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# The Complex Relationship between Teachers' Mathematics-related Beliefs and Their Practices in Mathematics Class

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**Abstract**

Mathematics-related beliefs play an important role in giving a teacher directions for taking decisions and for their behavior in a mathematics class. Therefore, the purposes of this research are to reveal the profile of teachers' mathematics-related beliefs, the consistency among belief dimensions, teachers' practical profile in a mathematics class, and the consistency between beliefs and teachers' practices in a mathematics class. This research used surveys with a cross-sectional design to collect data from 325 elementary school teachers in Jakarta. Teachers' beliefs instruments and teachers' practices in mathematics class were used to collect data. The findings of this research indicate that teachers tend to be constructivism-oriented but are not accompanied with suitable practices in mathematics class. Moreover, complex relationships also occur in both belief dimensions and in their relationships with the practices in a mathematics class.

**Keywords:** *teacher beliefs, teacher practices, mathematics class, elementary school teachers*

## Introduction

The gap between education research and its practice is a critical issue which has become a matter of contention among researchers, practitioners, and policy-makers (Broekkamp & van Hout-Wolters, 2007; Vanderlinde & van Braak, 2010), including in the area of mathematics education research and the practices of mathematics in class. Many potential factors contribute to the gap. From the usability and the practical value of the researcher's point of view, Broekkamp and van Hout-Wolters (2007) said that teachers' negative belief about research is one of the potential factors, causing them to reluctantly apply it in class. As found in literature, belief is a variable which has a role in guiding someone to take decisions and to behave in class (Ernest, 1989; Purnomo, Suryadi, & Darwis, 2016). In other words, when fundamental theories and research suggestions are parallel with the teacher's belief, then the belief will lead the teacher to apply it in class. A mathematics teacher plays an important role in creating meaningful mathematics learning to students. Besides content knowledge, pedagogical knowledge, and pedagogical content knowledge, the teacher's mathematics-related beliefs become variables that also play a role in guiding that knowledge to create meaningful mathematics learning. This was illustrated by Ernest (1989) about the role of belief; he gave an example of two mathematics teachers, who potentially had the same knowledge, but perhaps one teacher taught mathematics through a problem-solving orientation and the other teacher had a more didactic approach.

The teachers' beliefs system has multifaceted constructs. According to Ernest (1991), teachers' mathematics-related beliefs cover beliefs about the nature of mathematics, beliefs about mathematics teaching, and their beliefs about assessment. Ernest (1989) stated that someone's beliefs about the nature of mathematics are strongly related to mathematics philosophy as the discipline. When mathematics is considered as static knowledge or has an absolute validity which covers a set of rules, facts, or procedures used to get the right answer, teachers' beliefs about teaching make them teach through a transmission model which is signed by exposure, exercising, and memorizing known as instrumental teaching. In other words, the teaching option taken is how to guide students to be skilled and efficient in procedural operations and symbol manipulations without understanding the meaning and the reason for it. Constructivism shows that in order to build knowledge, learners must actively build it by themselves either through experiences they have had or by interactions. Here, the teacher is the learning facilitator who provides the students with opportunities to be involved in meaningful mathematics problem solving.

Besides teachers' beliefs about the nature of mathematics and mathematics teaching, responding to teachers' beliefs about assessment is important to predict, to design, and to pick the rational decision to support the mathematics learning process (Purnomo, 2015). Assessment is a set of integral activities in the mathematic learning process which provides information for both teachers, who make the teaching decisions, and students to know the learning progress and to reflect on certain points that need to be leveled up (Purnomo, 2015, 2016b). As assessment is an integral part of the learning process, Delandshere and Jones (1999) said that when learning is believed as facts, rules, and skills acquisition, assessment tends to be looked at as a way to give sanctions and verifications. On the other hand, if learning is believed to be a continuous building process strengthened by structural, purposeful, and educational experiences, then assessment tends to be perceived as documentation and feedback provision. Therefore, besides the beliefs of the nature of mathematics and mathematics teaching itself, it is important to respond to teachers' beliefs of assessment in mathematics learning.

