

The Relationship between pre-service elementary school mathematics teachers' beliefs about epistemology of mathematics, teaching and learning, and mathematics assessment

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Abstract: This study aims to examine the relationship between epistemological beliefs, teaching-learning beliefs and assessment beliefs in mathematics education. This research is a quantitative study with a correlational study. Data collection using the survey method with a cross-sectional design. The participants were 71 pre-service elementary school, mathematics teachers. The data on beliefs were collected through means of a questionnaire. The data collected from the questionnaire were then analyzed quantitatively through descriptive and inferential statistics. Descriptive statistics utilizes the mean value, maximum value, and standard deviation values. Inferential statistics use the product-moment correlation as well as path analysis. The research results show that there is a positive and significant correlation between static and dynamic beliefs on epistemology of mathematics, and the constructivist beliefs on mathematics teaching and learning, with the productive beliefs on mathematics assessment. In addition, there is seen to be a functional influence between both epistemological beliefs (both static and dynamic), as well as beliefs on teaching and learning (constructivist) and beliefs about mathematic assessment (productive). The results of this research signify the importance of considering one's beliefs about the epistemology of mathematics and mathematics teaching and learning when constructing their beliefs regarding mathematics assessment.

Keywords: assessment beliefs, epistemological beliefs, teaching and learning beliefs

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INTRODUCTION

Epistemological beliefs and mathematics teaching and learning beliefs are essential factors in understanding the practice of teaching and learning mathematics. Beliefs in these two aspects will determine teachers' approach for teaching mathematics in the classroom (Beswick, 2012; Felbrich et al., 2012; Lui & Bonner, 2016; Tamba et al., 2020; Yang et al., 2020). Even if one were to directly observe teaching and learning processes, it will not be enough to understand educational practice. The beliefs of a teacher, or, in this case, pre-service elementary school mathematics teachers, must be examined, in addition to their experience of observing in classrooms (Yang et al., 2020).

Assessment is another component that is equally crucial in mathematics teaching and learning. An assessment conducted in a classroom is highly determined by the beliefs of the teacher or pre-service teacher: what their beliefs on mathematics assessment are (Martínez-Sierra et al., 2020). However, there has been limited research on this topic compared to research on epistemological and teaching and learning beliefs (Martínez-Sierra et al., 2020). Even the research available (Brown & Hirschfeld, 2007; Dixon & Haigh, 2009; Suurtamm et al., 2016) does not regard mathematics assessment beliefs as being in the same system as epistemological and mathematics teaching and learning beliefs. Despite many works suggesting the importance of viewing beliefs as a system (Beswick, 2012; Martínez-Sierra et al., 2020; Purnomo, 2017). It means assumed that beliefs about the epistemology of mathematics, mathematics teaching and learning, and mathematics assessment influence each other. Therefore, it is essential to explore the relationship between these three dimensions of beliefs. There is minimal research studying the relationship between the three dimensions. Up to this paper's writing, there have been only two: Purnomo (2017) and Martínez-Sierra et al. (2020). Both have measured the relationship between epistemological, teaching and learning, and mathematics assessment beliefs explicitly. In their research, Martínez-Sierra et al. (2020) suggested that future researchers consider other methods to assess the relationship between the three dimensions of beliefs, namely the quantitative method. Purnomo (2017) has used the qualitative method, but, like Martínez-Sierra et al. (2020), Purnomo (2017) has not conducted this research on pre-service elementary school mathematics teachers. It is crucial to have a study that analyzes the relationship between beliefs about the epistemology of mathematics, mathematics teaching and learning, and mathematics assessment, and how these beliefs relate with each other in pre-service elementary school mathematics teachers context.

