**The effect of math anxiety on students' mathematics performance with the mediating role of math self-efficacy**

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**ABSTRACT**

The mathematics performance of Indonesian students is low, and there are still many students who have not reached the minimum level. Many factors affect students' mathematics performance, including math anxiety and math self-efficacy. This study was conducted to determine whether there is a mediating role of math self-efficacy on the effect between math anxiety and math performance. This research is quantitative research with a mediated path analysis model. The subjects were 236 students at MTs Nurul Huda Sedati who were taken using a proportionate stratified random sampling technique. To measure math anxiety and math self-efficacy, each used adaptations of the Scale for Assessing Math Anxiety in Secondary School (SAMAS) and Alat Ukur Efikasi Matematika Indonesia (AUKEMI). And the original score of the final semester exam to measure mathematics performance. The results showed (1) there is no direct effect between math anxiety and mathematics performance; (2) math self-efficacy fully mediates the effect between math anxiety and mathematics performance; (3) math anxiety has a negative effect on math self-efficacy. Thus, to improve mathematics performance will be more effective to focus on improving students' math self-efficacy.

**Keywords**: Math anxiety; math self-efficacy; mathematics performance.

**Introduction**

Based on the results of the PISA (Programme for International Students Assessment), Indonesian students obtained an average knowledge and proficiency score in mathematics of 386 from the average PISA mathematics score in 2015 of 490 (OECD, 2016), and decreased in PISA 2018 by obtaining a score of 379 from the average PISA math score of 489 (Schleicher, 2019). Additionally, the 2018 PISA results showed that only 28% of Indonesian students scored level 2 (minimum level) or above and only 1% of students scored level 5 or above in math (Avvisati et al., 2019). These results can be concluded that the mathematics performance of Indonesian students is low and there are still many students who have not reached the minimum level.

Similar conditions also occurred in one of the junior high schools, MTs Nurul Huda Sedati. From the results of the Computer-Based National Assessment in 2021, The school obtained a score of 1.82 in the field of numeracy, from the minimum competency with a range of 1.80 – 2.09. These results show that students' numeracy skills are still lacking even though they have reached the minimum competency, and only 40% of students have achieved basic competencies. While there are 2.52% of students who are under the basic competencies and require special handling.

The condition of students' low mathematics performance is cause for concern. Because mathematics is one of the most important sciences which supports various aspects of life (e.g., being part of the skill development required in the current modern society), and has a connection with various other disciplines (Julie et al., 2017; Rizki & Priatna, 2019; Sumiati & Agustini, 2020). Therefore, it is necessary to find out what factors play the most role in influencing students' mathematics performance, so it can be used as a basis for reference in finding the right solution to improve students' low mathematics performance.

Several factors are often mentioned in influencing students' mathematics performance. Prior research states that Math anxiety is negatively correlated with students' mathematics performance. (Finell et al., 2022; Luttenberger et al., 2018; J. Zhang et al., 2019). Whereas in other studies, it was mentioned that math self-efficacy also influences students' mathematics performance (Ozkal, 2019; Schöber et al., 2018).

Furthermore, previous research has found a reciprocal relationship between math anxiety and math self-efficacy (Chandra & Royanto, 2019; Du et al., 2021; Macmull & Ashkenazi, 2019). Additionally, Chandra & Royanto (2019) mentioned that math self-efficacy and math anxiety equally influence students' mathematics performance, although in that study math self-efficacy had a more significant effect on math performance (0.599; p<0.01) than math anxiety (-0.237; p<0.01). These results may indicate that there is a possibility that math self-efficacy mediates the relationship between math anxiety and mathematics performance, such as the research of D. Zhang & Wang (2020) which shows that math self-efficacy plays an important role in mediating the positive relationship between mathematics interest and mathematics achievement.

However, many studies have explained the relationship between math anxiety, math self-efficacy, and mathematics performance. But, a research model that examines the role of math self-efficacy as a mediator in the relationship between math anxiety and math performance is yet to be found. Hence, this study was conducted to examine whether math self-efficacy mediates the relationship between math anxiety and students' mathematics performance.

