have a rope sufficiently long enough to stretch between two poles 12 m apart, but he only has pieces of 1.5-m ropes. How many of these pieces would he need to tie together to stretch between the poles?*
3. *"School" = Bruce and Alice go to the same school. Bruce and Alice live at distances of 17 and 8 km, respectively, from the school. How far do Bruce and Alice live from each other?*
4. *"Water" = What will be the water temperature in a container if you pour one liter of water at 80℃ and one liter of water at 40℃ into it?*
5. *"Friend" = Carl and Georges have five and six friends, respectively. Carl and Georges decide to have a party together. They invite all their friends. All of their friends are present. How many friends were there at the party?*
6. *"Cycling" = Rudi and Arul cycled $6\frac{1}{2}$ and $2\frac{1}{2}$ km, respectively, from their houses to a city park on Sunday. What is the distance between their houses?*
7. *"Walk" = Mamad lives in a remote place. Every day he has to walk over the hill to reach his school. He walks at a 10 m/min speed, and it takes him 80 min to get to his school. What is the distance from his house to the school?*
8. *"Sailing" = Mr. Aiman went sailing to catch some fish in the sea because the weather was good. On a day, he caught 10.5 kg of fish. So, how many kilograms of fish did he catch in one week?*
9. *"Doll" = On Sunday, Ani made one wooden doll in 60 min. He started making the doll at 08:00 AM. What time would she finish if she wanted to make six dolls that day?*
10. *"Ship" = Idham went back to his village on Sapeken Island from the harbor of Dungkek Sumenep by ship. The ship could cover 3 km in 2 h. If the island and port distance is 120 km, how long would it take for the boat to arrive at Sapeken Island?*
11. *"Run Park" = Mamad runs around the city park every day. He requires 5 min to perform three laps. How long will it take for Mamad to perform 15 laps?*

12. *"Shoes" = There are 30 students in SD Guluk-Guluk IV. Among them, eight students wear black shoes, five wear white shoes, five wear red shoes, six wear blue shoes, and the rest wear gray shoes. How many students wear gray socks?*
13. *"Playing" = 34 students were playing at school during break time. Six students were playing marbles, five were playing Bekel, five were playing cards, four were playing Petak Umpet (hide and seek), and the others were playing a rope jumping game and jackstone. What games did students participate in the most?*
14. *"Cycling 2" = Samsul cycled 6¼ km. Musa cycled 2½ times the distance Samsul cycled. How many kilometers did Musa cover?*
15. *"Sailing 2" = Mr. Aiman went sailing to catch some fish in the sea. On a day, he catches approximately 5.5 kg of fish. How many kg of fish will Mr. Aiman catch for five days if he gets the same volume every day?*
16. *"Shoes 2" = 30 students went to school from Lengkong village. Six students wore black shoes, five wore white shoes, five wore blue-gray shoes, five wore red shoes, and the others wore blue shoes. What color of shoes is the most used?*
17. *"Drive" =Mamad drove a motorcycle to school at a constant speed of 20 km/h. How many hours would Mamad spend getting to school if the distance between his house and school was 5 km?*

APPENDIX H
Realistic word problem in the Indonesian version

1. Waktu yang diperlukan oleh John untuk berlari 100 meter adalah 17 detik. Berapa lama waktu yang diperlukan oleh John jika ia berlari sejauh 1 kilometer?

   a. Jawabannya jelas. 1 kilometer = 1000 meter
      1000 meter : 100 meter = 10
      Sehingga untuk berlari 1 kilometer memerlukan waktu 10 x 17 detik = 170 detik.
      Jadi waktu yang dibutuhkan 170 detik

   b. Dia memerlukan waktu 10 x 17 = 170 detik, dengan catatan John tidak lelah berlari sejauh 1 kilometer.

   c. Kita tidak punya cukup informasi. Kita tidak tahu apakah John akan mengalami kelelahan. Sehingga soal ini tidak dapat di selesaikan

2. Seorang anak memerlukan tali panjang untuk menghubungkan dua tiang dengan jarak 12 meter. Tetapi dia hanya memiliki potongan tali dengan panjang 1,5 meter. Maka berapa potong tali yang diperlukan untuk menghubungkan dua tiang tersebut?

   a. Jawabannya jelas. 12 meter : 1,5 meter = 8 potong. Jadi dia memerlukan 8 potong tali yang harus diikat dan disambungkan untuk menghubungkan dua tiang tersebut.

   b. Dia memerlukan tali lebih dari 8 potong, karena tali ketika disambungkan dan diikat akan menjadi lebih pendek. Sehingga ia memerlukan tali lebih dari delapan.

   c. Kami tidak informasi yang cukup, karena soal tersebut tidak lengkap. Sehingga soal tersebut tidak dapat diselesaikan.

