Preservice teacher belief on nature of mathematics and mathematics teaching and learning: a quantitative study

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Abstract. A quantitative study aims to investigate preservice teacher's beliefs in mathematics and mathematics teaching and learning. The participants were 103 preservice mathematics teachers who were studying at the Musamus University of Merauke. The TBTP questionnaire was used to measure the beliefs of preservice teachers. The results showed that there were differences in the beliefs of preservice teachers when teaching in classes dominated by high ability students and low ability students. Preservice teachers tend to have platonist beliefs when teaching in high ability classes and when teaching in low ability classes preservice teachers have instrumentalist beliefs. Most preservice teachers have instrumentalist beliefs in mathematics. The implications of the study provide recommendations for teacher educators to change the beliefs of preservice mathematics teachers into problem-solving views.

1. Introduction

Beliefs of a teacher have a significant role in planning and implementing learning practices in the classroom [1]. There is a relationship between a teacher's positive beliefs in solving mathematical problems and constructivist learning enable students to be actively involved in the learning process in classroom [2]. Conversely, teachers with traditional beliefs view such contexts as obstacles to problem solving. Teachers conceptualize about the nature of mathematics could be related with their style of teaching and learning of mathematics [3].

Beliefs as “psychologically held understandings, premises, or propositions about the world that are thought to be true [4]. Beliefs might be thought of as lenses that affect one’s view of some aspect of the world or as dispositions towards action” Belief is the basis for a person's behaviour and understanding that an individual has an event. Beliefs about mathematics, as individual understanding and feelings that shape the way individuals conceptualize and engage in mathematical behaviour [5]. Thus, mathematical beliefs can include mathematical subjects or things that happen to themselves and their surroundings.

There are conflicting views about teacher beliefs about teaching mathematics. For example, some researchers classify teacher beliefs about teaching in what is focused during the teaching process. Some categorize beliefs that focus on students, focus on content with conceptual understanding, focus on content with the performance, and focus on class. Beliefs that focus on students emphasize student involvement in constructing the meaning of what students are learning. Emphasis on content and with performance emphasizes mastery of rules and procedures.

Beliefs are not isolated with other beliefs but are interrelated that can form a belief system. For example, mathematical instrumental views tend to be linked to instructor teaching models, and texts or schemes are followed closely. It is also possible to be associated with obedient behaviour and mastery
of student skills. Mathematics as a unitary body of Platonist knowledge - teachers as explorers - learning as acceptance of knowledge; Mathematics as problem-solving - the teacher as a facilitator - learns as the active construction of understanding, maybe even problem solving and autonomous problem-solving.

Teacher beliefs about engagement, including self-efficacy that influenced student learning outcomes, to what extent they were willing to adopt practices that tended to increase student involvement [6]. Beswick [7], for example, relates the teacher's belief that skills-based repetitive tasks are appropriate for low-achieving students from assignments that might increase students' mathematical skills for lack of knowledge, and hence lack of self-efficacy, in relation to teaching math skills.

A holistic approach for three years and explored the relationship of 83 elementary teacher candidates with mathematics and mathematics teaching, separating belief from knowledge, and incorporating aspects of beliefs, knowledge, feelings, identity and involvement in relationships them with a construct of mathematics [8]. They found the relationship of preservice teachers with mathematics and teaching mathematics becoming more positive as their teaching of identity grew during their experience, which included interventions aimed at their mathematical content knowledge, explicit teaching about affective aspects, and positive role modelling. Moreover, teachers’ beliefs about mathematics teaching are informed by their experiences as learners in mathematics classes [9]. Thus, a study is needed to investigate preservice teachers’ belief about mathematics.

The results of research on beliefs that use a Likert scale instrument still show inconsistencies in teaching practices and mathematics learning of a teacher in the classroom. One reason is the Likert scale does not involve social contexts that can affect respondents' attitudes in responding to statements and questions. This is caused by data collected using the Likert scale only emphasizing on a statement then ranked. Meanwhile, using qualitative methods has a weakness that requires a long time in the process of collecting data and taking a limited sample. Therefore, study is needed to measure the beliefs of preservice mathematics teachers that consider the context or situation so that they can describe the consistency of the beliefs of teachers or preservice teachers with teaching practices and mathematics learning.

Most study on beliefs is still focused on teachers [2], [7]. The work on the preservice teacher's beliefs on mathematics and mathematics learning and teaching is rarely conducted. Whereas investigation on preservice teachers is very urgent to map beliefs to change beliefs during education and improve the quality of mathematics learning when becoming a teacher [10], [11]. To deal with a gap, the present study will provide lens on how mathematics ability effect on preservice mathematics teacher belief on nature of mathematics and mathematics teaching and learning.