Theoretical Framework

Beliefs about mathematics epistemology is a belief of the nature in mathematics and the acquiring of knowledge about mathematics (Felbrich et al., 2012; Y. W. Purnomo, 2017). Various schematics or systems correlate mathematics epistemological beliefs and mathematics teaching and learning beliefs developed. Ernest (1989) divided mathematics epistemological and teaching and learning beliefs into three views: the Platonist view (mathematics as static, heavily structured and with all its components related one to another), the instrumentalist view (mathematics as an accumulation of facts, skills, and methods that do not have any correlation one to another), and the problem-solving (mathematics as a dynamic and relative entity). Blömeke et al. (2008) divided the beliefs into four categories: perspectives related to schematics (mathematics as a collection of methods and formulas), the formalist perspective (emphasizes the formal and logical aspect of mathematics), the process-oriented perspective (mathematics as a problem solver), and the application perspective (mathematics as an applied science). This research uses a framework that views epistemology through two categories: the static belief (absolutism) and the dynamic belief (fallibilism).

The beliefs about the teaching and learning of mathematics pertain to the way through which mathematics is studied, concepts regarding the roles of teachers and students, activities, and the mental processes that take place (Ernest, 1989; Purnomo, 2017; Purnomo et al., 2018; Purnomo et al., 2016; Yuli et al., 2019). Various categorization systems have been used to map out mathematics teaching and learning (Beswick, 2012). This research uses the framework that classifies belief about mathematics teaching and learning into two parts: the knowledge transmission perspective, also known as the traditional perspective (where mathematics teaching and learning is viewed as a process of transmitting knowledge: the students passively receive knowledge from the teacher), and the constructivism perspective (where mathematics teaching and learning is seen as a process that emphasizes on how the students construct their understanding) (Döhrmann et al., 2012; Totto et al., 2008).

The framework used in this research to analyze beliefs about mathematics assessments is one constructed by NCTM (2014), which categorizes a teacher's beliefs about assessments into productive belief and unproductive belief. This categorization was constructed based on the role that an assessment plays in the teaching and learning process. Productive belief means that a teacher sees an assessment to encourage an effective teaching and learning process. Unproductive belief views assessment as merely a tool used to measure student achievement and limit students to only the core content and practice of mathematics (NCTM, 2014). An example of productive belief is the belief that students can assess their learning process. On the other hand, unproductive belief maintains that a party's assessments need to be done other than the student. This productive-unproductive belief framework on beliefs about mathematics assessments is used, seeing that several of research recommendations and mathematics education communities are pushing for an assessment reformation that promotes productive belief.

Research Purpose and Research Questions

Therefore, this research aims to analyze and determine the relationship between pre-service elementary school mathematics teachers' beliefs about the epistemology of mathematics, teaching and learning, and assessment. More specifically, this research will involve detailed investigation and analysis on these two elements: (1) the relationship between pre-service elementary school mathematics teachers' beliefs about mathematics epistemology, beliefs about teaching and learning, and beliefs about mathematics assessment (2) how beliefs about mathematics epistemology and beliefs about mathematics teaching and learning will interact and affect beliefs about mathematics assessment. Seeing these purposes, the questions that will guide this research are: (1) how are the relationship between pre-service elementary school mathematics teachers' beliefs about the epistemology of mathematics, beliefs about mathematics teaching and learning, and beliefs about mathematics assessment? (2) how do beliefs about mathematics epistemology and beliefs about mathematics teaching and learning interact and affect mathematics assessment beliefs?

METHODS

This research is a quantitative study with a correlational study. A correlational study was conducted to examine the relationship between the research variables, namely pre-service elementary school mathematics teachers' beliefs about the epistemology of mathematics (X_1), beliefs about mathematics teaching and learning (X_2), and beliefs about mathematics assessment (Y) (Figure 1).

Data collection uses the survey method with a cross-sectional design. This design was selected due to the need to gather data from different variables simultaneously (Cohen et al., 2018).

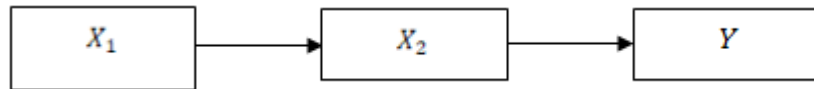


FIGURE 1. *Research design*

Participants

The participants in this research are 71 pre-service elementary teachers (10 males and 61 females). **Table 1** shows the demographic data of respondents.