3. Bruce dan Alice bersekolah di sekolah yang sama. Jarak rumah Bruce dengan sekolah 17 kilometer, sedangkan jarak rumah Alice adalah 8 kilometer. Berapakah jarak rumah Bruce dan Alice?

   a. Jawabannya jelas. 17 kilometer – 8 kilometer = 9 Kilometer. Jika rumah mereka berada di sisi dan jalur yang sama dari sekolah, 17 kilometer + 8 Kilometer = 25 kilometer jika sekolah tepat berada di antara rumah mereka. Jadi jawaban pertama 9 kilometer, dan jawaban kedua 25 kilometer.

   b. Jawabannya adalah $9 \leq x \leq 25$, karena arah sekolah ke rumah mereka belum tentu satu baris.

   c. Kami tidak informasi yang cuku. karena soal tersebut tidak lengkap. Sehingga soal tersebut tidak dapat diselesaikan.

4. Jika Anda menuangkan 1 liter air dengan suhu 80^0 Celsius terhadap ember yang berisi 1 liter air dengan suhu 40^0 Celsius. menjadi berapa suhu air di ember tersebut?

   a. Jawabannya jelas. 80 + 40 = 120. Sehingga suhu air di dalam ember menjadi 120^0 Celsius.

b. Suhu akan menjadi 60^0C, karena ember akan menjadikan air lebih dingin. 80 + 40 = 120, kemudian 120: 2 = 60. Sehingga suhu air di dalam ember sekitar 60^0C.

c. Kami tidak memiliki cukup informasi mengenai suhu dan udara di sekitar ember. Soal ini tidak cukup lengkap sehingga soal ini tidak dapat dikerjakan.

5. Carl memiliki 5 teman dan Georges memiliki 6 teman. Carl dan Georges memutuskan untuk mengadakan pesta bersama. Mereka mengundang semua teman mereka. Semua teman hadir. Berapa banyak teman di pesta itu?

   a. Jawabannya jelas. 5 + 6 = 11
   Sehingga ada 11 teman dalam pesta tersebut.

   b. Carl dan Georges berteman, sehingga kemungkinan teman Carl dan Georges kemungkinan sama. Sehingga kemungkinan temannya, bisa lebih atau sama dengan 6 namun lebih kecil sama dengan 13

   c. Kami tidak memiliki cukup data, karena soal tersebut tidak lengkap.
   Sehingga soal ini tidak dapat diselesaikan.

6. Rudi bersepeda sejauh 6.5 Km dari rumahnya ke taman kota pada hari minggu. Sedangkan Arul bersepeda sejauh 2.5 Km dari rumahnya ke taman yang sama. Maka berapakah jarak rumah keduanya? (operasi bilangan)

   a. Jawabannya jelas. 6.5 + 2.5 = 9 Km. Sehingga jarak rumah mereka adalah 9 Km.

   b. Jarak rumah mereka 9 Km, jika taman berada tepat di antara rumah mereka. Jika rumah mereka berada pada posisi yang sama, maka jarakanya kurang dari 9 Km.

   c. Kita tidak punya cukup informasi. Soal memberi tahu apakah rumah keduanya satu arah atau berbeda arah. Oleh karena itu soal ini tidak bisa diselesaikan.

7. Mamad hidup di daerah terpencil. Setiap hari dia harus melewati bukit untuk mencapai sekolahnya. Ia berjalan dengan kecepatan 20 m/menit dan membutuhkan waktu 80 menit untuk sampai ke sekolah. Berapakah jarak rumah Mamad dengan sekolah?

   a. Jawabannya jelas. s = v. t. Jarak rumah dan sekolah S = 20 × 80 = 1600 m. Sehingga, jarak antara rumah dan sekolah Mamad adalah 1600 m

   b. Kondisi jalan di tempat terpencil mempengaruhi kecepatan. Kemungkinan jarak rumah Mamad dan sekolah kurang dari 1800 m, karena ada kemungkinan dia melewati jalan yang becek atau terjal.

   c. Kita tidak punya cukup data. Kita tidak mengetahui bagaimana kondisi jalan. Sehingga soal ini tidak dapat diselesaikan.

8. Pak Aiman pergi berlayar untuk menangkap ikan di laut karena cuaca sedang bagus. Pada suatu hari ia menangkap ikan sebanyak 10.5 Kg. Berapa kg ikan yang dia tangkap selama satu minggu? (operasi bilangan)

a. Jawabannya jelas. 10.5 x 5 = 73.5 kg. Jadi pak Aiman mendapatkan ikan 73,5 kg selama satu minggu.

b. Pak Aiman akan mendapatkan 73.5 kg selama seminggu, jika setiap hari dia selalu mendapatkan ikan dengan jumlah yang sama. Bisa saja dia menangkap ikan lebih sedikit karena cuaca tidak bagus.

c. Kita tidak punya cukup data. Kita tidak punya cukup informasi apakah pak Aiman mendapatkan ikan dengan jumlah yang sama setiap hari atau tidak. Sehingga soal ini tidak dapat diselesaikan.