Therefore the research questions are (1) Are there differences in the preservice teacher's beliefs in mathematics teaching and learning when teaching in high and low ability classes?; (2) How preservice teacher's beliefs on nature of mathematics?

2. Methods
This study is a quantitative study that aims to investigate the effect of students' mathematical abilities on preservice mathematics teachers’ belief about mathematics and mathematics teaching and learning. Beliefs of preservice teachers in mathematics teaching and learning in classes dominated by high ability students and low ability students. Participants in this study were 103 preservice teachers who were studying in the Mathematics Education department, Musamus University, Merauke. The response participant collected by using online TBTP (Teacher's Belief Teaching Practice) which developed by Safrudiannur [12]. This approach which uses rank-then-rate items classified into three themes: (1) Teaching and learning of mathematics (Theme 1), (2) teaching and learning of problem solving (Theme 2), and (3) the nature of mathematics (Theme 3) and considers social contexts at school related to students’ abilities. Theme 1 consists of 8 items while theme 3 consists of 4 items. Each item has three statements. Each statement is related to one of the views of mathematics (instrumentalist, platonist and problem solving). In this work, we only employed theme 1 and theme 3 because pandemi Covid-19. To respond to an item in the TBTP, firstly, a respondent must order the three statements of the item by
assigning a rank 1 (the most important), 2, or 3 (the least). Preservice teachers’ response data is then analyzed using jasp (version 0.12.1.0).

3. Result and Discussion
Before presenting the results of data analysis, the authors state the Cronbach TBTP Alfa coefficient for each dimension of beliefs about learning and teaching mathematics.

| Belief          | Statement                                      | α     |
|-----------------|------------------------------------------------|-------|
| Instrumentalist | A1 (item 1), A1 (item 2), B1 (item 3), B1 (item 4), C1 (item 5), C1 (item 6), D1 (item 7), D1 (item 8) | 0.719 |
| Platonist       | A2 (item 1), A2 (item 2), B2 (item 3), B2 (item 4), C2 (item 5), C2 (item 6), D2 (item 7), D2 (item 8) | 0.620 |
| Problem Solving | A3 (item 1), A3 (item 2), B3 (item 3), B3 (item 4), C3 (item 5), C3 (item 6), D3 (item 7), D3 (item 8) | 0.909 |

**Figure 1.** Instrument reliability

Figure 1 shows that instrument reliability. The figure 1 shows that items on each dimension have high reliability.

3.1. Preservice teachers’ beliefs about mathematics teaching and learning
The following table is presented about the rates given by preservice teachers to items 1-8. The results of the Wilcoxon signed-rank tests show that preservice teachers give different rates when teaching classes with high abilities and low abilities.

| Items        | Statements | Views | Mean (sd) of Teachers’ rate (N=103) | Test Statistic (z) | Sig. (2-tailed) |
|--------------|------------|-------|-------------------------------------|--------------------|-----------------|
| 1 and 2      | A1 Ins     | 5.48 (1.35) | 6.51 (0.81)                         | 272.000             | < 0.001         |
|              | A2 Pla     | 6.07 (1.21) | 6.01 (0.73)                         | 1267.500           | 0.282           |
|              | A3 Pro     | 4.52 (1.70) | 3.82 (1.32)                         | 1194.000           | < 0.001         |
| 3 and 4      | B1 Ins     | 5.31 (1.24) | 6.17 (0.87)                         | 432.000            | < 0.001         |
|              | B2 Pla     | 6.03 (1.23) | 6.26 (0.86)                         | 990.000            | 0.130           |
|              | B3 Pro     | 5.08 (1.66) | 4.02 (1.27)                         | 2224.000           | < 0.001         |
| 5 and 6      | C1 Ins     | 5.53 (1.13) | 6.55 (0.75)                         | 441.500            | < 0.001         |
|              | C2 Pla     | 6.33 (0.97) | 6.08 (0.71)                         | 1815.500           | 0.015           |
|              | C3 Pro     | 4.64 (1.70) | 4.05 (1.24)                         | 1145.000           | < 0.001         |
| 7 and 8      | D1 Ins     | 5.34 (1.22) | 6.15 (1.02)                         | 591.000            | < 0.001         |
|              | D2 Pla     | 6.19 (1.14) | 6.29 (0.83)                         | 1075.500           | 0.538           |
|              | D3 Pro     | 5.09 (1.61) | 4.15 (1.24)                         | 1713.500           | < 0.001         |

