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The effect of mathematical belief, self-regulated learning, and self-efficacy on the mathematics learning achievement among secondary school students

Naufal Rizqullah, Syamsuri*, Anwar Mutaqin

Department of Mathematics Education, Universitas Sultan Ageng Tirtayasa, Serang 42163, Indonesia

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Abstract

This study aims to measure the effect of mathematical beliefs, self-regulated learning, self-efficacy on learning achievement in mathematics. Using a survey as a research method, it was conducted in public and private secondary schools in Serang City. In this study, the population referred to all secondary school students in Serang City, Banten Province, Indonesia in which 394 students were involved as the sample. The sampling was carried out through several stages, started from the selection of schools based on their accreditation using quota sampling. Furthermore, using cluster sampling, classes were selected from each school accreditation. The instruments used in this study were questionnaires about mathematical beliefs, self-regulated learning and self-efficacy, and a list of final semester exam scores for the 2023-2024 academic year. The data collected were then analyzed using a partial least square - structural equation model (PLS-SEM) approach. The results of this study showed that a structural equation model described the effect of mathematical beliefs, self-regulated learning, self-efficacy on mathematics learning achievement. The goodness of fit test showed that the model was classified as appropriate. The model also showed a relatively significant effect of the variables of self-efficacy and self-regulated learning on mathematics learning achievement.

Keywords: Mathematics beliefs; self-regulated learning; self-efficacy; mathematics learning achievement; structural equation model

1. Introduction

Education is an vital part of human life. Its development is critical for the growth and development of a country. In Indonesia, education excellence has been being improved as an effort to develop the learning quality at certain educational levels enabling this country to grow in a better direction. Currently, the education phenomenon in Indonesia is in the development stage, thereby necessitating a learning improvement. Apart from that, education aims to produce the next generation that integrates intellectual, religious, social ethics, and national personality values.

Improving human resources for the future is deemed critical. At this point, secondary school education as formal education at the secondary level becomes the basis for upper secondary and tertiary education. Education is a conscious effort to foster high-quality human resources that are capable of using and developing science and technology. Likewise, the aim of national education is to educate the nation's life in accordance with the science development.

Learning achievement is one indicator of attaining national education goals. In a learning process, it reflects the evidence of success achieved at school not only limited to cognitive aspects but also including psychomotor and affective aspects. Student achievement habitually is assessed in these three domains, which refer to the student's overall learning achievement. King (2015) concluded that behavioral and emotional engagement are positively related to learning achievement. Pietarinen et al (2014) , meanwhile, stated that students' learning achievement and cognitive influence are positively correlated.

Slameto (2010) stated that learning achievement is a individual's effort to change his/her overall behavior in view of his/her own experiences with his/her environment. Meanwhile, Azwar (1999) said that learning achievement or success can be measured through report cards, study achievement index, graduation rate, or success predicate. Clemons (2008) viewed learning achievement as the result of a complex relationship between personal abilities, self-view, assessment of tasks, expectations of achievement, thinking and self-regulation strategies, gender factors, parenting methods, socioeconomic conditions, performance and individual attitudes towards educational process. This means that there are a number of factors determining student learning achievement, which then create differences in the achievement of everyone.

As a part of general subjects, mathematics learning achievement is deemed important for every individual. Efforts to understand and master mathematics will determine mathematics learning achievement. This subject is not limited to certain learning since every student should have an ability to think mathematically.

* Corresponding author.
Email: syamsuri@untirta.ac.id
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In addition, a few students perceive mathematics lessons as difficult, boring and less interesting due to their low mathematical beliefs (Imran et al., 2019). Those with a positive learning attitude towards a subject are a good start to the learning process; conversely, a negative perspective towards subjects can lead to challenges in learning or result in less than ideal outcomes in education (Permatasari et al., 2023). Research by Corte et al., (2008) on mathematical beliefs found evidence regarding a role and function of teachers in determining students' mathematical beliefs. Students who have beliefs about the significance of mathematics will have strong motivation in learning. Mathematical beliefs are also formed from students' mathematical experiences at previous levels that can be in the form of the learning model applied or the mathematics books used. From these experiences, beliefs will be formed in students.

Another factor presumedly determining mathematics learning achievement is self-efficacy. As stated by Bandura (1998), self-efficacy is an individual's assessment of his/her ability to carry out a task at hand and it plays a role in generating mathematical beliefs. In addition, Zimmerman (2010) argued that students with high self-efficacy are able to produce better achievements and self-confidence, motivate themselves in carrying out tasks, control their emotions and manage their abilities well. While, those who have low self-efficacy will lack self-confidence and motivation in doing assignments, and are unable to control their emotions and manage their abilities well.