**Literature Review**

**Mathematics Performance**

Many studies examine math performance (i.e. Chandra & Royanto, 2019; Finell et al., 2022; Ozkal, 2019; J. Zhang et al., 2019). Unfortunately, there are no studies that clearly explain what mathematics performance is. Therefore, in this study mathematics performance is defined based on the definition of mathematics ability which refers to the ability to use numbers (i.e. basic number representation, simple arithmetic, and operations skills) and solve mathematical problems (i.e. find the solutions or strategy from an abstract representation of mathematical relations in context-rich problem) (Muncer et al., 2022). According to Liviananda & Ekawati (2019), mathematics performance can be defined as the capability that students have in the fields of knowledge, skills, and attitudes that are reflected in their habits of thinking and how they solve mathematical problems. Thus, mathematics performance can be defined as the student's ability to learn and do or solve problems in math.

**Math anxiety and mathematics performance**

Mathematics is often considered a difficult subject by most students. The results of the PISA study in 2012 reported that 59% of students often worried that math lessons would be difficult for them, 33% stated that they felt very tense when they had to complete math homework, and another 31% stated that they felt nervous when solving math problems (Luttenberger et al., 2018; OECD, 2013). The circumstances when individuals feel anxious, tense, and fearful when dealing with math tasks are defined as math anxiety. (Ashcraft, 2002; Chandra & Royanto, 2019). Math anxiety is also defined as an intense and negative fear and emotional response to math (Mutlu, 2019; Sherard, 1981).

Math anxiety is often considered a problem among students (Hadi et al., 2020). People who experience math anxiety will be difficult to absorb information and learn concepts, affecting the quality of learning, and learning outcomes are not optimal, so it will reduce student mathematics achievement (Berliana & Adirakasiwi, 2021). A meta-analysis of 49 research articles identified a strong negative relationship between math anxiety and math performance. (J. Zhang et al., 2019). Moreover, math anxiety showed a negative relationship with students' numeracy skills (Commodari & La Rosa, 2021), and have a long-lasting effect on learning, which makes them susceptible to a variety of harmful learning behaviors that can hinder student performance (Luttenberger et al., 2018; Mazana et al., 2019).

**Math self-efficacy and mathematics performance**

Academic achievement is often linked to self-confidence, and one of the most important aspects of self-confidence is self-efficacy (Rusyda et al., 2020; Schöber et al., 2018). Self-efficacy refers to a consideration of how much a person believes about his ability or competence in carrying out several learning activities and his ability to complete learning tasks (Ardiansyah, 2018; Somawati, 2018). Whereas Math self-efficacy is defined as a student's belief or self-assessment of their ability to solve a particular mathematical problem and tasks related to mathematics. (Masitoh & Fitriyani, 2018).

Schöber et al. (2018) found that there is a positive reciprocal effect between math self-efficacy and math and reading achievement. Students who have higher math self-efficacy tend to perform well on math achievement tests (Xu & Jang, 2017). Additionally, students who have high math self-efficacy can obtain better math performance (Ozkal, 2019), and can make students more motivated during the learning process (Masitoh & Fitriyani, 2018). Thus, if students have high math self-efficacy, their math performance will also improve and ultimately make their math achievement better.

**Math anxiety and math-self efficacy**

Students' feelings of efficacy play an important role in generating anxiety in students (Bandura et al., 1999; D. Zhang & Wang, 2020). The more an individual feels unsure of their abilities, the more anxious they will feel (Fitriyani & Miatun, 2022; Sujarwo, 2014). Previous research found that high math anxiety can cause low math self-efficacy and vice versa (Du et al., 2021; Macmull & Ashkenazi, 2019).

Thomaes et al. (2020) stated that when students who have negative beliefs about their competence experience difficulties in solving math problems, they tend to be anticipatory and worry about failure. So, it can trigger them to disengage from the task and ultimately reduce their mathematics performance.

**Method**

This research is a quantitative study with math anxiety as the independent variable, math self-efficacy as the mediator variable, and math performance as the dependent variable, with the research design shown in Figure 1. The population in this study were all students at MTs Nurul Huda Sedati with a total of 358. The sample size of 236 participants were determined based on the Isaac and Michael table with an error rate of 1% (Sugiyono, 2022). Of the 236 participants, 55.1% were male and 44.9% were female. The age range of participants is between 12 - 15 years old.

