Do Student Beliefs Have a Relationship with Mathematics Learning Outcomes?

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**Abstract**. This study aims to describe a relationship between beliefs and mathematics learning outcomes. We have collected empirical evidence about positive relationship between beliefs and mathematics learning outcomes from a reputable online journal database and synthesized using a systematic literature method. Sixteen articles were found meet the following criteria: (1) Published between 2000-2020, (2) Articles contain empirical evidence about the relationship between beliefs and mathematics learning outcomes, (3) Research subjects are students both from elementary school to higher education. The results showed that beliefs have a positive correlation with student mathematics learning outcomes in both cognitive and affective aspect. From the cognitive aspect, belief have a positive correlation with achievement, problem solving, and conceptual understanding. While from the affective aspect, beliefs have a positive correlation with motivation and a negative correlation with math-anxiety.

1. Introduction

Research in mathematics education does not only focus on cognitive aspects but also affective aspects. This is because the affective aspect also influences the success of learning mathematics. In the world of mathematics education, there are several affective aspects which are the core aspects of learning mathematics, namely beliefs, values, attitude, and emotion [1]. These aspects are interrelated and become one of the success factors in learning mathematics [2].

Belief is an affective aspect that has an important role in learning mathematics [3] [4]. Students' belief in mathematics influences student behavior toward mathematics learning. Its mean that Students’ beliefs about mathematics and mathematics learning influence their interest in mathematics, their enjoyment of mathematics, and their motivation in mathematics classes [5]. According to [6] student beliefs are classified as positive and negative beliefs. Students who have negative beliefs such as “mathematics is difficult”,”I never understand mathematics’ will be less receptive to mathematics, on the other hand, students who have positive beliefs such as “I enjoyed learning mathematics” will have more interest in mathematics and enjoy in learning mathematics. Therefore, beliefs hold an important role in learning mathematics.

Kloosterman [7] defines beliefs as students' personal beliefs that underlie students in making decisions about the actions they take. Peter [5] defines beliefs in mathematics as subjective assumptions held by students about mathematics education, about themselves as mathematicians, and about the context of mathematics classrooms. From that definition we can conclude there are three categories of student beliefs. Student beliefs about mathematics education is what student think about mathematics as subject, learning and teaching mathematics and problem solving. Beliefs about themselves as mathematician include self-efficacy beliefs, control beliefs, task-value beliefs and goal orientation beliefs. Beliefs about social context of mathematics classroom is what student think about role and functioning of the teacher and student in their own class. These three category of beliefs became a framework of student belief system.

Students' belief in mathematics has a strong influence on individual behavior and problem-solving abilities. [6] [8] students who have positive beliefs have better problem-solving abilities than students who have negative beliefs. In line with this [9] found that beliefs have an effect on response time and efficiency in solving a problem. Student beliefs also have a relationship with mathematics abilities, mathematics achievement, conceptual understanding, and mathematical reasoning. Not only in cognitive aspect, beliefs also closely related to affective aspects such as motivation [10]. Students who have positive beliefs have high motivation in learning mathematics. Beliefs are also closely related to emotions [11] and math anxiety [12]. Because there is a lot of research that shows that beliefs have a relationship with affective and cognitive aspects, it is important to present the evidence comprehensively.

This study aims to explain the relationship between beliefs and abilities in mathematics learning outcomes. The results of this study can be used as a theoretical basis for research relating to students' beliefs in mathematics learning.

1. Method

This study uses systematic literature reviews by referring to the following phase: (1) establishing the review question (2) defining conclusion and exclusion criteria (3) articulating the search strategy (4) screening the article (5) reporting the result of search strategy (6) extracting relevant data (7) assessing the methodological quality (8) synthetizing (9) drawing conclusions [13]

## Research question

This study aims to answer question about what abilities in mathematics learning outcomes relate to student beliefs