Moreover, Maulani et al. (2020) in their research entitled the contribution of self-efficacy to mathematics learning achievement in high school students found that self-efficacy had a positive effect on increasing mathematics learning achievement. Another research by Indirwan et al. (2021) showed that self-efficacy had a significant effect on students' mathematics learning achievement. Students with high self-efficacy are those that have high commitment, put in a lot of effort, never give up, are optimistic, accept difficult tasks, and are more willing to take risks. Vice versa, students with low learning achievement in mathematics are those with low confidence in their abilities.

A high learning achievement not only depends on the high level of self-efficacy, but also requires the application of effective learning strategies in understanding learning materials. The process of self-control in a learning context, including setting learning goals and choosing the strategies to use, is often called as self-regulated learning or independence in learning.

Barry J. Zimmerman & Martinez-Pons (1990) defined self-regulated learning as the degree to which participants actively involve metacognition, motivation, and behavior in the learning process. It is also defined as a condition of independent learning activities that do not always involve asking other people, who are responsible for the decisions the students themselves make. Self-regulated learning will be realized if students actively control everything they do, evaluate and plan something deeper in the learning they are going through and participate actively in the process (Juli et al., 2021). There are several indicators used to measure self-regulated learning, including, (1) learning initiative; (2) diagnosing the learning needs; (3) setting the learning targets and objectives; (4) monitoring, organizing and controlling the learning progress; (5) viewing difficulties as challenges; (6) utilizing and searching for relevant sources; (7) selecting and implementing learning strategies (8) evaluating learning processes and outcomes and; (9) having a self-concept (Sumarmo, 2004).

Self-regulated learning is crucial for students' future progress, especially when it comes to mathematics as it allows students to organize and discipline themselves. When the students have responsibility for their learning, they will be more active, creative, and confident in their own abilities. This explains that the better a student's self-regulated learning, the better the achievement results to be achieved. This is shown in research by Hidayat (2019) showing that independence had a significant effect on mathematics learning achievement.

This research was designed to investigate the role of a student's personal variables on mathematics learning achievement. To achieve this, three independent variables: mathematics beliefs, self-efficacy and self-regulated learning were measured and analyzed using a structural equation model to confirm the model related to theoretical principles in mathematics education aimed at determining the magnitude of the direct and indirect effect of mathematical beliefs, self-regulated learning, and self-efficacy for mathematics learning achievement.

2. Methodology

2.1. Data collection sources and techniques

Data were collected by authors by giving instruments to students as the research samples. It was carried out in several stages according to the research plan and schedule according to the time agreed between the authors and the school.

2.2. Population and sample

The population of this research referred to all students in class VIII of public and private secondary schools in Serang City in the period of 2023-2024 academic year. Based on data obtained from basic education data for 2023, there were 84 public and private junior high schools in Serang City, each of which had 27,389 students. The population was grouped based on accreditation A, B, and C and sampling was carried out using the Slovin formula with margin error 5%. The results obtained stated a sample of 394 students to be tested. Subsequently, by using random sampling according to strata, a sample of schools was obtained, namely SMP Negeri 2 Serang City, SMP Islam Al-Azhar 11 City Serang, SMP Negeri 15 Serang City, SMPIT Bina Bangsa, and SMP Ihsaniyah. Furthermore, the proportionate stratified random sampling technique was used to determine the number of samples required from each school based upon the proportions of each stratum.

Thus, the number of samples obtained from each school selected from class VIII included 175 students from SMP Negeri 2 Serang City, 49 students from SMPI Al Azhar 11 City of Serang, 146 students from SMP Negeri 15 Serang City, 11 students from SMPIT Bina Bangsa, and 13 students from SMP Ihsaniyah.

2.3. Statement items, scales, and scores

This research involved four variables: mathematics confidence, self-regulated learning, self-efficacy and mathematics learning achievement. To measure mathematics confidence, self-regulated learning and self-efficacy, a measuring instrument was used in the form of a statement of each indicator for each variable submitted to respondents via a rating scale. In this study, statements used were analyzed quantitatively using a Likert scale. Also, the data collection technique involved a list of odd semester final exam scores for the 2023-2024 academic year to measure secondary school students' mathematics learning achievement.

2.4. Classification and operational definition of variables

The variables in this research were classified into exogenous and endogenous variables. The exogenous variables referred to mathematics beliefs (X_1), self-regulated learning (X_2) and self-efficacy (X_3). Meanwhile, the endogenous variable in this research referred to mathematics learning achievement (Y).