Table 1 shows that the preservice teachers provide significantly different rates for instrumentalist views and problem-solving between high class and low class. The rate indicates that most preservice mathematics teacher have platonist beliefs (mean A2, B2, C2, and D2 > 6) when teaching in high class while when teaching in low-class preservice teachers tend to associated instrumental beliefs (mean A1 and C1 > 6) and platonist beliefs (mean B2 and D2 > 6). These results prove that preservice teachers elicit different beliefs when teaching in classes that have high and low abilities. In low class, they give low rates to all statement which associated problem solving view (A3 and C3) [letting students discover
the formula] and B3 and D3 [students deduce the formula]). The mean rates of four statements are in between slightly not important and neutral. In contrast, for HA classes, the mean rates of four statements are in between neutral and slightly important, indicating the beliefs that the styles are more appropriate for HA classes than LA classes. However, there is no significant rate difference given by preservice teachers to the platonist view. This indicates that preservice teachers consider it important to provide an explanation when teaching mathematics both high and low class [13].

Beliefs are not closed or isolated with other beliefs but are connected that can construct a belief system. For example, mathematical instrumental views tend to be linked to instructor teaching models, and texts or schemes are followed closely. It is also possible to be associated with obedient behaviour and mastery of student skills. Mathematics as a unitary body of Platonist knowledge - teachers as explorers - learning as acceptance of knowledge; Mathematics as problem-solving - the teacher as a facilitator - learns as the active construction of understanding, maybe even problem solving and autonomous problem-solving.

3.2. Preservice teachers’ beliefs about mathematics

The following table portray preservice teachers’ rates to items 1-4 which associated with belief about nature of mathematics.

| Items | Statements | Views | Mean (sd) of Teachers’ rate (N=103) |
|-------|------------|-------|-------------------------------------|
| 1     | E1         | Ins   | 6.36 (1.02)                         |
|       | E2         | Pla   | 5.31 (1.15)                         |
|       | E3         | Pro   | 4.69 (1.31)                         |
| 2     | F1         | Ins   | 5.94 (1.12)                         |
|       | F2         | Pla   | 5.47 (1.22)                         |
|       | F3         | Pro   | 4.98 (1.31)                         |
| 3     | G1         | Ins   | 5.92 (1.24)                         |
|       | G2         | Pla   | 5.29 (1.25)                         |
|       | G3         | Pro   | 4.60 (1.53)                         |
| 4     | H1         | Ins   | 5.93 (1.09)                         |
|       | H2         | Pla   | 5.24 (1.26)                         |
|       | H3         | Pro   | 4.71 (1.54)                         |

Table 2 shows that preservice teachers’ response in item 1-4 (Theme 3) on the TBTP express that they may have a mixed view about nature of mathematics. Most participants in this study give rates associated with instrumentalist beliefs. The mean rates given on the four statements are in between slightly agree and agree. Preservice teachers’ instrumentalists views mathematics as a set of tools that are made up of facts and rules to be used in solving various problems [2], [7], [13]. Moreover, the instrumentalist view that mathematics is an accumulation of facts, rules, and skills to be used in the pursuit of some external end. Thus, mathematics is a set of unrelated but utilitarian rules and facts. While the mean (E3, F3, G3, and H3) is the lowest rates associated with problem-solving view. Preservice teachers’ problem solving views mathematics as a space for human discovery that is continuously developing and where patterns emerge and are subsequently filtered to become knowledge. Moreover, the problem-solving teachers view of mathematics as a dynamic, continuously expanding field of human creation and invention, a cultural product [2], [7], [13]. Mathematics is a process of inquiry and coming to know, not a finished product, for its results remain open to revision.
4. Conclusion
Mapping the beliefs of preservice teachers is very important to improve the quality of learning when they become teachers. In addition, the ability of students should be a factor that needs to be considered in choosing methods in learning mathematics. They should be directed by teacher educators to have problem-solving beliefs. This type of belief is very much in line with the 2013 curriculum and freedom learning that was launched by the Ministry of Education and Cultural. In addition, preservice teacher students who have a problem-solving belief will be more concerned with the context or problem in starting learning. The problem-solving teachers will enable productive classroom discussion that is the engagement of students and the ability to construct knowledge independently which will eventually become independent learners that are in line with the 21st century's core competencies.

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