* 1. *Data collection* 
     1. Database Searched Searching for research papers was conducted on the reputable database journals: Scopus, Sciencedirect, ERIC, focusing on the subject of mathematics education
     2. Search keyword The keywords used in the search for research papers on the online database are “student beliefs”, “mathematical beliefs”, and “beliefs relationship”
     3. Selection of papers Selected papers for further review must meet following criteria: : (1) Published between 2000-2020, (2) Articles contain empirical evidence about the relationship between beliefs and mathematics learning outcomes, (3) Research subjects are students both from elementary school to higher education.
  2. Data analysis
     1. Extraction of selected papers. 16 selected papers that meet the criteria in 2.2.3 were extracted by observing the following data: author, year of publication, data analysis, research subject, geographic origin data, and research results.
     2. Synthesis of results. The synthesis of the results was carried out by looking at the extraction results at 2.3.1. Data regarding the relationship between student beliefs and mathematics learning outcomes were grouped based on the cognitive and affective aspects

1. Results and Discussion

The result of searching for papers related to keywords as specified in 2.2.2 and meet the criteria for selecting papers can be shown in Table 1.

**Table 1.** Relevant search result paper

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Author (year publication)** | **Data analysis** | **Subject** | **Origin** |
| 1. | Szydlik (2000) [14] | Qualitative | Undergraduate mathematic student | US |
| 2. | Buehl & Alexander 2005 [10] | Qualitative | Undergraduate student | US |
| 3. | House (2009) [15] | Multiple regression | Grade 8 | US |
| 4. | Callejo & Villa (2009) [16] |  | 12-13 years old | Spain |
| 5. | Rastegar, Jahromi, Haghighi, &Akbari (2010) [17] | Path analysis | Undergraduate | Iran |
| 6. | Suthar, Tarmizi, Midi &Adam (2010) [18] | Logistic regression | Undergraduate mathematics student | Malaysia |
| 7. | Sangcap (2010) [19] | T test | Undergraduate student | Filipina |
| 8. | Jones, Wilkins, Long & Wang (2012) [20] | Path analysis | Ninth-grade students | US |
| 9. | Van Dooren, Chen & Verschaffel (2013) [21] | Pearson Correlation test | Fifth-grade student | China |
| 10. | Ozturk & Guven (2016) [6] |  | Ninth-grade students | Turkey |
| 11. | Stankov & Lee (2017) [22] | Correlation |  |  |
| 15. | Jäder, Sidenvall J & Sumpter (2017) [23] | Qualitative | Upper secondary school | Swedish |
| 16. | Henschel & Roick (2017) [12] | Multivariate regression | Fourth grade | German |
| 12. | Pitsia, Biggart, & Karakolidis (2017) [24] | Multilevel Analysis | 15 years old | Greek |
| 13. | Rincon,Fernández Cézar & Hernandez (2020) [25] | Correlation | 3th grade elementary student | Colombia |
| 14. | Usman, Bambang, Hasbi & Mardhiah (2020) [26] | Qualitative | Undergraduate mathematics student | Indonesia |

Selected papers that meet the criteria are then extracted by referring to 2.3.1. The extraction result data is processed and analyzed for further synthesis of the relationship between student beliefs and mathematics learning outcomes arranged based on cognitive and affective aspects. The results of the synthesis of the relationship between student beliefs and mathematics learning outcomes can be shown in Table 2.

**Table 2.** Result of relationship between beliefs and mathematics learning outcomes

|  |  |  |
| --- | --- | --- |
| **Aspect** | **Variable** | **Number of research** |
| Cognitive | Achievement | 7 |
|  | Problem solving | 4 |
|  | Conceptual understanding | 2 |
|  | Mathematics reasoning | 1 |
| Affective | Motivation | 1 |
|  | Math anxiety | 1 |

The table above shows that student beliefs have a close relationship with mathematics learning outcomes. Student beliefs are not only related to cognitive aspects but also the affective aspects

* 1. *Relationship between student beliefs and mathematics learning outcomes on cognitive aspect*

The results of the synthesis of research papers as Table 2 shows that student beliefs have a positive relationship on mathematics learning outcomes on cognitive aspects, which include learning achievement, problem-solving ability, conceptual understanding, and mathematics reasoning.