Mathematics beliefs (X_1) referred to the nature of students' self-confidence in various mathematics learning processes. In this research, the indicators of mathematics beliefs included four aspects: beliefs about mathematics, beliefs about oneself in mathematics, beliefs about teaching and learning mathematics, and beliefs about the usefulness of mathematics. Self-regulated learning (X_2) referred to a student's awareness activity to learn without coercion from the surrounding environment to realize responsibility as a student in facing learning difficulties. Several indicators used to measure self-regulated learning, including 1) learning initiative, 2) diagnosing learning needs, 3) setting learning targets and goals, 4) monitoring, organizing and controlling learning progress, 5) viewing difficulties as challenges, 6) utilizing and searching for relevant sources, 7) selecting and implementing learning strategies, 8) evaluating learning processes and outcomes and 9) having a self-concept. Self-efficacy (X_3) referred to a person's belief about his/her ability to produce a certain level of performance affecting events in their life. In this research, self-efficacy indicators included three aspects: (1) *Magnitude* or level of task difficulty; (2) *Generality* or generality, closely related to the broad field of behavior where someone feels confident in his/her abilities based on previous experience; and (3) *Strength*, related to a person's confidence about the extent to which he/she believes that he/she will be capable of carrying the duties at best. Mathematics learning achievement (Y) referred to the result of learning activities to achieve the aspects of students' knowledge, skills and attitudes. In this study, researchers observed the student's achievement through final semester examination scores.

2.5. Data analysis technique

Research data were analyzed using descriptive and inferential statistical technique. Descriptive statistics aimed to provide a natural description of sample data from research variables in the form of mean, median, mode, standard deviation, variance, range, minimum, maximum, and percentage analysis. Inferential statistics, meanwhile, aimed to analyze and validate both the proposed models and hypothesis tests. Furthermore, the data analysis applied the PLS-SEM approach.

3. Results and Discussion

The results of the research showed that the mathematics confidence of class VIII students at public and private secondary schools in Serang City was in the medium category with an average of 95.9. While, the self-regulated learning of class VIII students at public and private secondary schools in Serang City was in the medium category with an average of 107.22. Furthermore, the self-efficacy of class VIII students at public and private secondary schools in Serang City was in the medium category with an average of 80. Meanwhile, the mathematics learning achievement of class VIII students at public and private secondary schools in Serang City was in the medium category with an average of 80.17.

Table 1. Results of descriptive analysis of each variable

Statistics	MB (X_1)	SRL (X_2)	SE (X_3)	MLA (Y)
Average	95.9	107.22	80	80.17
Maximum	130	140	113	93
Minimum	59	65	38	60
Standard deviation	12.8	13	12.55	4.456
Variance	164	168.9	157.4	19.86
Median	96	106	79	79

Table 2. Category percentage

Latent variable	MB (X_1)	SRL (X_2)	SE (X_3)	MLA (Y)
High	19%	25.57%	23.1%	26%
Moderate	66%	66%	69.3%	72%
Low	14.7%	8.1%	7.6%	2%

Convergent validity aims to determine which constructs should be highly correlated. The indicator validity test can be measured by looking at the loading factor value for each construct indicator. To declare the convergent validity, the loading factor is greater than or equal to 0.7 value. If it is invalid, the indicator will be discarded (dropped) in the next analysis (Haryono, 2016). Subsequently, construct reliability testing was carried out using composite reliability and Cronbach's alpha. In the interpretation of Composite Reliability (CR), the limit value greater than or equal to 0.7 is acceptable, and the value greater than or equal to 0.8 is very satisfactory (Haryono, 2016).

As shown in Table 3, the Cronbach's alpha value for all variables was greater than 0.7 and the composite reliability value for all variables was greater than 0.7. Besides, AVE was greater than or equal to 0.5 showing good convergent validity. The AVE values also surpassed the minimum criterion of 0.50, confirming convergent validity with SE showing the highest AVE (0.768), followed by SRL (0.659) and MB (0.657). These findings supported the conclusion that the measurement model exhibited strong reliability and adequate convergent validity.

Discriminant validity test aims to prove whether the indicators in a construct will have the largest loading factor on

a construct formed from loading factors with other constructs. This can be figured out through the Forner-Lacker criterion value or cross loading (Haryono, 2016) as also done in this study.

Table 3. Construct reliability

Variable	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	AVE
MB (X_1)	0.740	0.744	0.852	0.657
SRL (X_2)	0.741	0.752	0.852	0.659
SE (X_3)	0.849	0.849	0.908	0.768

Table 4. Discriminant validity of the Forner-Lacker criterion value

Variable	SE (X_3)	LI (X_2)	MB (X_1)	MLA (Y)
SE	0.876			
SRL	0.631	0.812		
MB	0.664	0.554	0.811	
MLA	0.378	0.338	0.282	1.000

As shown in Table 4, it was determined that discriminant validity was satisfactory since the correlation among variables within each latent construct in this research was greater than the correlation among other variables. The square root of AVE for SE (0.876), SRL (0.812), and MB (0.811) was higher than their respective inter-construct correlations. Therefore, there was no issue with multicollinearity among the latent variables. These results confirmed that all latent constructs demonstrated adequate discriminant validity.

