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, 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.

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

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.

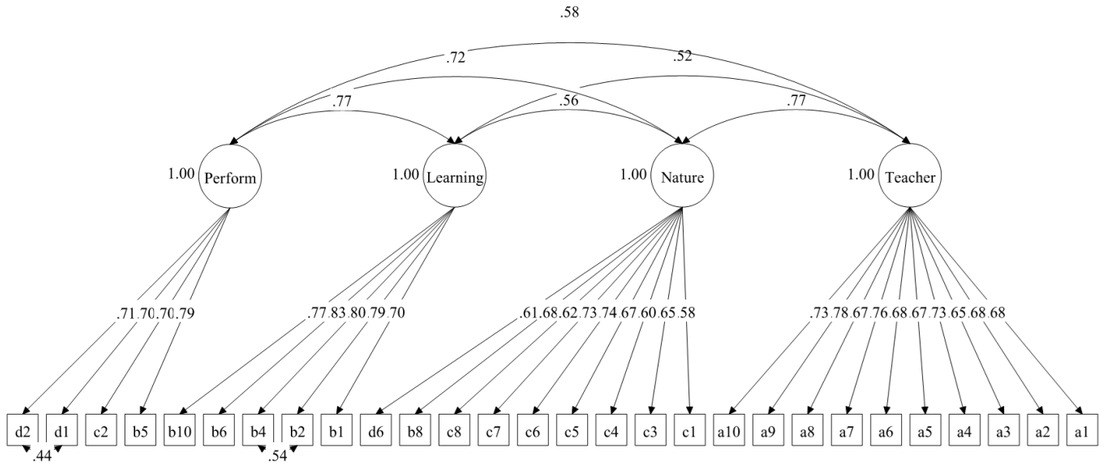

Figure 1: Confirmatory factor analysis of students' mathematical beliefs

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