TABLE 1. *The demographic data of respondents*

Demographic Information	Frequency	Percentage
Gender		
Male	10	14,1%
Female	61	85,9%
Language of instruction		
English	19	26,8%
Bahasa	52	63,2%
Age		
19	15	21,1%
20	36	50,7%
21	15	21,1%
22	5	7,1%
Total	71	100%

The participants were selected through purposive sampling. It is done because the researchers required pre-service teachers with an adequate understanding of mathematics, pedagogy (mathematics teaching and learning), and mathematics assessment. All participants have completed university courses on the topics of teaching and learning, assessment, mathematics content materials (basic mathematics, geometry, elementary school mathematics), and are currently taking a course on mathematics teaching.

Instrument

Questionnaires were used to collect data for this research. The questionnaire is divided into three parts and utilizes a 6-point scale (1 being “strongly disagree” and 6 being “strongly agree”). The questionnaire used in this study consisted of three parts (**Table 2**). The first part of the questionnaire consists of 12 questions on beliefs about the epistemology of mathematics (6 questions relating to static belief, and 6 relating to dynamic belief). These questions were taken from TEDS-M (Döhrmann et al., 2012; Tatto et al., 2008), then translated into Indonesian. The first part (epistemology of mathematics) has an internal validation value that is adequate, with its Pearson correlation value in the range of 0.313 to 0.742, and that is significant for $\alpha = 0.05$. It also has a high reliability, with a Cronbach’s Alpha value of 0.786 (greater than 0.5). The second part of the questionnaire addresses the beliefs about mathematics teaching and learning. The question items for this part were also taken from the TEDS-M questionnaire but leaving out several questions: the seventh question (regarding traditional belief/content-centered beliefs), the ninth question (regarding constructivist belief/student-centered beliefs), and the eleventh question (also regarding constructivist belief/student-centered beliefs). These three questions were left out because their initial validation testing value proves to be not significant ($\alpha = 0,05$) (Döhrmann et al., 2012; Tatto et al., 2008). Thus, the second part of the questionnaire, which analyzes beliefs about mathematics teaching and learning, features eleven question items. A second validation testing was conducted after the seventh, ninth, and eleventh questions from the TEDS-M had been removed. The The

second validation testing showed that the second part of the questionnaire is adequate, with the Pearson correlation value ranging from 0.239 to 0.647 and significant for $\alpha = 0,05$. The reliability is high, with a Cronbach's Alpha value of 0.664 (greater than 0.5). The third part of the questionnaire analyzes the beliefs about mathematics assessment. The question items in this part were taken from NCTM (2014), consisting of five items relating to productive belief (P1-P5) and three items relating to unproductive belief (P7, P9, P10). The third part has a good Pearson validation value, with their Pearson correlation values ranging from 0.236 to 0.695 and significant for $\alpha = 0,05$. This part also has high reliability, with a Cronbach's Alpha value of 0.612 (> 0.5).

TABLE 2. *The belief questionnaire framework*

Belief	Dimension	Item
Beliefs about Epistemology of Mathematics	Static belief	1,2,5,7,11,12
	Dynamic belief	3,4,6,8,9,10
Belief about Teaching and Learning	Traditional belief	1,2,3,4,5,6
	Constructivist belief	8,10,12,13,14
Belief about Mathematics Assessment	Unproductive belief	1,2,3,4,5
	Productive belief	7,9,10

Data Analysis

Data analysis were done quantitatively (using both quantitative descriptive and quantitative inferential (correlation) statistics. In the first stage of the analysis, the data were analyzed using the descriptive method by calculating the mean and standard deviation values (Döhrmann et al., 2012; Totto et al., 2008; Yang et al., 2020). The descriptive statistics of each dimension were then calculated.