The teacher's mathematics-related beliefs are built from the early days on, when they acquire experience, especially school experience, and peak when they gain experience at the college level. Regarding this, the education for elementary school teacher candidates in college does not specifically include mathematics. Therefore, this research focused on examining elementary school teachers' beliefs so that we could generate ideas and suggestions for elementary school teacher preparation at the college level.

In the literature, previous studies examined the relationship between the teacher's mathematical beliefs and their teaching practices in mathematics class (Stipek, Givvin, Salmon, & MacGyvers, 2001; Wijaya, van den Heuvel-Panhuizen, & Doorman, 2015). There are also studies that have examined the relationship between beliefs about assessment and assessment practices in class (Azis, 2014; Calveric, 2010). Nevertheless, there is a lack of large-scale studies which comprehensively examine the relationship between belief variables (i.e., the nature of mathematics, teaching and learning, and assessment), as well as their relationship with the practice of teaching and assessment in a mathematics class. Stipek et al. (2001) examined the relationship between teachers' beliefs about mathematics, teaching and learning, and their relation to the teaching and assessment practices. However, these studies do not focus on assessing beliefs about assessment and its relation to assessment practices in mathematics class. Furthermore, there are also few literature findings in studies that examine teachers' beliefs and practices in mathematics class in the context of teachers in Indonesia. For these reasons, this research endeavored to contribute both theoretical and empirical knowledge as a complement to previous studies.

This research aimed to reveal teachers' mathematical belief profile, consistency among belief dimensions (factor), teachers' practical profile in a mathematics class, and consistency between beliefs and the teacher's practices in mathematics class. For these purposes, four research questions will be discussed: (1) What are the mathematic-related beliefs that tend to be held by teachers? (2) Is there any consistency among suitable belief factors held by teachers? (3) What is the teacher's practical tendency in mathematics class? (4) Do teachers' practices in the mathematics class reflect what they believe?

## Method

### Participants

The research used a survey with a cross-sectional design. The sample included 325 elementary school teachers (69 public schools and 6 private schools) in East Jakarta during the 2015/2016 school year, who were selected conveniently. This method was chosen because it was not expensive, was not time-consuming, and was easily administered. It was started by choosing one of six cities in Jakarta. Then, the elementary schools in that selected city were selected randomly. Next, the teachers of those selected schools participated conveniently. The participants consisted of 80.9% female and 17.5% male teachers, while 1.5% of those were not clear. 12.3% of the participants had 3 years or less of teaching experience, 22.2% had 4–10 years of experience, 21.8% had 11–20 years of experience, 4.6% of them had more than 20 years of experience, and 3.1% of them were not clear.

### Instrument and procedure

The instruments of this research were two questionnaires: teachers' mathematics-related beliefs and teachers' practices in a mathematics class. Belief and practice scales were developed according to the literature and analyzed by factor analysis. An exploratory factor analysis was used to build the factor structure and then confirmed by a confirmatory factor analysis. The detailed analysis of those statistics could be found in Purnomo (2016a). The questionnaire of teachers' mathematic-related beliefs consisted of three subscales. There were 9 items for beliefs about the nature of mathematics (BNM), 11 items for beliefs about the teaching of mathematics (BTM), and 10 items for beliefs about the assessment of mathematics learning (BAM). All the subscales had adequate construction validity (convergent and discriminant validity). The alpha coefficient ranged from 0.715 to 0.787, so it had an adequate internal consistency coefficient. On the other hand, the questionnaire of practice in a mathematics class covered 11 items for teaching practice (TP) in mathematics class and 11 items for assessment practice (AP) in mathematics class. Construction validity for each subscale of teachers' practice in mathematics class was at a good level. Internal consistency was also above the adequate level, which was in the range of 0.704 to 0.742 for each subscale.

