

THE EFFECT OF STEM-PjBL AND ADVERSITY QUOTIENT ON HIGH SCHOOL STUDENTS' PROBLEM SOLVING ABILITY

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Abstract

The mathematics learning development is colored by advances in science and technology. The integration of STEM (Science, Technology, Engineering, and Mathematics) in today's mathematics learning should be a priority. This is due to the improving need for Human Resources who are competent in the STEM field, includes the ability to solve complex problems. In digital era, Mathematical Problem Solving Ability (KPMM) is needed. The students' are required to be competent in technology. By collaborating STEM-PjBL in learning activity, it is expected. that students' have KPMM improvement. This research aims to determine the effect of STEM-PjBL and Adversity Quotient (AQ) on KPMM. This research used quantitative approach with quasi-experimental method and nonequivalent pretest-posttest research design. This research used two classes, namely the experimental class for STEM-PjBL model and the control class for scientific approach. This research was conducted in one of the high schools in Tangerang with a population of all students in grade XI with sample around to 39 students who were selected by purposive sampling. This study used two instruments, namely the problem solving ability test instrument and the AQ non-test instrument. The results showed that STEM-PjBL and scientific learning had a positive effect on KPMM. Meanwhile AQ also had a positive effect in all categories. Beside that, this research also showed there was no interaction effect between the two of learning models and AQ on students' KPMM. Students who received STEM-PjBL and scientific learning obtained n-gain of 0.48 and 0.35, which means that there was an improvement in KPMM with a quite good category.

Keywords: Adversity Quotient; Problem Solving; Project Based Learning; STEM.

Abstrak

Perkembangan pembelajaran matematika diwarnai oleh kemajuan sains dan teknologi. Integrasi STEM (Science, Technology, Engineering, and Mathematics) dalam pembelajaran matematika saat ini harus menjadi prioritas. Hal ini karena meningkatnya kebutuhan Sumber Daya Manusia (SDM) yang berkompeten dalam bidang STEM, mencakup kemampuan pemecahan masalah yang kompleks. Penelitian ini bertujuan untuk mengetahui pengaruh model STEM-PjBL dan Adversity Quotient (AQ) terhadap Kemampuan Pemecahan Masalah Matematis (KPMM). Penelitian ini menggunakan pendekatan kuantitatif dengan metode kuasi eksperimen dan desain penelitian nonequivalent pretest-posttest. Penelitian ini dilaksanakan di salah satu SMA kota Tangerang dengan populasi seluruh siswa kelas XI dengan sampel sebanyak 39 siswa yang dipilih secara purposive sampling. Penelitian ini menggunakan dua kelas, kelas eksperimen untuk model STEM-PjBL dan kelas kontrol untuk pendekatan saintifik. Penelitian ini menggunakan dua instrumen yaitu instrumen tes kemampuan pemecahan masalah dan instrumen non-tes AQ. Hasil penelitian ini menunjukkan bahwa STEM-PjBL dan pembelajaran saintifik memiliki pengaruh positif terhadap KPMM. Begitupun dengan AQ yang juga berpengaruh positif terhadap KPMM di semua kategorinya. Selain itu, penelitian ini juga menunjukkan tidak adanya pengaruh interaksi antara kedua model pembelajaran dan AQ terhadap KPMM. Siswa yang mendapatkan model STEM-PjBL dan pembelajaran Saintifik memperoleh n-gain sebesar 0,48 dan 0,35 yang artinya terjadi peningkatan KPMM dengan kategori cukup baik.

Kata kunci: Adversity Quotient; Pembelajaran Berbasis Proyek; Pemecahan Masalah; STEM.



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INTRODUCTION

The 21st century education system is one example of how is the education adapting to the times. One of the fields of science that has an important role in the development of science and technology is mathematics. (Febriani & Yuspriyati, 2023; Rabbani, Jihad, & Juariah, 2022). The advances of science and technology have transformed mathematics learning, but it is necessary to pay attention to the principle of technology integration so that the use of technology is effective (Milah, Susilawati, Widiastuti, & Ariany, 2022), so that there are perceived benefits such as increased learning motivation and student problem solving skills (Seyedaliyan & Salehi, 2021). Therefore, advances in technology have opened the door to a variety of new approaches in learning mathematics, one of which is STEM.

Nowadays, teaching and learning assessment using STEM has become a necessity (Kinboon, Sanghuaypai, & Nantachukra, 2019). STEM integration in mathematics learning has a positive influence on 21st century skills, especially in problem solving (Saputri & Herman, 2022). STEM integration efforts are made to solve the problem of low student problem solving skills as seen from the results of the PISA study which states that Indonesia has always ranked in the bottom 10 for more than a decade (Zahro, 2022). Problem solving through STEM is a core standard in education to address the challenges of the 21st century (Amalina & Vidákovich, 2022).