In the second stage, the analysis was conducted by determining the Pearson product-moment correlation value between mathematics epistemology beliefs, beliefs about mathematics teaching and learning, and beliefs about mathematics assessment. The analysis using the Pearson product-moment correlation aims to answer the first research question. The value and significance of the Pearson product-moment correlation will provide answers to the relationship between beliefs. The analysis of Pearson product-moment correlation results used to construct the path models. The third stage, then, is to conduct a path analysis to assess the interactive function between the three dimensions of belief according to the path models that have been constructed. This analysis will answer the second research question concerning interact and affect mathematics epistemology and beliefs about mathematics teaching and learning towards beliefs about mathematics assessment. The quantitative descriptive and Pearson product-moment correlation analysis were done using the SPSS 20.0 software. Path analysis was done using the SPSS AMOS 26.0 software.

RESULTS

The results of the research will be presented in three parts. The first part will be about the descriptive analysis of the three dimensions of belief (beliefs about the epistemology of mathematics, mathematics teaching and learning, and mathematics assessment). The second part will present the results of the correlation analysis between beliefs. The third part will present the path analysis results: the interactive function between the three dimensions of beliefs.

Descriptive Results

As seen in **Table 3**, regarding beliefs about mathematics' epistemology, relatively, the mean value of static beliefs is greater than the mean value of dynamic beliefs. What this means is that pre-service elementary school mathematics teachers tend to hold static beliefs. However, the mean value of dynamic beliefs is greater than 4. It indicates that in addition to static beliefs, pre-service elementary school mathematics teachers hold dynamic beliefs simultaneously. The first part of the questionnaire shows that pre-service elementary school mathematics teachers tend to hold mixed beliefs about the epistemology of mathematics.

TABLE 3. Description of pre-service elementary school mathematics teachers' beliefs about epistemology of mathematics and mathematics teaching and learning

	Min.	Max.	Mean	Std.Dev.
Static Belief	3.17	6.00	5.21	0.51
Dynamic Belief	3.00	5.83	4.62	0.67
Traditional Learning Belief	1.71	5.00	3.33	0.66
Constructivist Learning Belief	3.00	6.00	4.77	0.63
Unproductive Belief	1.40	5.60	4.15	0.79
Productive Belief	3.00	6.00	5.16	0.53

Regarding mathematics teaching and learning, the mean value of beliefs on constructivist learning is greater than the mean value of traditional learning beliefs. It shows that pre-service elementary school mathematics teachers tend to hold constructive beliefs when it comes to learning. However, the mean value of beliefs on traditional learning is greater than 3. It indicates that pre-service elementary school mathematics teachers tend to hold both constructivist and traditional beliefs (mixed beliefs). On beliefs about mathematics assessment, pre-service elementary school mathematics teachers also tend to hold mixed beliefs. It is seen through the results: even though the mean value for productive belief is higher, the mean value of unproductive belief also is greater than 4.

The Correlation between Beliefs

The correlation between beliefs about the epistemology of mathematics, mathematic teaching and learning, and mathematic assessment is shown in **Table 4**. It can be seen that there is a positive and significant correlation between static beliefs regarding the epistemology of mathematics and dynamic beliefs, as well as between the constructivist belief about mathematics teaching and learning and the productive belief about mathematics assessment. However, static belief does not show any significant correlation with traditional beliefs on mathematics teaching and learning, as well as on unproductive belief on mathematics assessment.

The dynamic beliefs on mathematics epistemology shows a positive and significant correlation on all dimensions of beliefs, except on unproductive belief about mathematics assessment. It means that pre-service elementary school mathematics teachers who hold dynamic beliefs on mathematics epistemology also hold strong static beliefs, traditional beliefs, constructivist beliefs and productive beliefs. Traditional beliefs do not show any positive correlation with constructivist beliefs on mathematics teaching and learning. It also does not show any positive correlation with both unproductive and productive beliefs on mathematics assessment. It means that pre-service elementary school mathematics teachers who have traditional beliefs do not hold strongly other beliefs. On the other hand, the constructivist belief about mathematics teaching and learning shows a positive and significant correlation with productive belief, but does not show a positive and significant correlation with unproductive belief on mathematics assessment. It means that pre-service elementary school mathematics teachers who hold the constructivist belief about

mathematics teaching also tend to see assessment in a productive framework. In addition, the correlation between unproductive belief and productive belief in mathematics assessment proves to be negative and not significant. This means that pre-service elementary school mathematics teachers who believe in assessment in a productive framework no longer hold unproductive beliefs and vice versa. It can also be said that pre-service elementary school mathematics teachers do not hold mixed beliefs in terms of mathematics assessment.

