

**DOCTORAL SCHOOL OF EDUCATION
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**STUDENTS' MATHEMATICS-RELATED BELIEFS AND ACADEMIC
PERFORMANCE: CROSS-SECTIONAL STUDIES IN INDONESIA**

SUMMARY OF THE DISSERTATION

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1.1.General Introduction

1.2. Personal epistemology framework

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's 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).

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. The author pointed out that those epistemological beliefs entailed four dimensions: certainty of knowledge, justification for knowing, source of knowledge, and attainability of truth. While extensive research has been conducted on epistemological beliefs in certain nations and field studies, there remains a need for clarification on several significant issues. One such issue pertains to the delineation of whether personal epistemological beliefs exhibit a more general or domain-specific nature across various cultural contexts. Furthermore, within specific domains like mathematics, it is essential to explore the types of beliefs that students may manifest regarding the subject.

1.3.The mathematics-related belief system framework

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; (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.

Op't Eynde and De Corte (2003) developed a mathematics-related belief system 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 belief systems 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).

1.4. 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.

Second, taking into account the theoretical framework, the significance of mathematics-related beliefs, and the importance of investigating students' mathematics-related belief systems in Indonesia, since the instruments of these beliefs were unavailable in Indonesia, the adaptation of MRBQ should be conducted.

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. 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.

Fifth, limited studies regarding students' implicit beliefs about problem-solving and their implication to realistic 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. RQ4: Do mathematical beliefs predict behavioral and emotional engagement among primary education students?
4. RQ5: What insight can be discovered from the investigation of beliefs, attitudes, motivation, and achievement?
5. RQ3: How do students' implicit beliefs about mathematical word problems manifest in the Indonesian context?

2. Research methods.

This dissertation is study-based format. All the empirical studies in this dissertation were cross-sectional study with quantitative approach. 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. Table 1 summarize my empirical studies.

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	1. CFA and Cronbach alpha 2. Descriptive statistics 3. Independent sample t-test 4. One-way ANOVA 5. Regression analysis

		(DSBQ]; Hofer, 2000), GPA, and attitudes questionnaire	
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 engagement among primary education students: the mediating role of self-efficacy. (Hidayatullah, Csíkos, & Syarifuddin, 2023)	Sample: 500 students in grades 5-6 Instruments: Mathematics-related beliefs system questionnaire (MRBQ); Op 't Eynde & De Corte, 2003) and mathematical engagement questionnaire (Skinner et al., 2009)	1. Descriptive statistics 2. Partial-least square structural equation 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	3. CFA, and Cronbach alpha 4. Descriptive statistics 5. 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

3. Result and discussion

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 adapt the 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 general awareness among Indonesian people that teacher is one who should be appreciate. Accordingly, all the students should show good behavior and 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.

There were inconsistencies result when studying the relationship between epistemological beliefs and gender. 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 problematic 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).

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.

Limitations and future directions

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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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. <i>The Asia-Pacific Education Researcher</i> . 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. <i>Asia Pacific Education Review</i> . 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. <i>The Asia-Pacific Education Researcher</i> . 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. <i>Education 3-13</i> . 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. <i>Revista de Educación a Distancia (RED)</i> , 23(72), 1–26. https://doi.org/https://doi.org/10.6018/red.540251	Scopus, Q2
6	Hidayatullah, A., & Csíkos, C. (2022). Mathematics-related belief system and word problem-solving in the Indonesian context. <i>Eurasia Journal of Mathematics, Science and Technology Education</i> , 18(4), 1–16. https://doi.org/10.29333/ejmste/11902	Scopus, Q2
7	Hidayatullah, A., & Csíkos, C. (2023). Exploring students' mathematical beliefs : gender, grade, and culture differences. <i>Journal on Efficiency and Responsibility in Education and Science</i> , 16(3), 186–195. https://doi.org/https://doi.org/10.7160/eriesj.2023.160303	Scopus Q3
8	Hidayatullah, A., & Csíkos, C. (2023). Students' responses to the realistic word problems and their mathematics-related beliefs in primary education. <i>Pedagogika</i> , 150(2), 21–37. https://doi.org/https://doi.org/10.15823/p.2023.150.2	Scopus, Q4
9	Amien, S., Abidin, R., Hidayatullah, A., & Muhammad, R. (2023). Investigating the Source of Student Self-Efficacy and Its Relations to Affective Factors in Mathematics Learning. <i>Journal of Elementary Education</i> , 16(4), 375-391.	Scopus, Q4
10	Amien, M., & Hidayatullah, A. (2023). Assessing students' metacognitive strategies in e-learning and their role in academic performance. <i>Jurnal Inovasi Teknologi Pendidikan</i> , 10(2), 158-166. https://doi.org/10.21831/jitp.v10i2.60949	
Article under review		
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