9. Pada hari minggu Ani membuat sebuah boneka kayu *handmade.* Ia mampu membuat satu buah boneka dalam waktu 60 menit. Ia memulai membuat boneka tersebut dari pukul 08.00 pagi. Jika ia ingin membuat 6 boneka hari itu, maka pukul berapa dia selesai?

   a. Jawabannya jelas. 6 x 60 menit = 360 menit atau 6 jam. Sehingga ia akan selesai pada pukul14.00.

   b. Ia akan berhasil menyelesaikan boneka tersebut 6 jam jika dia tidak lelah dan terus membuat mainan tersebut.

   c. Kita tidak punya cukup informasi. Soal ini tidak memberikan informasi apakah Ani membuat terus dalam setiap jam. Sehingga soal ini tidak dapat diselesaikan.

10. Idham pulang kampung ke pulau Kangean dari Pelabuhan Dungkek Sumenep dengan perahu. Perahu tersebut mampu menempuh laut sejauh 3 Km dalam waktu 2 jam. Jika jarak kedua pulau tersebut adalah 120 Km, maka berapa lama waktu yang dibutuhkan oleh perahu tersebut untuk sampai di pulang kangean?

    a. Jawabannya jelas. 120 : 3 = 40 Km x 2 jam = 80 jam. Jadi Idham akan sampai di pulau Kangean dalam waktu 80 jam.

    b. Ia membutuhkan waktu sekitar 80 jam, jika perahu tersebut berjalan dengan konstan dan tidak ada rintangan cuaca apapun.

    c. Kita tidak punya cukup informasi. Soal tersebut kurang lengkap, ada informasi yang kurang. Sehingga soal ini tidak dapat di selesaikan.

11. Mamad berlari di sekitar taman kota setiap hari. Dia memerlukan waktu 5 menit untuk berlari mengelilingi taman kota sebanyak 3 putaran. Berapa lama yang diperlukan Mamad untuk berlari 15 putaran di taman kota?

    a. Jawabannya jelas. 5/3 x 15 = 25
    Sehingga untuk mengitari taman kota sebanyak 15 putaran, Mamad butuh waktu 25 menit..

    b. Dia membutuhkan waktu 25 menit untuk berlari lima belas putaran di taman kota, tetapi dia akan membutuhkan waktu lebih dari itu jika dia lelah.

c. Kita tidak punya cukup informasi. Kita tidak tahu bagaimana dan kapan Mamad akan Lelah. Sehingga soal ini tidak dapat diselesaikan.

12. Ada 30 siswa di sekolah SD guluk-guluk IV. Dari jumlah siswa tersebut 8 orang menggunakan sepatu hitam, 5 orang menggunakan sepatu putih, 5 orang pakai sepatu berwarna merah, 6 orang pakai sepatu berwarna biru dan sisanya memakai sepatu berwarna abu-abu. Berapakah siswa yang memakai kaos kaki berwarna abu-abu?
    a. Jawabannya jelas. Siswa yang memakai sepatu abu-abu adalah 30-8-5-5-6 = 6. Jadi yang memakai sepatu berwarna abu-abu 6 orang, sehingga siswa yang memakai kaos kaki berwarna abu-abu 6 orang.
    b. Yang memakai kaos kaki abu-abu 6 orang, dengan catatan seluruh siswa memakai kaos kaki yang sama dengan warna sepatu mereka.
    c. Soal tersebut tidak lengkap. Sehingga kita tidak memiliki informasi apakah semua siswa memakai kaos kaki. Soal ini tidak dapat dikerjakan.
13. Tiga puluh empat orang siswa sedang bermain di sekolah saat istirahat. Enam orang bermain kelereng. Lima orang bermain dakon. Lima orang bermain kartu. Empat orang bermain petak umpet. Sisanya bermain lompat tali dan bola bekel. Permainan apakah yang paling banyak diikuti siswa?

    a. Jawabannya cukup jelas. 34 – 6 -5-5-4 = 14.
    Jadi 12 orang siswa bermain lompat tali dan bola bekel, 10: 2 = 7
    Jadi yang permainan yang paling banyak diikuti siswa adalah lompat tali atau bola bekel.

    b. Permainan yang paling banyak diikuti siswa adalah lompat tali atau bola bekel, masing-masing permainan tersebut diikuti oleh 7 orang siswa

    c. Kita tidak punya cukup data. Kita tidak tahu berapakah siswa yang bermain lompat tali atau bermain bola bekel. Sehingga soal ini tidak bisa diselesaikan.