**Figure 1**

Study Design

**Math Self-Efficacy**

**Math Anxiety**

**Mathematics Performance**

a

b

c

Independent Variable

Dependent Variable

Mediator Variable

This research uses a proportionate stratified random sampling technique, by dividing the population into three strata based on grade level (i.e. grade 7, 8, and 9) with details in Table 1. Then take a random sample in each stratum based on a predetermined percentage with a balanced proportion. Data collection was conducted by distributing the research information along with a link to the online questionnaire for the participants to fill out.

**Table 1**

Distribution of Participants in Each Class

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Class** | **Number of Participants** | **Percentages** |
| 1 | 7 | 61 | 26% |
| 2 | 8 | 79 | 33% |
| 3 | 9 | 96 | 41% |
|  | Total | 236 | 100% |

The measurements in this study were a series of questionnaires consisting of two types of scales. The measurement tool for math anxiety is adapted from the Scale for Assessing Math Anxiety in Secondary Education (SAMAS) (Yáñez-Marquina & Villardón-Gallego, 2017). then translated into Indonesian through a process of review and translation by 3 experts. SAMAS consists of 20 items in three dimensions, namely everyday life's math anxiety (e.g. “I get nervous when calculating the total price of what I bought”), math learning anxiety (e.g. “I get nervous at the thought of having to study again math next year”), and math test anxiety (e.g. “I got nervous the previous day of a math test”). With a continuous response scale ranging from 0 (Strongly disagree) to 10 (Strongly Agree). The internal consistency in everyday life's math anxiety factors of α = 0.83, math learning anxiety of α = 0.86, and math test anxiety of α = 0.84 (Yáñez-Marquina & Villardón-Gallego, 2017). The reliability test on the SAMAS scale after being administered to the subject, showed a reliability result of α = 0.897. The results of confirmatory factor analyses (CFA) using the DWLS estimator are presented in Table 2, showing that the three dimensions have met the suitability index standards.

The measurement tool for math self-efficacy uses Alat Ukur Efikasi Matematika Indonesia (AUKEMI) (Mubarrak et al., 2022). AUKEMI consists of 23 items which consist of four dimensions, namely positive views (e.g. “I am confident about my answers when calculating math problems”), negative affect (e.g. “I feel math is a terrifying subject”), math application (e.g. “I am able to calculate and manage the money that I use daily”), and out-of-class learning (e.g. “I have an extra time to study outside of class to learn math”). With a range of answer options ranging from 1 (Strongly Disagree), 2 (Disagree), 3 (Neutral), 4 (Agree), and 5 (Strongly Agree). Whereas all items in the negative affect dimension are unfavorable items, so the calculation of the score is reversed. The reliability of AUKEMI on positive view was 0.92, the negative effect was 0.83, the math application was 0.79, and learning out of class was 0.72, and the overall reliability was 0.918 (Mubarrak et al., 2022). The reliability test of the AUKEMI scale after being administered to the subject, showed a Cronbach's alpha reliability result of α = 0.850. The CFA results with the ML estimator are presented in Table 3, showing that the four dimensions have met the suitability index standard.

**Table 2**

CFA Model Fit Index Test on SAMAS

|  |  |  |  |
| --- | --- | --- | --- |
| **Fit Indices** | **Indices Value** | **Standard Value** | **Description** |
| χ2 | 157.541 (*df* = 167; p = 0.688) | p > 0.05 | Model Fit |
| SRMR | 0.062 | < 0.08 | Model Fit |
| TLI | 1.003 | > 0.90 | Model Fit |
| CFI | 1.000 | > 0.90 | Model Fit |
| RMSEA | 0.000 | < 0.07 | - |

**Table 3**

CFA Model Fit Index Test on AUKEMI

|  |  |  |  |
| --- | --- | --- | --- |
| **Fit Indices** | **Indices Value** | **Standard Value** | **Description** |
| χ2 | p < .001 | p < .001 | - |
| SRMR | 0.047 | < 0.08 | Model Fit |
| TLI | 0.907 | > 0.90 | Model Fit |
| CFI | 0.918 | > 0.90 | Model Fit |
| RMSEA | 0.064 | < 0.07 | Model Fit |

*Source.* Mubarrak et al. (2022)

Meanwhile, mathematics performance is measured based on the original mathematics score on the Odd Semester Final Examination which is compiled based on the applicable curriculum at school and has been given to each student according to grade level. The score data is obtained from the original document of the odd semester final exam results in mathematics which have been obtained by researchers from the school administration.