### Data Analysis

The first and third questions were analyzed using descriptive statistics such as mean, standard deviation, and mean range. In order to see the data tendency from every factor, a t-test with a 5% significance level was conducted. The effect size (ES) was also used to complete and see how big the impact was. The Spearman correlation test was performed to find out the consistency among the belief factors and to reveal the consistency between the beliefs the teachers held and the practice conducted in the mathematics class.

## Results

***Research question 1:***
***What are the mathematics-related beliefs that tend to be held by teachers?***

The data for dynamic factor at BNM are negated first and given the absolute label. The results of the analysis are presented in Table 1.

**Table 1.** Comparison among factors at BNM, BTM, and BAM

| Subscale | Factor | Mean | SD | Mean range of items | Mean comparison | ES |
|---|---|---|---|---|---|---|
| BNM | Relevant | 5.012 | 0.569 | 4.594–5.432 | $t(322) = 13.849$; $p = 0.000$ | 0.771 |
| | Absolute | 4.072 | 1.130 | 3.970–4.272 | | |
| BTM | Relational | 5.032 | 0.474 | 4.836–5.352 | $t(317) = 8.950$; $p = 0.000$ | 0.502 |
| | Instrumental | 4.635 | 0.748 | 4.484–4.849 | | |
| BAM | Integrated | 5.122 | 0.458 | 4.478–4.897 | $t(317) = 10.646$; $p = 0.000$ | 0.597 |
| | Isolated | 4.782 | 0.628 | 4.997–5.270 | | |

As presented in Table 1, the teachers' beliefs about the nature of mathematics are more dominated by their view about relevant mathematics than their absolute view (p-value < 0.05). This difference is also supported by the ES score of 0.771, which can be considered as a large difference. A significant difference (p-value < 0.05) also occurs on the teachers' belief factors about teaching. The findings indicate that the participants tend to have a more relational teaching view than an instrumental one. An ES score of 0.502 shows that the size of the difference between them is medium. Meanwhile, the BAM that is held by the teachers is dominated by a view that assessment is an integral part of the learning process. The significant difference is shown by the p-value < 0.05 and this medium sized difference is shown by the ES score of 0.597.

***Research question 2:***
***Is there any consistency among suitable belief factors?***

The Spearman correlation analysis was chosen to see the relationship among the belief factors. The results of the analysis are shown in Table 2.

**Table 2.** Correlation among factors on the belief scale

| Sub-scale | Factor | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| BNM | **1** (Relevant) | 1 | -0.137* | 0.016 | 0.068 | 0.107 | -0.043 |
| | **2** (Dynamic) | | 1 | 0.020 | 0.042 | 0.019 | 0.045 |
| BTM | **3** (Relational) | | | 1 | 0.238** | 0.270** | 0.137* |
| | **4** (Instrumental) | | | | 1 | 0.250** | 0.226** |
| BAM | **5** (Integrated) | | | | | 1 | 0.435** |
| | **6** (Isolated) | | | | | | 1 |

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed).

Based on Table 2, consistency is shown by a significant correlation between the relational factor and the integrated factor at the 1% level of significance. A significant correlation is also shown by the instrumental teaching factor and the isolated factor at the 1% level of significance. On the other hand, the dynamic and relevant factors in the BNM subscale both have a weak correlation to other factors. Nevertheless, those two factors have a significant negative correlation ($\alpha = 5\%$) as indicated by the correlation coefficient value of -0.137. A significant correlation among factors in the same subscale also occurs on BTM and BAM. The relational factor correlates positively with the instrumental factor ($\alpha = 5\%$). A similar result is shown by the integrated factor which has a significant correlation with the isolated factor ($\alpha = 1\%$). This result also implies logically with the correlation among the results of factor analysis which indicate inconsistency among belief factors such as between the relational and the isolated factor as well as the instrumental factor and the integrated factor.