TABLE 4. *Matrix of bivariate correlation between beliefs*

	SB	DB	TB	CB	UB	PB
Static Beliefs (SB)	1	0,449**	0,161	0,367**	0.106	0.544**
Dynamic Beliefs (DB)		1	0,317*	0,354**	0.189	0.463**
Traditional Beliefs (TB)			1	0,108	0.310	-0.048
Constructivist Beliefs (CB)				1	0.015	0.419**
Unproductive Beliefs (UB)					1	-0.045
Productive Beliefs (PB)						1

** . Significant correlation on the level of 0.01; * . Significant correlation on the level of 0.05

Path Analysis Results

Based on the correlation analysis results indicated above, a path analysis was conducted to investigate the correlation between static beliefs, dynamic beliefs, constructivist beliefs, and productive beliefs. Traditional beliefs do not play a part in this path analysis because, as shown previously, the correlation analysis results show that traditional beliefs have a correlation that is not significant with beliefs about mathematics assessment (both productive and unproductive beliefs). In addition, unproductive beliefs (which is a dimension of beliefs on mathematics assessment) will also not be used in the path analysis because it does not significantly correlate with any of the other beliefs.

TABLE 5. *The goodness of fit test data*

Goodness of Fit Indices	Cut - Off Value	Value
χ^2	Expected small	7,13
Probability (p)	$\geq 0,05$	0,415
CMIN/DF (χ^2/df)	$\leq 2,00$	1,02
GFI	$\geq 0,95$	0,969
TLI	$\geq 0,95$	0,996
CFI	$\geq 0,95$	0,998
RMSEA	$\leq 0,08$	0,016

As stated in the theoretical framework, the functional correlation that will be examined is that beliefs about epistemology of mathematics affect beliefs about mathematics teaching and learning and beliefs about mathematics assessment; two, that beliefs about mathematics teaching and learning affect beliefs about mathematics assessment. The path coefficient for the final model (which has a significant path coefficient) is shown in **Figure 2**. The final model in **Figure 2** has been tested with The Goodness of Fit test. **Table 5** shows the results of The Goodness of Fit test. Value in **Table 4** shows that all cut-off value criteria have been met. The meaning of the results of The Goodness of Fit test is that the model correlates with the data.