The data analysis in this study used a mediated path analysis model by using JASP 0.14.1.0 software to see the direct effect (i.e. the relationship between math anxiety and math performance). And the indirect effect (i.e. the mediating role of math self-efficacy on the relationship between math anxiety and math performance).

**Result**

**Descriptive Statistics Analysis**

The results of descriptive statistical analysis in Table 4 showed an average math anxiety score of 66,153 (SD = 11,087), math self-efficacy of 102,644 (SD = 33,530), and mathematical performance of 34,936 (SD = 13,404), so the data showed heterogeneous traits.

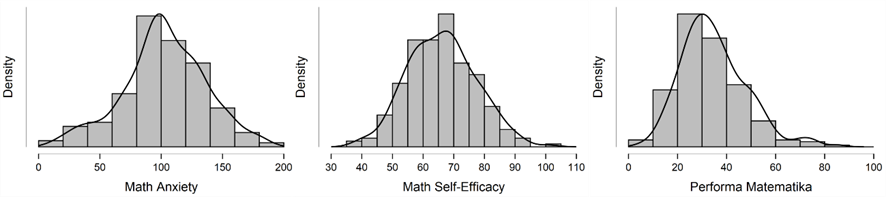
**Table 4**

Descriptive Statistics Analysis

|  | | | |
| --- | --- | --- | --- |
|  | **Math Anxiety** | **Math Self-Efficacy** | **Mathematics Performance** |
| Valid | 236 | 236 | 236 |
| Missing | 0 | 0 | 0 |
| Mean | 102.644 | 66.153 | 34.936 |
| Std. Deviation | 33.530 | 11.087 | 13.404 |
| Variance | 1124.239 | 122.913 | 179.677 |
| Minimum | 13.000 | 38.000 | 5.000 |
| Maximum | 184.000 | 101.000 | 85.000 |
|  | | | |

The normality test is determined based on the distribution plot diagram displayed on each variable. Based on the output display in Figure 2, it shows that the data distribution on the math anxiety and math self-efficacy variables, shows a bell-shaped data distribution pattern, so the data distribution is considered normally distributed. While in the math performance variable, the data distribution pattern in Figure 2 shows a distribution pattern that deviates to the left, although the data distribution pattern is still shaped like a bell, so the data on the math performance variable is interpreted as normally distributed data.

**Figure 2**

Distribution Plot Diagram of Math Anxiety, Math Self-Efficacy, and Mathematics Performance Variables

**Correlation Test**

The correlation test results in Table 5 show that no relationship existed between math anxiety and math performance (p=0.052). While the relationship between math anxiety and math self-efficacy shows a significant relationship (p<.001), with a negative degree of relationship. This study also shows a positive and significant relationship between math self-efficacy and math performance (p=0.007).

**Table 5**

Correlations Test

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pearson's Correlations** | | | | |
| **Variable** |  | **Math Self-Efficacy** | **Math Anxiety** | **Mathematics Performance** |
| 1. Math Self-Efficacy | Pearson's r | — |  |  |
|  | p-value | — |  |  |
| 2. Math Anxiety | Pearson's r | -0.437 | — |  |
|  | p-value | < .001 | — |  |
| 3. Mathematics Performance | Pearson's r | 0.175 | -0.127 | — |
|  | p-value | 0.007 | 0.052 | — |
|  | | | | |

**Mediation Path Analysis**

In this study, mediation path analysis was conducted to see the direct effect between math anxiety and math performance, and the indirect effect between math anxiety and math performance with math self-efficacy as the mediator variable. Then the total effect estimates the direct effect and indirect effect. The results of the analysis that examined the direct effect between math anxiety and math performance in Table 6, showed a z-value = 0.873 and p = 0.382 (p>0.05), indicating that there is no direct effect between math anxiety and math performance.