Collinearity assessment in the structural model has a similar concept as the formative measurement model, that is by considering the VIF value. The VIF value must be less than 5. This suggests that the model displays no signs of multicollinearity among the predictors for any of the responses, allowing for testing to proceed to the next phase (Hair et al., 2021).

Table 5. Collinearity assessment VIF

Latent variable	SE (X_3)	MLA (Y)
SE (X_3)		2.192
SRL (X_2)	1.436	1.763
MB (X_1)	1.436	1.881

As presented in Table 5, the VIF values for each construct variable were below 5.0. The calculation of the VIF values indicated that none of the variables exhibited the signs of multicollinearity, allowing them to be used in the subsequent analysis.

Table 6 shows R-Square value endogenous variables that can be explained by exogenous variables.

Additionally, the data used in SmartPLS analysis has no a need to follow a normal distribution since SmartPLS employs the bootstrapping or random doubling technique. As a result, the assumption of normality does not pose an issue for PLS (Harahap, 2020). Bootstrapping aims to evaluate the coefficients of the structural model that are utilized to test hypotheses by determining which relationships have a significant impact.

Table 6. R-Square

Latent variables	R-square	R-square adjusted
Self-efficacy	0.272	0.265
Mathematics learning achievement	0.160	0.153

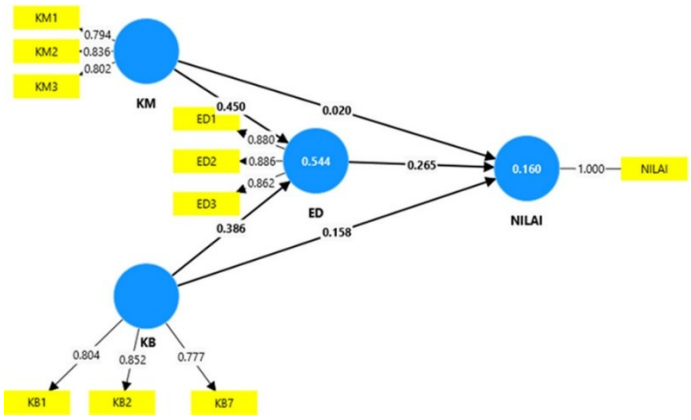

Fig. 1. Results of the structural equation model concerning the latent variables Mathematical beliefs/MB (KM), Self-regulated learning/SRL (KB), Self-efficacy/SE (ED), Mathematics learning achievement/MLA (NILAI)

Fig. 1 depicts a structural equation modeling (SEM) framework examining the connections between mathematical beliefs (MB), self-regulated learning (SRL), self-efficacy (SE), and mathematics learning achievement (MLA). MB and SRL acted as exogenous variables that impact SE, which subsequently influenced student performance. The indicators for each latent construct demonstrated strong standardized factor loadings. MB was assessed through KM1, KM2, and KM3, all of which surpassed 0.8, suggesting substantial construct validity. Likewise, SE was evaluated using ED1, ED2, and ED3, with loadings ranging from 0.830 to 0.880. The SRL construct is represented by KB1, KB2, and KB3, with acceptable loadings between 0.777 and 0.852.

Structurally, MB exerted a direct effect on SE ($\beta = 0.450$), and an indirect effect on student achievement through SE. SRL also significantly contributed to SE ($\beta = 0.386$), implying that both MB and SRL are the substantial predictors of self-efficacy. SE showed a positive effect on achievement scores ($\beta = 0.265$), confirming its mediating role in the model. The coefficient of determination (R^2) for SE was 0.544, indicating that approximately 54.4% of the variance in self-efficacy was explained by MB and SRL.

Depicted in Table 7, the mathematical beliefs indicators (KM), namely KM1, KM2 and KM3, had an original sample (O) of 0.807, 0.826 and 0.799, respectively. KM1 is the belief aspect about mathematics, KM2 is belief in one's own abilities, and KM3 is belief about teaching and learning mathematics. From these three indicators, p-value was obtained smaller than 0.05, meaning that KM1, KM2, and KM3 in the structural equation model had significant results.

The indicators for self-regulated learning (KB), namely KB1, KB2 and KB7, had an original sample (O) of 0.808, 0.848

and 0.0778, respectively. Indicator KB1 is learning initiative, KB2 is diagnosing learning needs and KB7 is selecting and implementing learning strategies. From these three indicators, a p-value was obtained smaller than 0.05; it indicated the significant results of the indicators KB1, KB2, and KB7 in the structural equation model.