Based on the results of preliminary observations that have been made, one of the problems that appear is the low of students' KPMM. Nowadays, math learning only focuses on calculations to find results without

knowing the benefits of the material learned for everyday life. In addition, the monotonous delivery of material and the use of inappropriate learning media can cause students' interest to decrease, which will affect their fighting power in solving problems. When students think that Mathematics is difficult, they tend to lose their interest and are not interested in learning, which affects their fighting power, motivation and learning achievement (Rustan, Ihsan, & Nurlindasari, 2022; Selfara, Wijayanti, & Faulina, 2022). It is in accordance with research of Pertiwi et al., (2019) revealed that there is a significant relationship between fighting power and math learning outcomes.

Fighting power can be referred to the Adversity Quotient (AQ). According to Stoltz (2000), AQ is a measurement tool of how far a person can survive to face and overcome the difficulties he faces. Each student has a different AQ when facing difficulties, therefore encouraging them to handle difficulties using their own way. However, to achieve maximum results in solving a problem must follow several stages as described by Polya. Students who have gone through these stages with strong AQ support tend to have good problem solving skills. This is in accordance with the literature review and research on AQ and problem solving ability (Septianingtyas & Jusra, 2020; Sutisna, Novaliyosi, Hendrayana, & Mutaqin, 2022; Sutisna & Pujiastuti, 2023).

Efforts can be made to improve KPMM by choosing the appropriate learning model. In the selection process, teachers must consider the students' need in developing 4C skills. This school implements the 2013 curriculum in its learning. PjBL is one of the recommended models in the 2013

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curriculum and can be integrated with the STEM approach (Priatna, Nurhayati, & Lorenzia, 2021). This is based on several research findings related to the implementation of the STEM approach in improving students' KPMM (Faoziyah, 2021; Priatna, Avip, & Sari, 2022), and can improve student participation and enthusiasm in the learning process (Diana & Sukma, 2021). Thus, STEM-PjBL encourages students to be actively involved in learning, increase interest in problems, and strengthen AQ in solving problems, so that they can get the best results in solving the given problems.

Based on the previous description, this research aims to determine the effect of STEM-PjBL and AQ on KPMM. It's expected that the STEM-PjBL can improve students' KPMM in all AQ categories, whether low, medium, or high.

RESEARCH METHOD

This research method is quasi-experimental of quantitative with the nonequivalent pretest-posttest research design. The stages of this research consist of several parts: (1) giving pretest KPMM and AQ questionnaire; (2) giving treatment using STEM-PjBL model, (3) giving posttest of KPMM; (4) drawing conclusions, interpreting the results obtained.

This research was conducted in one of the high schools in Tangerang city with a population of all students in grade XI. The sample in the study amounted to 39 students who were selected by purposive sampling. There are two classes in this study, the experimental class using the STEM-PjBL model amounted to 20 students and the control class using scientific learning amounted to 19 students with learning material is a circle.

In this research, there are two types of instruments used, namely problem solving ability test instrument consisting of four questions and AQ non-test instrument consisting of fifteen statements. The results of the validity and reliability tests, both test instruments have met the valid and reliable criteria with a high correlation (Lestari & Yudhanegara, 2015).

The problem solving ability test instrument consists of four questions in the form of descriptions that have been prepared based on problem solving indicators adapted from NCTM (2000) based on four problem solving standards that students must have, namely 1) building new mathematical knowledge through problem solving, 2) solving problems that arise in mathematics and in other contexts, 3) applying and adapting various appropriate strategies to solve problems, and 4) observing and reflecting on the problem solving process. While problem solving used follow the stages according to Polya (1973), namely: 1) understanding the problem, 2) devise a plan, 3) carry out the plan, and 4) looking back.

Data analysis in this study used descriptive and inferential statistics with two-way Anava. The students' AQ categorization is determined based on the scores that have been obtained. The student' AQ mean was 64.13 with a standard deviation of 5.71. The grouping of students based on AQ level is categorized seen in Tabel 1.

Table 1. AQ Category

Interval	AQ Level
$X \geq 69,84$	High
$58,41 < X < 69,84$	Medium
$X \leq 58,41$	Low

Source: Azwar (2022).

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RESULT AND DISCUSSION

The data of this study came from the results of the mathematical problem solving ability pretest and posttest and students' AQ obtained from students before learning. The results of the AQ distribution of both experimental and control classes have a relatively similar distribution, 4 students with high AQ, 3 students with low AQ and the remaining students with medium AQ. Both classes contain the majority of medium AQ categories, it means that students have medium abilities in mathematical problem solving (Sutisna et al., 2022; Sutisna & Pujiastuti, 2023).