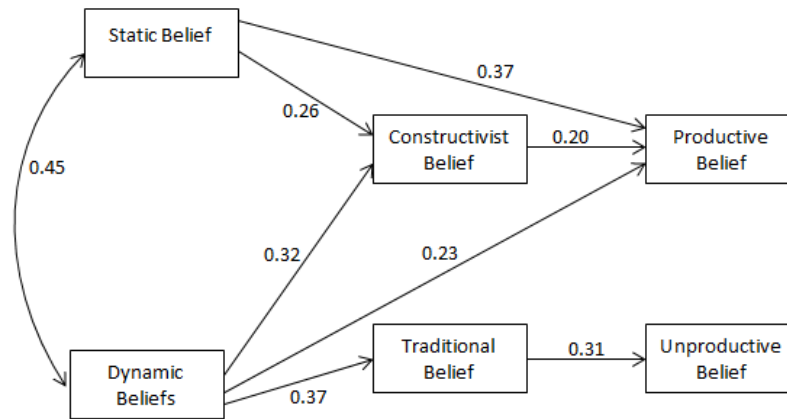


FIGURE 2. Path analysis results

The path analysis results reveal several findings: First, static beliefs and dynamic beliefs about the epistemology of mathematics, as well as constructivist beliefs about mathematics teaching and learning, have predicted productive beliefs about mathematics assessment in a positive and significant manner ($\beta = 0.37$; 0.23 and 0.20 , respectively). It means that static beliefs, dynamic beliefs, and constructivist beliefs directly influence productive beliefs about mathematics assessment. In other words, productive beliefs about mathematics assessment held by pre-service elementary school mathematics teachers are influenced and generated from static beliefs, dynamic beliefs, and constructivist beliefs they hold. It can also be said that pre-service school elementary mathematics teachers hold static beliefs and constructivist beliefs simultaneously, and dynamic beliefs and constructivist beliefs simultaneously hold productive beliefs about mathematics assessment. Second, static and dynamic beliefs about mathematics' epistemology have a positive correlation with constructivist beliefs ($\beta = 0.26$ and 0.32). This means that their static and dynamic beliefs influence the constructivist beliefs held by pre-service elementary school mathematics teachers. Third, static and dynamic beliefs about mathematics' epistemology, through the mediation of constructivist beliefs, have an indirect and positive influence on productive beliefs on mathematics assessment (the total of indirect influence being $\beta = 0.053$ and 0.049 , respectively). In other words, productive belief on mathematics assessment that pre-service elementary school mathematics teachers own is also influenced by their belief in mathematics' epistemology, which affects belief of teaching and learning mathematics. Fourth, traditional beliefs about mathematics teaching and learning can predict unproductive beliefs about mathematics assessment ($\beta = 0.31$). This result means that pre-service elementary school mathematics teachers who hold traditional beliefs will likely also believe in mathematics assessment in the unproductive framework. Fifth, through traditional beliefs, dynamic beliefs have an indirect influence on unproductive beliefs about mathematics assessment (the total of indirect influence being $\beta = 0.098$). In other words, unproductive beliefs on mathematics assessment that pre-service elementary school mathematics teachers own are also influenced by their dynamic beliefs, affecting the belief of teaching and learning mathematics (traditional beliefs).

DISCUSSION

This research uses a framework and instruments developed by TEDS to analyze beliefs about epistemology of mathematics and mathematics teaching and learning. The framework suggested by NCTM is used to analyze beliefs about mathematics assessment. The research results show that pre-service elementary school mathematics teachers tend to hold both static and dynamic beliefs on mathematics' epistemology. Likewise, pre-

service elementary school mathematics teachers tend to hold both traditional and constructivist beliefs about mathematics teaching and learning beliefs. These findings are consistent with previous studies specifying that pre-service elementary school mathematics teachers tend to hold mixed beliefs (Beswick, 2012; Felbrich et al., 2012; Tamba et al., 2020; Tang & Hsieh, 2014; Yang et al., 2020). This contradictory result is probable: Xenofontos (2018) stated that teachers could hold explicitly fallibility (dynamic) beliefs while at the same time holding Platonic (static) beliefs. However, based on each dimension of beliefs' mean value, pre-service elementary school mathematics teachers tend to lean towards dynamic beliefs rather than static beliefs when it concerns the epistemology of mathematics. In beliefs about mathematics teaching and learning, they tend to hold constructivist beliefs rather than traditional beliefs. These findings are consistent with the results presented in previous research (Tamba et al., 2020). The beliefs about mathematics assessment, pre-service elementary school mathematics teachers tend to hold productive beliefs rather than unproductive beliefs. Productive beliefs are parallel to integration beliefs about mathematics assessment, which is discussed by Purnomo (2017). The findings in this paper have also echoed findings by Purnomo (2017), showing that pre-service teachers tend to hold integration (or productive) beliefs rather than isolation (unproductive) beliefs.

A critical discovery, which is also the answer for the first research question of this paper, is that there is a positive and significant correlation between beliefs about mathematics epistemology (both static and dynamic) with beliefs about mathematics assessment. Both static and dynamic beliefs about mathematics epistemology show a positive and significant correlation with productive mathematics assessment belief. However, these two beliefs (static and dynamic beliefs) do not significantly correlate with unproductive belief. In beliefs about mathematics teaching and learning, the constructivist belief positively and significantly correlates with productive belief about mathematics assessment. Meanwhile, the traditional belief shows a positive and significant correlation with unproductive belief about mathematics assessment. These results are consistent with the results of the research conducted by Martínez-Sierra et al. (2020), suggesting that there exists a correlation between epistemological beliefs in mathematics and mathematics assessment. Martínez-Sierra et al. (2020) state that epistemological becomes the “central belief” of one’s beliefs about assessment. However, this result differs from the research results presented by Purnomo (2017), who suggested that there is no correlation between epistemological beliefs and assessment beliefs.