Table 7. Test the hypothesis for each exogenous variable indicator

Exogenous Variable Indicators	Original sample (O)	T statistics	P values	Evaluation
ED1 <- SE	0.882	69.734	0,00	Significant
ED2 <- SE	0.887	70.685	0,00	Significant
ED3 <- SE	0.859	50.737	0,00	Significant
KB1 <- SRL	0.808	36.115	0,00	Significant
KB2 <- SRL	0.848	51.220	0,00	Significant
KB7 <- SRL	0.778	28.679	0,00	Significant
KM1 <- MB	0.807	33.843	0,00	Significant
KM2 <- MB	0.826	44.814	0,00	Significant
KM3 <- MB	0.799	29.271	0,00	Significant

The self-efficacy indicators (ED), namely ED1, ED2 and ED 3, had an original sample (O) of 0.882, 0.887 and 0.859, respectively. ED1 is the aspect of self-efficacy in magnitude (level of task difficulty), ED2 is strength, and ED3 is generality. From these three aspects, a p-value was obtained smaller than 0.05, meaning that the ED1, ED2 and ED3 indicators in the structural equation model had significant results.

Table 8. Hypothesis test of the direct effect of the research model

Path Coefficient	Original sample (O)	T statistics	P values	Evaluation
MB (X_1) -> MLA (Y)	0.020	0.320	0.749	Insignificant
SE (X_3) -> MLA (Y)	0.265	4.010	0.000	Significant
SRL (X_2) -> MLA (Y)	0.260	5.338	0.000	Significant
MB -> SE	0.450	8.453	0.000	Significant
SRL-> SE	0.386	6.987	0.000	Significant

Table 8 shows that the relationship between students' ideas about mathematics and their learning achievement had a p-value of 0.749, larger than 0.05, and an Original Sample (O) value of 0.020. The p-value indicated that students' learning achievement in mathematics was positively and marginally affected by the mathematics confidence variable.

Additionally, the Original Sample (O) value of 0.260 and the p-value of 0.008, less than 0.5, indicated a direct relationship between self-regulated learning and mathematical learning achievement. These findings suggest that student self-regulated learning has a good and significant impact on mathematical learning achievement.

Furthermore, the Original Sample value of 0.265 and the p-value of 0.00, less than 0.05, indicated a direct relationship between self-efficacy and mathematics learning achievement. These numbers indicated that students' learning achievement in mathematics was positively and significantly impacted by their level of self-efficacy.

Both the Original Sample (O) value of 0.450 and the p-value of 0.000 for mathematics beliefs -> self-efficacy were less than 0.05. These values suggest that self-efficacy and mathematical beliefs have a positive and significant relationship.

Both the Original Sample (O) value of 0.386 and the p-value of 0.000 for self-regulated learning -> self-efficacy were less than 0.05. These values suggest that students' self-regulated learning and their views about mathematics have a positive and significant relationship.

Table 9. Test the indirect effect hypothesis of the research model

Path Coefficient	Original sample (O)	T statistics	P values	Evaluation
SRL -> SE -> MLA	0.102	3.261	0.001	Significant
MB -> SE -> MLA	0.119	3.524	0.000	Significant

In Table 9, the relationship between mathematics beliefs, self-efficacy, and learning accomplishment had a p-value of 0.000, less than 0.05, and an original sample (O) value of 0.119. These values suggest that attitudes about mathematics have a favorable and significant impact on self-efficacy and self-regulated learning.

Self-regulated learning -> self-efficacy -> mathematics learning achievement had an initial sample (O) value of 0.102 and a p-value of 0.001, less than 0.05. From these values, it can be inferred that self-efficacy has a positive and meaningful impact on mathematics learning achievement via self-regulated learning.

3.1. Structural equation modeling of mathematics belief variables

The validity of the student mathematical beliefs variable in the structural equation model was obtained in the aspects of KM1, KM2 and KM3. In other words, these three aspects were valid and could be used for the next tests. However, the KM4 aspect was found invalid for having *an* outer loading not meeting the criteria; as a consequence, this aspect was removed. The highest loading factor is the aspect of belief in one's own abilities. Beliefs about oneself have beliefs about self-efficacy towards mathematics, being able to control oneself towards mathematics, being confident about the task-value beliefs towards mathematics and being confident about goal-orientation towards mathematics. This means that the aspects of beliefs about oneself are the biggest factor in measuring mathematical beliefs. Thus, in the mathematics learning process, students' learning experiences must focus on task-value beliefs and be confident in their goal-orientation towards mathematics.