Based on the pretest and posttest results in diagram 1, it shows that the pretest average of the experimental class is lower than the control class. However, the posttest results show the opposite, namely the average posttest of the experimental class is higher than the control class. Thus, this shows that there is an increase in ability from the pretest and posttest results in description. Meanwhile, the average n-gain for the experimental and control classes was 0.48 and 0.35 respectively, which means that there was an improvement in KPMM with a quite good category (Lestari & Yudhanegara, 2015).

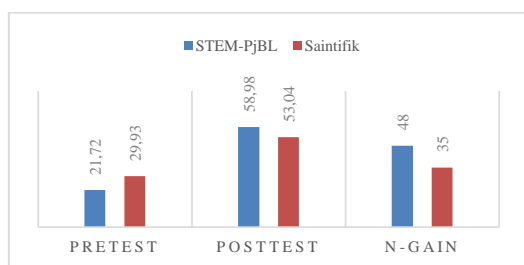


Diagram 1. Pretest, posttest, and n-gain score averages

Based on the t-test of the pretest results in Table 2, it was found that there was a difference in the average of students' mathematical problem solving

between the experimental and control classes. Therefore, to see the effect, the n-gain test was conducted.

Table 2. t-test of Pretest

Class	t-test		
	t	df	p
Experiment-Control	-2,306	37	0,027

Hypothesis testing uses the results of the interpretation of inferential statistical calculations of students' mathematical problem solving ability N-gain because the pretest data is significantly different. Data processing in this study used two-way Anava with a 3x2 research design. Testing with two-way Anava requires two prerequisites, namely normally distributed data and homogeneous variance.

The normality test of students' KPMM n-gain data was carried out 11 times in each data category to ensure that all data were fully normally distributed. The normality test used is Shapiro-Wilk with the test criteria in making decisions for the significance level $\alpha = 0.05$ is: Reject H_0 if p-value $< \alpha$ and accept H_0 for other values. Based on the normality test results, students' mathematical problem solving ability n-gain values in all categories obtained p-values greater than α . Because the p-value $> \alpha$, H_0 is accepted. So it can be concluded that students' mathematical problem solving ability n-gain data is normally distributed in all categories.

The homogeneity testing of students' mathematical problem solving ability n-gain data using the Levene Statistic test. It same like the normality test, the homogeneity test was conducted 7 times on each data category to ensure that all data came from the same population. The test criteria in

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making decisions for the significance level $\alpha = 0.05$ are: Reject H_0 if $p\text{-value} < \alpha$ and accept H_0 for other values. Based on the homogeneity test results, the mathematical problem solving ability n-gain values of students in all categories obtained a p value greater than α . Because the p value $> \alpha$, H_0 is accepted. So it can be concluded that

the population variance of students' mathematical problem solving ability n-gain scores is homogeneous in all categories.

The results of calculating the mean n-gain of students' mathematical problem solving ability using two-way Anava are presented in Table 3.

Table 3. Students' mathematical problem solving ability n-gain two way anava

Source	Sum Square	Df	Mean Square	F Value	<i>p</i> -value
Learning Model	0,089	1	0,089	5,279	0,028
AQ	1,149	2	0,575	33,98	0,000
Interaction between learning model and AQ	0,009	2	0,005	0,273	0,763

Based on the results of the calculation with Anava in Table 3 on learning model, the p -value is 0.028. Based on the test criteria, H_0 is rejected. This means that the mathematical problem solving ability of the experimental class is higher than the control class. This shows that the STEM-PjBL model has a positive effect on students' mathematical problem solving ability.

Based on the results of the calculation with Anava Table 3 on AQ, the p -value is 0.000. Based on the test criteria, H_0 is rejected. This means that high AQ has a better mathematical problem solving ability than medium AQ, and medium AQ has a better mathematical problem solving ability than low AQ. This shows that AQ has a positive effect on mathematical problem solving ability at all levels of AQ.

Based on the results of the calculation with Anava in Table 3, the interaction of the learning model with AQ, obtained a p -value of 0.763. Based on the test criteria, H_0 is accepted. This means that the STEM-PjBL model has a strong influence at all AQ levels. The mathematical problem solving ability of

students who received the STEM-PjBL model was always better in all AQ categories of high, medium, and low than the scientific approach. This indicates no influence by AQ level. Thus, the STEM-PjBL model is recommended to be used for all AQ levels, whether high, medium or low.

Project-Based Learning Model with STEM Approach has A Positive Effect on Mathematical Problem Solving Ability

The students who involved in the STEM-PjBL model learning showed a better improvement in mathematical problem solving ability compared to the scientific approach even though the average achievement of the final results in both experimental and control classes had not reached of 60. They have been able to identify problems better, apply STEM knowledge in problem analysis, develop effective problem-solving strategies, and evaluate the resulting solutions. These results are in line with research of Lathiifah & Kurniasi (2020) which illustrates that students have been able to solve problems based on mathematical problem solving ability

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indicators very well. This shows that achieving the best results in solving a problem can be obtained in line with the process that is passed.