***Research question 3:***
***What is the teacher's practical tendency***
***in mathematics class?***

The analysis to answer the third question is similar to what was conducted to answer the first question. The results of the analysis are shown in Table 3.

**Table 3.** Comparison of factors on TP and AP in mathematics class

| Subscale | Factor | Mean | SD | Mean range of items | Mean comparison | ES |
|---|---|---|---|---|---|---|
| TP | Instrumental | 4.324 | 0.469 | 4.100–4.540 | $t(324) = 17.862$; $p = 0.000$ | 0.991 |
| | Relational | 3.619 | 0.593 | 3.357–3.969 | | |
| AP | *AoL* | 4.477 | 0.449 | 4.158–4.676 | $t(322) = 25.225$; $p = 0.000$ | 1.404 |
| | *AfL* | 3.347 | 0.714 | 3.053–3.622 | | |

As shown in Table 3, the TP profile is intended more to emphasize an instrumental practice than a relational one. The difference is significant due to the p-value which is less than 0.05 and has a large-sized difference because the ES score is 0.991. A significant and very large difference is also found at the AP. The significant difference is shown by the p-value, which is less than 0.05, and a very large-sized difference is shown by the ES score, which is 1.404. In other words, AP conducted by the teacher tends to be A*o*L practice than A*f*L in mathematics class.

*Research question 4: Do the practices in the mathematics class reflect the beliefs held by the teachers?*

The analysis using the Spearman correlation was conducted to find out the correlation between the beliefs and the practices in mathematics class. The results of the analysis are presented in Table 4.

**Table 4.** Correlation between belief factors and practice factors.

| Beliefs | | Practices | | | |
|---|---|---|---|---|---|
| | | TP | | AP | |
| | Factor | Relational | Instrumental | AfL | AoL |
| BNM | 1. Relevant | 0.184** | 0.131* | 0.100 | 0.149** |
| | 2. Dynamic | 0.052 | -0.042 | 0.001 | -0.067 |
| BTM | 3. Relational | 0.171** | -0.016 | 0.078 | 0.028 |
| | 4. Instrumental | 0.097 | 0.070 | 0.140* | -0.064 |
| BAM | 5. Integrated | 0.077 | 0.119* | 0.062 | 0.030 |
| | 6. Isolated | -0.004 | 0.125* | 0.214** | 0.027 |

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed).

Based on Table 4, there seem to be some consistencies between the beliefs and practices in the mathematics class shown by (1) the relevant factor and the relational teaching practice factor; (2) the relational factor and the relational teaching practice factor; and (3) the isolated factor and the instrumental practice. On the other hand, an inconsistency can be shown by the significant correlation (α = 5%) between the instrumental teaching practice and the relevant factor at the BNM. The instrumental teaching practice also has a correlation with the irrelevant factor; there is an integrated factor at the BAM. Some other inconsistencies can be seen by the significant correlation between the A*f*L practice to instrumental factor at the BTM and the integrated factor at the BAM.

## Discussion

The research results indicate that the participants in this study tend to hold the belief of constructivism, either on their belief about the nature of mathematics, mathematics teaching, or about the assessment in mathematics learning. It is parallel with the results from earlier research (Purnomo et al., 2016; Wijaya et al., 2015), which similarly indicated that teachers tend to have a constructivism view. Nevertheless, the teachers' responses are not fully consistent in one category. For example, in this research, the teachers tend to agree that mathematics teaching is important to understand the relevant problem and context, but on the other hand, they also agree that mathematic problem solving should be done quickly and instantly. The other contradiction in one category can also be found in the beliefs about the nature of mathematics and assessment in mathematics class. The contradiction can also be verified by looking at the significant correlation among factors in one category. Moreover, the analysis found a complex correlation among the teachers' beliefs, on the one hand there are consistencies among suitable beliefs, but on the other hand, there are some inconsistencies among suitable beliefs.