Student's self-beliefs have a relationship with students' learning achievement and mathematical abilities [22]. In line with this [18] also argues that students 'beliefs about the importance of mathematics lessons and beliefs towards mathematical abilities affect students' mathematical abilities. These two beliefs are entered into category beliefs, students about mathematics, and self-beliefs. The student who has positive beliefs about mathematics and mathematical abilities have higher learning achievement. On the other hand, students who express negative beliefs got a low grade in mathematics tests. Not only from the score of mathematical ability. Jones reveals the relation between beliefs and motivation in learning again its can affect student learning presences. From some of the statements above, it can be concluded that students' beliefs in mathematics and themselves as mathematicians have a positive relationship to learning achievement.

Beliefs also have a relationship with students' problem-solving abilities. [21] found that there are strong correlations between student beliefs and problem-solving abilities. Students' belief in mathematics influences how students perceive a problem and the problem-solving process. Both of these affect students' problem-solving abilities [16]. On the other hand, students 'beliefs in mathematics are also related to students' motivation in solving problems [19]. Students who believe that computational skill is the core of mathematics have less effort in solving a problem. These beliefs are negative mathematical beliefs. On the other hand, students who have positive beliefs, believe that problem-solving ability is the essence of mathematics to have more effort in solving a problem. Thus, can be concluded that beliefs have a positive relationship with their problem-solving ability. In addition to problem-solving, student beliefs also have a relationship with students' mathematical reasoning abilities. This ability is one of the abilities that students must master in the problem-solving process [27]. [23] revealed that student beliefs have a relationship with mathematical reasoning abilities in problem-solving. Students have a belief of expectation for the questions given. These expectations make students choose mathematical reasoning to use.

In the cognitive domain, students' beliefs towards mathematics also have a relationship with the ability to understand concepts. Students 'belief in mathematics influences students' understanding of these concepts. In [14], it is explained that students who have the belief that mathematics consists of concepts that must be memorized cannot explain the theory of a fact or procedure. It can be concluded that students with negative beliefs have less understanding of the concept. Conversely, students who believe that mathematics consists of logical and consistent statements can explain a concept well and avoid misconceptions. So it can be concluded that beliefs have a positive relationship with the ability to understand concepts.

* 1. *Relationship between student beliefs and mathematics learning outcomes on affective aspect*

The results of the synthesis of research papers as Table 2 shows that student beliefs have a positive and negative relationship on mathematics learning outcomes on affective aspects. Student beliefs have positive relationship with motivation. While student beliefs have a negative relationship with math anxiety.

Kloosterman in [1] explains that student beliefs affect students' motivation and interest in learning mathematics. In line with this [12] explain the relationship beliefs with students' learning motivation. Students who have better beliefs have higher motivation in learning mathematics. This shows that students' beliefs have a positive relationship with learning motivation. Another affective aspect that has a relationship with student beliefs is math anxiety. Math anxiety is a condition of feeling tension, respond negatively, and fear when asked to solve mathematical problems [28]. Students' beliefs about mathematics have a negative relationship with math anxiety. Based on [12] control belief has a strong negative correlation with affective math anxiety. This means that students who have good beliefs will have low math-anxiety levels. This appears as a result of his positive belief about mathematics.

From the results of the discussion above, the impact of discovery learning on students' mathematics learning outcomes can be mapped as shown in Figure 1

Student Beliefs

Beliefs about mathematics

Self Beliefs

Achievement

Problem solving

Conceptual understanding

Mathematical reasoning

Motivation

Math-anxiety

Cognitive

Affective

: Positive Relationship

: Negative Relationship

**Figure 1.** The relationship between student beliefs and mathematics learning outcomes

1. Conclusion

This study can be concluded that beliefs have a relationship with mathematics learning outcomes includes cognitive and affective aspects. To develop the student ability in mathematics teachers should develop positive beliefs. Also in this study, it was found that student beliefs have a positive relationship with achievement, problem-solving skill, conceptual understanding, mathematical reasoning, and motivation, its can conclude that positive beliefs can improve these abilities. Student beliefs also have a negative relationship with math-anxiety. It means that the math-anxiety level can be decreased by developing positive beliefs.

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