14. Samsul mengendarai sepeda sejauh 6¼ Km. Sedangkan Musa mengendarai sepeda 2 ½ jarak yang dilalui Samsul. Berapa kilometer yang ditempuh oleh Musa?
    a. Jawabannya jelas. 6 ¼ × 2 ½ = $15\frac{5}{8}$. Sehingga musa mengendarai sepeda sejauh $15\frac{5}{8}$ km.

    b. Musa mengendarai sepeda lebih jauh dari Samsul, karena dia mengendarai dua kali lebih jarak yang ditempuh oleh Samsul. Ia mengendarai sekitar $15\frac{5}{8}$ km jika dia tidak kelelahan Ketika mengendarai sepeda.

    c. Kita tidak punya cukup informasi. Sehingga soal ini tidak dapat dikerjakan.

15. Pak Aiman pergi menangkap ikan di laut. Dia menangkap ikan rata-rata 5,5 kg setiap hari. Berapa kilogram yang didapatkan oleh Pak Aiman jika dia setiap hari mendapatkan jumlah ikan yang tetap selama lima hari?

    a. Jawabannya jelas. 5.5 × 5 = 27.5 kg. Sehingga Pak Aiman akan berhasil menangkap 27.5 kg selama lima hari.

b. Pak Aiman akan menangkap ikan sebanyak 27.5 kg dalam lima hari, jika cuaca bagus. Kemungkinan hasil tangkapan akan kurang, jika cuaca buruk.

c. Kita tidak punya cukup informasi. Kita tidak tahu apakah cuaca buruk atau tidak sehingga soal ini tidak dapat di selesaikan.

16. Ada 30 siswa pergi ke sekolah dari desa lengkong. Enam orang menggunakan sepatu hitam, lima orang menggunakan sepatu putih, lima orang menggunakan sepatu abu-abu, lima orang menggunakan sepatu merah dan sisanya menggunakan sepatu biru. Sepatu warna apa yang paling banyak digunakan?

    a. Jawabannya jelas. Sepatu biru = 30-6-5-5-5= 9. Jadi sepatu biru merupakan warna sepatu yang paling banyak digunakan oleh siswa.

    b. Sepatu yang paling banyak digunakan oleh siswa adalah biru. Ada sekitar 9 orang siswa yang memakai sepatu warna tersebut jika mereka menggunakan sepatu semua.

    c. Kita tidak punya cukup informasi. Sehingga soal ini tidak dapat diselesaikan

17. Mamad mengendarai sepeda motor ke sekolah dengan kecepatan tetap 20 Km/ jam. Berapa lama yang dibutuhkan oleh Mamad untuk sampai ke sekolah, jika jarak rumahnya dan sekolah adalah 5 Km?

    a. Jawabannya jelas . Rumus $s = v. t$. Jadi $5 = 20 \times t$. Hasilnya $t = \frac{1}{4}$ jam. Atau 15 menit. Sehingga dia akan sampai ke sekolah dalam waktu 15 menit.

    b. Dia akan sampai ke sekolah dalam waktu 15 menit, jika dia tidak mengalami permasalahan di jalan. Atau dia akan membutuhkan waktu lebih lama.

    c. Kita tidak punya cukup informasi. Sehingga soal ini tidak dapat diselesaikan.

AUTHOR'S PUBLICATION

No	Article published	Indexing
1	Hidayatullah, A., & Csíkos, C. (2023). The role of students' beliefs, parents' educational level, and the mediating role of attitude and motivation in students' mathematics achievement. *The Asia-Pacific Education Researcher*. https://doi.org/10.1007/s40299-023-00724-2	**Scopus, Q1**
2	Hidayatullah, A., Csíkos, C. (2023). Association between psychological need satisfaction and online self-regulated learning. *Asia Pacific Education Review*. https://doi.org/10.1007/s12564-023-09910-9	**Scopus Q1**
3	Hidayatullah, A., Csíkos, C. & Setiyawan, R. (2023). The role of belief sources in promoting goal orientation beliefs, self-efficacy, and beliefs about the role of teachers in mathematics learning. *The Asia-Pacific Education Researcher*. https://doi.org/10.1007/s40299-024-00813-w	**Scopus Q1**
4	Hidayatullah, A., Csíkos, C. & Syarifuddin (2023). Beliefs in mathematics learning and utility value as predictors of mathematics engagement among primary education students: the mediating role of self-efficacy. *Education 3-13*. https://doi.org/10.1080/03004279.2023.2294141	**Scopus Q2**
5	Hidayatullah, A., Csíkos, C., & Wafubwa, R. N. (2023). The dimensionality of personal beliefs ; the investigation of beliefs based on the field study. *Revista de Educación a Distancia (RED)*, 23(72), 1–26. https://doi.org/https://doi.org/10.6018/red.540251	**Scopus, Q2**
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