**Table 6**

Direct Effects

|  | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | |  | **95% Confidence Interval** | |
|  |  |  | **Estimate** | **Std. Error** | **z-value** | **p** | **Lower** | **Upper** |
| Math Anxiety | → | Mathematics  Performance | -0.002 | 0.002 | -0.873 | 0.382 | -0.006 | 0.002 |
|  | | | | | | | | |
| *Note.*  Delta method standard errors, normal theory confidence intervals, ML estimator. | | | | | | | | |

Meanwhile, the results that examined the indirect influence between the math anxiety variable and the math performance variable with the math self-efficacy variable as a mediator in Table 7, showed z-value = -2.006 and p = 0.045 (p < 0.05). These results indicate that there is a significant indirect influence between math anxiety and math performance when the math self-efficacy variable is included as a mediator variable.

**Table 7**

Indirect Effects

|  | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | | | **95% Confidence Interval** | |
|  |  | | |  | **Estimate** | **Std. Error** | **z-value** | **p** | **Lower** | **Upper** |
| Math Anxiety | → | Math Self-Efficacy | → | Mathematics Performance | -0.002 | 9.625e -4 | -2.006 | 0.045 | -0.004 | -4.443e -5 |
|  | | | | | | | | | | |
| *Note.*  Delta method standard errors, normal theory confidence intervals, ML estimator. | | | | | | | | | | |

While in the results of the total influence that can be seen in Table 8, the value of z-value = -1965 and p = 0.049 (p < 0.05). These results indicate that there is a mediating role for math self-efficacy variables in the relationship between math anxiety and math performance.

**Table 8**

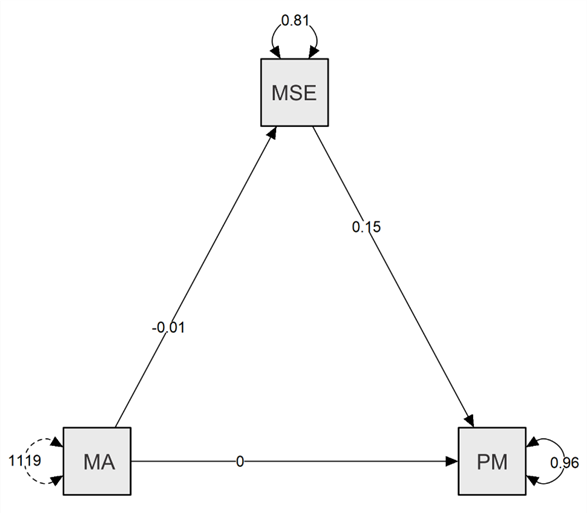
Total Effects

|  | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | **95% Confidence Interval** | |
|  |  |  | **Estimate** | **Std. Error** | **z-value** | **p** | **Lower** | **Upper** |
| Math Anxiety | → | Mathematics Performance | -0.004 | 0.002 | -1.965 | 0.049 | -0.008 | -9.610e -6 |
|  | | | | | | | | |
| *Note.*  Delta method standard errors, normal theory confidence intervals, ML estimator. | | | | | | | | |

Similarly, the results revealed that there was a negative influence between math anxiety and math self-efficacy (β = -0.01), and math self-efficacy also had a positive effect on math achievement (β = 0.15). However, there was no effect between math anxiety and math achievement (β = 0) which can be seen in Figure 3. These results indicate that math self-efficacy fully mediates the effect between math anxiety and math performance.

**Figure 3**

Model Plot



*Description.* MA = Math Anxiety; MSE = Math Self-Efficacy; PM = Mathematics Performance

**Discussion**

**The effect between math anxiety and mathematics performance**

The present study contributes to the previous literature by validating a theoretical model of the effect between math anxiety and students' mathematics performance. This study found that there was no direct relationship or influence between math anxiety and students' mathematical performance. The result is contrary to the prior studies which stated that there is a relationship between math anxiety and math performance (Berliana & Adirakasiwi, 2021; Commodari & La Rosa, 2021; Finell et al., 2022; J. Zhang et al., 2019). In other words, high or low math anxiety in students does not affect their math performance. This result also refutes the results of previous meta-analysis on the relationship between math anxiety and math performance which states that the negative effect between math anxiety and math performance increases in the middle school period. (J. Zhang et al., 2019).