In testing the first hypothesis, the original sample (O) was obtained successively from the highest, namely confidence in one's own abilities (KM2), beliefs about mathematics (KM1), and beliefs about teaching and learning mathematics (KM3). From these three indicators, a p-value was obtained smaller than 0.05, meaning that KM1, KM2, and KM3 in the structural equation model had significant results. Here, in the aspect of mathematics beliefs, beliefs in one's own abilities and beliefs

about teaching were in the good category. This is in line with the opinion of Izzatul (2017) stating that overall aspects of class VIII students' mathematical beliefs were in the good category regarding problem solving abilities. Furthermore, according to (Defi et al., 2021), students' mathematical epistemological beliefs and emotional intelligence had a positive effect on students' knowledge attainment.

Experiences related to students' beliefs about a subject can be shaped by teachers by creating a conducive learning atmosphere using various strategies to manage the class effectively including building positive relationships with students, recognizing students' individual characteristics, showing enthusiasm through performance, applying appropriate punishments for bad behavior, setting rules independently, and communicating class procedures effectively (Yopianti & Sadiq, 2023). Thus, teachers play an important role in determining students' learning experiences by learning to explore knowledge and learning media as tools, communication tools and tools for developing mathematical thinking in accordance with the characteristics and needs of their students.

3.2. Structural equation model of self-regulated learning variables

The validity of the self-regulated learning variable in the structural equation model showed that the aspects of learning initiative (KB1), diagnosing learning needs (KB2), and implementing learning strategies (KB7) were declared valid and could be carried out for further testing. The highest *loading factor* was found in the indicator for diagnosing learning needs (KB2). Diagnosing learning needs was an indicator that had the most effect on self-regulated learning. In the process of learning mathematics, students need to analyze their own needs by knowing what they lack when studying, choosing what material they need to study, and being prepared to face every problem. In line with the opinion of Ambiyar et al., (2020), that the indicators for diagnosing learning needs can be seen in students' learning attitudes when they know the mathematics material that must be re-studied, they feel anxious about their own shortcomings in mathematics lessons, and are burdened when determining the mathematics material they need to re-learn.

In testing the second hypothesis for the indicators KB1, KB2 and KB7, a p-value was obtained smaller than 0.05. reflecting the significant results of the indicators KB1, KB2 and KB7 in the structural equation model. Overall, the results of every aspect of self-regulated learning for class VIII SMP students in Serang were in the good category. These results are strengthened by research conducted by Rahayu & Aini (2021) showing that the average self-regulated learning in mathematics learning for secondary school students was 56.85%, emphasizing that most students were able to learn independently.

3.3. Structural equation model of self-efficacy variables

The validity of the self-efficacy variable in the structural equation model showed that the aspects of magnitude (ED1), strength (ED2), and generality (ED3) met the outer loading criteria. It then indicated that these three aspects were valid and acceptable for further test. The strength aspect had the largest loading factor in measuring student self-efficacy. According to (Moma, 2014), the strength dimension refers to the strength or weakness of a person's belief in the difficulty of a task that can be done. A person with weak self-efficacy is easily defeated by difficult experiences. While, the one with strong self-efficacy in competence is able to maintain their business even though they experience difficulties.

In testing the third hypothesis, the original sample (O) of the three self-efficacy indicators obtained a p-value smaller than 0.05, meaning that the indicators ED1, ED2, and ED3 in the structural equation model had significant results. In this research, the self-efficacy of secondary school students in Serang City was 69.3% or 273 students were in the medium category. This is in line with research by Aulia et al., (2022) that overall self-efficacy in learning mathematics among secondary school students was at a medium level. According to Sunaryo (2017), self-efficacy at a moderate level illustrates that when students are faced with challenging and difficult mathematics tasks, their level of tenacity and perseverance is at a moderate level. Principally, they will not easily give up or avoid tasks given by the teacher, only if they have tried hard but the task cannot be completed, then they will give up. Furthermore, the degree of anxiety or calmness they experience when maintaining tasks that encompass their lives is also at a moderate level, meaning that students are not too anxious and not too optimistic or confident but remain in a calm state.

3.4. The effect of mathematics beliefs on mathematics learning achievement

The results of the research showed that from 261 students out of 394 student samples, the mathematics beliefs of class VIII SMP students in Serang City were in the medium category. Here, the highest percentage was found in the indicator of having beliefs regarding *goal orientation beliefs* towards mathematics, 49% answered often. Mathematics beliefs: Students who are good at achieving mathematics learning have beliefs about mathematics, beliefs about their own ability to control mathematics, beliefs about mathematics learning, and beliefs about the usefulness of mathematics in everyday life.