The path analysis then answers the second research question: the functional influence between beliefs about the epistemology of mathematics and beliefs about mathematics teaching and learning. The path analysis results show that beliefs about epistemology of mathematics and beliefs about mathematics teaching and learning have a positive and significant correlation on beliefs about mathematics assessment. This research also discovers that the dimension of belief will determine, or influence, the belief about mathematics assessment. It means that the pre-service elementary school mathematics teachers who hold constructivist beliefs in mathematics teaching and learning will also hold the productive belief when it comes to mathematics assessment. Consequently, pre-service elementary school mathematics teachers who hold traditional teaching and learning beliefs will hold unproductive beliefs on mathematics assessment. This influence relationship, however, does not work the other way.

Based on the results discussed in this section, this research will contribute to the ongoing research efforts on the topic of the relationship between beliefs about epistemology of mathematics, beliefs about mathematics teaching and learning, and beliefs about mathematics assessment. Firstly, this research used a different theoretical framework to analyze beliefs about mathematics assessment. This research used the productive-unproductive belief framework to analyze beliefs about mathematics assessment, which had not been used in previous studies such as that of Purnomo (2017), who had used the “integration” and “isolation” categorization, or that of Brown (2006),

who had used the categorization framework of “assessment improves education” (assessments can contribute to the improvement of the teaching and learning process), “school accountability” (assessments can be used to evaluate the effectiveness of schools and teachers), “student accountability” (assessments can validate student performance, holding them accountable for results), and “assessment is irrelevant” (assessments may be deemed fundamentally irrelevant to the professional and personal lives of teachers and students). The framework used in this research focuses on assessment beliefs and their contribution to the teaching and learning process (NCTM, 2014). Secondly, this research provides an overview of beliefs about assessment and how this correlates with beliefs about the epistemology of mathematics and beliefs about mathematics teaching and learning that pre-service elementary school mathematics teachers hold.

CONCLUSION

As stated previously, the results of this research show a positive and significant correlation between static and dynamic beliefs about epistemology of mathematics, and the constructivist beliefs about mathematics teaching and learning, with productive belief about mathematics assessment held by pre-service elementary school mathematics teachers. This research has also shown that unproductive belief on mathematics assessment only correlates with mathematics teaching and learning. Therefore, it can also be concluded that beliefs about epistemology of mathematics (both static and dynamic), and beliefs about teaching and learning (constructivist), indeed have a functional influence on beliefs about mathematics assessment (productive belief).

Despite these results, this research has limitations. Firstly, other than translating it into Indonesian, this research does not implement any modifications to the TEDS-M instrument. Tamba et al. (2020) suggest that instrument contextualization is necessary to ensure that research instruments fit the participants’ conditions. Several previous studies have developed their instruments to accommodate their research contexts well (e.g. Brown & Gao, 2015; Brown & Remesal, 2012; Y. W. Purnomo, 2017). Future research should focus on developing an instrument that is more fitted for the participants’ contexts. Secondly, instrument construction needs to be conducted in a strict and detailed manner. In this research, instruments were not constructed using the exploratory factor analysis, which could have helped analyze deeper the factors that had been assumed theoretically. The factors have indeed been theoretically mapped; however, an exploratory factor analysis might remain necessary to elaborate those factors (Andrews et al., 2017; Worthington & Whittaker, 2006). Future researchers need to reexamine the instruments used in a strict and detailed manner, starting from conducting an exploratory factor analysis.

This research contributes to practical implications for teacher education and the practice of teaching in the classroom itself. This research suggests the importance of considering one’s beliefs in the advancement towards the reform of teaching and learning in the classroom. The findings in this research indicate a reform in the practice and beliefs regarding mathematics assessment, can be achieved only by assessing and shaping the beliefs held by pre-service elementary school teachers on epistemology of mathematics and teaching and learning.

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