Complexity also occurs in the correlation between belief and practice in a mathematics class where the teachers' practices in a mathematics class do not always reflect the beliefs they hold. On the one hand, the teachers in this study tend to hold the belief of being constructivism-oriented, but on the other hand, they tend to use more traditional practices. The teachers appear more inclined towards instrumental teaching practice than relational practice. Instrumental teaching practice is identical with result-based learning than process-based teaching, so it often ignores relevant learning by the students' context. This finding strengthens earlier findings from research on Indonesian teachers' teaching practices in mathematics class (Purnomo, Kowiyah, Alyani, & Assiti, 2014; Purnomo et al., 2016; Wijaya et al., 2015), where it was found that teachers' practices are more dominated by mechanistic practices. Wijaya et al. (2015), through class observation, found out that mathematics teachers tend to teach through directive approaches. Teachers are more dominating during the learning activity in class by giving problems, telling what should be done, and focusing on the mathematics solution without linking it to the context of the problem. Furthermore, teachers also tend to do traditional assessment in the mathematics class. Traditional assessment practices refer to the practices that focus more on formality and accountability aspects than on relevant learning practices or students' context. The teachers in this study tend to use summative tests as a part of the assessment and give marks and scores on the students' worksheets as a form of feedback to the students. Some researchers (Purnomo, 2015, 2016b) agree that feedback, e.g. constructive comments, is more desirable and has a more positive impact on the students than giving marks or scores. Moreover, the teachers are also usually more intent on using external assessment standards than suitable standards for the students' real conditions. This surely separates assessment and learning.

Although the results of this research indicate that there are consistencies between the beliefs and practices of several factors, it is mostly dominated by inconsistencies between beliefs and practices in mathematics class. Similar findings can be found in earlier research (Purnomo et al., 2016; Raymond, 1997), revealing that the correlation between beliefs and practices is a complex correlation. Possible factors that potentially contribute to the inconsistencies between beliefs and practices can come from either internal or external factors. Some potential indications of internal factors are (1) the teachers' knowledge about the philosophy of mathematics and the learning perspective; (2) the teachers are hesitant to break their habits. The learning they conduct just focuses on fixed references (books or curriculum), causing the teachers to often think more of the risks than think of the relevant object or the learning context for the students; (3) mathematics knowledge for teaching. When the belief is not accompanied by the knowledge about how the content should be taught, the practice tends to follow experiences and fixed rules; and (4) experience, especially experience from becoming a student in school. Furthermore, the teachers also have a complex position so the practices conducted are often influenced by external factors, such as time pressure, curriculum, social norm, and learning environment. Another external factor is high-stake accountability. Policy implementation often forces the teacher to adjust their practices to the rules which are often irrelevant to the context in the field. Excessive emphasis on result-based accountability causes educational stakeholders to ignore the process and at the end to fail to achieve the expected results, but also to go through an irrelevant process in the context.

## Conclusion

The results of this research indicate that the teachers' beliefs are dominated by beliefs leading to a constructivism view. Nevertheless, there is some evidence that the teachers' responses do not always consistently fall in one category. This research also finds complex correlations among belief dimensions and the correlation with practices in mathematics class. The implication can be identified and emphasized in two elements. They are the government policy and teacher education program. Contradiction occurs when the government encourages teachers to develop the curriculum. However, it turns out that the government acts as the curriculum developer. Teachers in Indonesia tend to be the curriculum implementers, who wait for instructions as a form of their responsibility (cf. also Azis, 2014). Therefore, it is important for the government to try to understand and to build teachers' beliefs, knowledge, and literacy, and to respond to every education policy they make. It is also important for teacher education and development programs in Indonesia to focus on building beliefs and mathematics knowledge for teaching, especially during the teacher candidate education period. The rational argument for this is that even though there is an excess of focus on the content of a mathematics curriculum, the way the content is taught to elementary school students should not be disregarded.

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