The findings of the fourth hypothesis test showed that the mathematics confidence variable had a positive but not significant effect on students' mathematics learning achievement. These results showed that the relationship between mathematics beliefs and learning achievement was positive. Students' mathematical beliefs were formed from both themselves and their environment. If students have good mathematical confidence, they are able to control themselves in learning, provide ideas in learning and use mathematical solutions in everyday life, thereby enabling them to excel in learning mathematics.

The results of this research are in line with the results of research by Isharyadi & Deswita (2017) stating that there was no significant effect between mathematics beliefs and students' mathematics learning achievement. The contribution of mathematics beliefs to learning achievement was relatively low at 10.8% and the rest was affected by external factors.

In the meantime, as noted by Chirove et al., (2022), belief

systems encompass systematic, utilitarian, and exploratory convictions. Systematic belief structures encompass convictions in mathematics as a logical discipline, adhering to an organized sequence of steps in math tasks and problems, with students being dependent upon the notes and educators for learning. Utilitarian belief systems encompass mathematical principles applicable to various subjects and daily life, activities with clear solutions, issues resolvable with established algorithms, and learners dependent on educators for knowledge. The exploratory belief system encompasses a view of mathematics involving problem-solving and making connections, an emphasis on engagement with difficult scenarios, and students' reliance on their own skills for learning. Furthermore, Chirove et al., (2022) stated that the difference in average problem solving scores between groups who hold systematic, utilitarian and exploratory beliefs is not statistically significant. However, systematic beliefs explain a greater percentage of changes in students' strategies in solving problems compared to utilitarian and exploratory ones.

3.5. The effect of independent learning on mathematics learning achievement

The research results showed that the self-regulated learning of 262 out of 394 secondary school students in Serang City was in medium category. 57% of students answered frequently on indicators evaluating learning processes and outcomes. Students applying independent learning had an ability to regulate their own motivation, and were able to do everything with their abilities and to pursue long-term tasks until the tasks were completed on time (Siti Nurfadilah & Hakim, 2019).

The results of fifth hypothesis test showed a positive and significant effect of self-regulated learning on the mathematics learning achievement among secondary school students in Serang City. Thus, the higher the student's self-regulated learning, the higher the student's mathematics learning achievement.

These results indicated the positive relationship between self-regulated learning and mathematics learning achievement. If students have good self-regulated learning, they are able to control themselves in learning, apply appropriate strategies and evaluate the learning process and results achieved to improve mathematics learning achievement. This finding is in line with research by Duru & Okeke (2021) stating that *self-regulated learning* skills had a significant effect on students with high and low achievements in mathematics. Furthermore, Hidayat (2019) found out that high, medium or low student self-regulated learning also affected mathematics learning achievement. Furthermore, Saprizal et al., (2021) found some differences in the mathematics self-regulated learning of students at SMPN 7 Serang City based on sex. It was found that the average mathematics self-regulated learning of male students was found higher than that of female ones. Furthermore, Lusiana et al. (2022) stated that there was a positive and significant effect between student self-regulated learning and students' perceptions of teachers on mathematical problem solving abilities.

Students with self-regulated learning will be proactive in motivating themselves and using strategies that enable them to improve the desired academic results, especially in mathematics lessons which are characterized by abstract study objects where the characteristics of these lessons are different from the ones in other subjects. Empirical facts showed that though students' abilities are high, they are unable to achieve optimal academic achievement in view of their failure to self-regulate (Zahary, 2015). Self-regulated learning is an ability to be an active participant in metacognition, motivation and behavior in the learning process. For this, it can be concluded that independent learning has a role in achieving optimal learning achievement for students.

3.6. The effect of self-efficacy on mathematics learning achievement

The research results showed that the self-efficacy of 273 out of 394 secondary school students in Serang City was in the medium category, explaining that most of students had quite good self-efficacy. Six indicators were controlled here, including confidence in one's ability to overcome difficult tasks, adapting to difficult tasks, assessing oneself as capable of completing tasks, having confidence in the success of what one does, able to carry out tasks in different fields, and responding to situations. and various conditions in achieving goals. It can be concluded that the self-efficacy of secondary school students in Serang City is in the moderate category and is quite good to achieve mathematics learning achievement.