The lack of relationship between math anxiety and math performance may be due to the fact that students who have entered adolescence are more focused on social issues, such as exploring various roles to build an identity or finding their identity to fit the perspective of their peers. Thus, anxiety at this time is more focused on social relationship issues than on issues related to academic performance (Chandra & Royanto, 2019).

**The effect between math anxiety and math self-efficacy**

This study has relevance to previous research which states that there is a significant relationship between math anxiety and math self-efficacy (Du et al., 2021; Macmull & Ashkenazi, 2019). This means that the more anxious students are when dealing with math, the less confidence they have in their ability to solve math problems.

Thomaes et al. (2020) state that when students with negative competence beliefs work on mathematics problems, they are prone to anticipate and worry about failure. Thus, it can trigger them to disengage from the task and ultimately reduce their math performance.

Additionally, Fitriyani & Miatun (2022) stated that when students who have high self-confidence in mathematics cannot do math problems, which makes them feel anxious about mathematics, they will try to find ways to make the anxiety disappear.

**The effect between math self-efficacy and mathematics performance**

Meanwhile, this finding also shows that there is a significant effect between math self-efficacy and students' mathematics performance. Therefore, every increase in math self-efficacy is accompanied by an increase in math performance. The results support the previous research which also states that there is a relationship between math self-efficacy and students' mathematics performance (Chandra & Royanto, 2019; Ozkal, 2019; Schöber et al., 2018). Additionally, students who have higher math self-efficacy tend to perform well on math achievement tests (Xu & Jang, 2017). And when students' math performance has increased, it can make students able to do learning activities or academic tasks smoothly, thus making students more motivated in the learning process and eventually can get better mathematics achievement (Masitoh & Fitriyani, 2018; Ozkal, 2019; Somawati, 2018).

**Math self-efficacy as a mediator**

The mediation analysis in this study shows that math self-efficacy fully mediates the effect between math anxiety and math performance, which means that the effect between math anxiety and math performance is always mediated by math self-efficacy. In other words, it shows that any increase in math anxiety in students cannot explain the effect on students' math performance. However, when mediated by math self-efficacy, making any increase in math anxiety can explain the effect on math performance. These results support the results of previous studies on the relationship between math interest and math achievement, which show the important role of math self-efficacy in mediating the positive relationship between math interest and math performance (D. Zhang & Wang, 2020). Additionally, the research of Finell et al. (2022) found that there is a significant indirect effect of math anxiety on mathematics performance when adding working memory as a mediator variable.

Therefore, from the results of the study, an effective intervention in improving students' low math performance is by providing interventions that focus more on increasing math self-efficacy, rather than doing interventions that focus on math anxiety. One of the approaches that can be done to improve students' math self-efficacy is problem-based learning or brain-based learning approach. (Masitoh & Fitriyani, 2018; Negara et al., 2022; Rusyda et al., 2020).

**Limitation**

The study had some limitations. First, data collection is carried out quantitatively through self-report scales which tend to be influenced by social desirability bias, so the data obtained is not deep and complex enough, especially to measure math anxiety can be obtained through observation. Second, the participants were limited to one school population, so these results may differ if conducted in a population with different characteristics or with a more varied sample (J. Zhang et al., 2019).

Third, the studied independent and moderator variable in this research (i.e. math anxiety and math self-efficacy) are both included in the internal factors that can affect math performance, So this research is limited to the internal factors that affect math performance. Therefore, perhaps future research can explore the dynamics of the relationship between variables that become external factors in influencing students' mathematics performance, such as parental and teachers' social support (Fane & Sugito, 2019; Putrie & Fauzia, 2019; Uran et al., 2019).

**Conclusion**

The results of this study show that math anxiety has no relationship with students' mathematics performance. Furthermore, there is a significant negative relationship between math anxiety and math self-efficacy. And there is a significant positive relationship between math self-efficacy and math achievement. The results also show whether there is a fully mediating role of math self-efficacy on the influence between math anxiety and mathematics performance. Where any increase in math self-efficacy can reduce students' math anxiety and make students' mathematics performance increase.

Therefore, to improve students' mathematics performance, it can be effectively done by conducting interventions that focus on increasing students' mathematics self-efficacy, such as conducting problem-based learning or conducting mathematics learning with a brain-based learning approach.

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