The results of the sixth hypothesis test on the self-efficacy variable on mathematics learning achievement showed that the self-efficacy on mathematics learning achievement had a positive and significant effect. It reflects that the higher the student's self-efficacy, the higher the mathematics learning achievement achieved. These results are in line with other research showing a positive and significant effect of self-efficacy on mathematics learning achievement (Maulani et al., 2020). A research by Indirwan et al., (2021) showed that self-efficacy had a positive and significant effect on mathematics learning achievement. The three dimensions of self-efficacy become one of the benchmarks for increasing students' mathematics learning achievement. It is also in line with research by Oktariani (2018) stating that the role of self-efficacy is significant in students' mathematics learning achievement. Students with high mathematics learning achievements are those with good analytical skills, confidence in working on problems and in learning mathematics and high curiosity. Furthermore, Schöber et al., (2018) stated that students with a migration background showed a lower average level of achievement compared to their peers who did not have one. It is because students with a migration background have not effectively utilized their self-efficacy. Furthermore, Schöber et al., (2018) explained that structural equation modeling revealed a positive effect of mathematics self-efficacy on mathematics learning achievement and reading achievement on reading self-efficacy

3.7. The effect of mathematics beliefs on mathematics learning achievement through self-efficacy

The result of the seventh hypothesis test showed that mathematics confidence affected students' mathematics learning achievement indirectly through the mediation of self-efficacy. The magnitude of the effect was indirectly proven by the significance of the p-value. Based on the calculation results,

the students' mathematical beliefs had a significant effect on mathematics learning achievement indirectly through self-efficacy. This means that mathematical beliefs indirectly have a positive effect on mathematics learning achievement through self-efficacy. In other words, the better a student's mathematical confidence, the better their mathematics learning achievement, both indirectly and through self-efficacy.

The results of this research are also in line with research by Kamalimoghaddam et al., (2016) with an aim to determine both the factors affecting mathematics beliefs on learning achievement through self-efficacy and the coefficients between latent variables using a measurement model. The results of this research showed that the structural equation model estimation revealed a direct and indirect effect of mathematics beliefs on mathematics learning achievement. The model determines both mathematics beliefs and mathematics achievement.

3.8. The effect of independent learning on mathematics learning achievement through self-efficacy

The eighth hypothesis test showed the indirect effect of self-regulated learning on mathematics learning achievement through self-efficacy. The calculation results confirmed that the self-regulated learning had an indirect significant effect on mathematics learning achievement through self-efficacy. This means that self-regulated learning indirectly has a positive effect on mathematics learning achievement through self-efficacy. The better a student's self-regulated learning, the better their mathematics learning achievement to be achieved indirectly through self-efficacy.

Based on the research results, it is figure out then that efficacy is determined by the student's own self-regulated learning. This is because increased self-regulated learning is closely related to students' self-efficacy. Self-regulated learning plays an important role in students' enthusiasm and self-efficacy in learning. The continuous failures and improvements experienced by students can encourage them to find the right learning strategies for themselves. By so doing, when students succeed in implementing self-regulated learning effectively, this tends to increase their self-efficacy (Wicaksana & Rachman, 2014). In line with the results of research by Wulandari & Sari (2019) conducted to determine the effect of self-regulated learning and self-efficacy together on mathematics learning achievement, showing a significant effect between self-regulated learning and self-efficacy together on mathematics learning achievement in vocational school students.

4. Conclusion

Based on the results of the research and discussion, it can be concluded that the structural equation model between mathematics confidence, self-regulated learning and self-efficacy for mathematics learning achievement had low accuracy estimates while the rest was determined by external factors. The specific tests are presented as follows: (1) the significant indicators in measuring mathematical beliefs in the structural equation model included mathematical beliefs, self-ability and beliefs about teaching and learning mathematics; (2) the significant indicators in measuring mathematics self-regulated learning in the structural equation model included learning initiative, diagnosing learning needs and implementing learning strategies; (3) the significant indicators in measuring self-efficacy in the structural equation model included the level of task difficulty, strength, and generality; (4) mathematics confidence had no significant effect on the mathematics learning achievement of secondary school students in Serang City. The contribution of self-efficacy was low; (5) self-regulated learning had a positive and significant effect on the mathematics learning achievement of secondary school students in Serang City. The higher the self-regulated learning, the higher the students' mathematics learning achievement; (6) self-regulated learning had a positive and significant effect on the mathematics learning achievement of secondary school students in Serang City. The higher the self-regulated learning, the higher the students' mathematics learning achievement; (7) mathematics beliefs had a positive and significant effect on mathematics learning achievement indirectly through self-efficacy; (8) independence in learning mathematics had a positive and significant effect on mathematics learning achievement indirectly through self-efficacy.

It is expected that future research should dig more carefully and explore the mathematical beliefs, self-regulated learning and self-efficacy of students, thereby enabling them to be used as comparisons with the results of this research, and should conduct more in-depth research related to the variables of mathematical beliefs, self-regulated learning and self-efficacy by adding Other variables affecting mathematics learning achievement apart from the variables researched by the author were external and internal factors.

The future research are also expected to consider the right time to collect sample data with the school agenda to get good time without a need to rush, choose school accessibility to make the sample focused on a uniform condition and school level at a certain level and to reach wider results.

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