This research uses students' worksheet that have been prepared in accordance with the theme of the universe. The use of students' worksheet allows the students to understand the relationship between the four aspects of STEM through the theme of the universe. They learn to understand how the universe works based on existing theories from the results of research that has been done previously by experts. Students become so enthusiastic and foster curiosity to learn about it. This illustrates how the STEM-PjBL model has a positive effect on student learning interest. Interest in learning mathematics is a key factor for students for their future, because it is a predictor in determining interest in pursuing a career in the STEM field (Leyva, Walkington, & Perera, 2022).

The application of the STEM-PjBL model also makes students actively involved in learning. They are not only receive knowledge passively, but also engage in exploration, investigation and real problem solving by integrating knowledge and skills from the four aspects of STEM on circle material with the theme of the universe. In line with Vygotsky's suggestion, the implementation of collaborative learning facilitates students to interact with each other and develop effective problem-solving strategies in each Zone of Proximal Development (ZPD) (Agustyaningrum, N., Pradanti, P., 2022). During project activities, students are faced with problems that exceed their understanding or knowledge. Teachers or more skilled team members act as mediators or facilitators within students' ZPD. They

provide the necessary guidance, support and resources to enable students to extend their abilities, deepen their understanding and achieve the desired project outcomes, which is in line with Vygotsky's ZPD principles. Project activities are able to facilitate students' abilities in communication, teamwork, leadership, and adaptability in unexpected situations in solving the problems they face. These results can be seen in ongoing learning activities in the classroom. This illustrates that learning with the STEM-PjBL model contributes positively to the development of students' attitudes. In line with these results, STEM-based learning has a positive effect on student attitudes which have an impact on optimal cognitive learning outcomes (Pambayun & Shofiyah, 2023).

Furthermore, students are directed to solve problems related to the core material, namely circles. They learn how a circle can be formed with a predetermined distance so that they can think with patterns and logic critically in solving problems. Students are also invited to think creatively, explore various solutions using the geogebra application to find and strengthen the understanding needed to solve the problem. This directly contributes to the improvement of students' mathematical problem solving ability. Direct involvement of students in solving a problem makes them able to construct their knowledge and skills. Another study showed that students will better understand trigonometry material because of the project assignment to make and use clinometer props which have an impact on increasing students' mathematical problem solving ability (Priatna et al., 2022). In addition, the increase in mathematical problem solving ability is also due to the use of

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students' worksheet that have been designed in accordance with STEM aspects to train problem solving skills (Alatas & Yakin, 2021).

The application of the STEM-PjBL model has a positive effect on students' ability to solve geometry problems. Through project activities, students are able to apply the understanding that has been obtained. Students feel directly how the concepts and principles of geometry are applied in everyday life, thus increasing their interest in learning and motivation to learn it. This is in line with research of Han et al., (2016) that the application of the STEM-PjBL model has shown positive results in improving students' geometry skills. The application of the scientific approach also has a positive effect on mathematical problem solving ability but the effect is not better than the STEM-PjBL model. One of the effects seen in the third mathematical problem solving ability test instrument, which shows an increase in mathematical problem solving ability better than the STEM-PjBL model. The application of the scientific approach builds students' competence in solving problems through knowledge, critical thinking, and higher order thinking, using the scientific method (Nuralam & Eliyana, 2017).

AQ has A Positive Effect on Students' Mathematical Problem Solving Ability

Problem solving ability has a positive influence on AQ. Every student has confidence and fighting power when solving a problem they face. Whether the problem can be solved or choose to give up and hopeless. The success and failure of students in solving math problems at school is related to their AQ (Amir, Nurdin,

Azmi, & Andrian, 2021; Maini & Izzati, 2019; Rahmi, Putra, & Kurniati, 2021).

The ability to manage adversity is one of the main benefits of having high fighting power, students who have high AQ see difficulties as an opportunity to face challenges, and their success in overcoming challenges makes them resilient individuals and more skilled in solving math problems (Hastuti, Sari, & Riyadi, 2018). AQ not only plays a role in how students manage difficulties, but also as a construct that affects student achievement, independence, and motivation to learn (Safi'i et al., 2021). Developing fighting power in students can be the key to improving problem solving skills in solving math problems at school.

Students who have high AQ are able to see problems from various perspectives and find effective solutions. They have strong diligence, continue to look for solutions in various ways so as to gain sufficient understanding to solve the problem. They continue to work through difficulties until they find the best solution, although some of them still make mistakes in finding the right solution. In line with these results, the high level of difficulty of mathematics problems may not necessarily be solved by students who have high AQ (Hadi & Zaidah, 2020). The final results obtained by high AQ students are not always correct, but they are able to follow the stages of a good problem solving process. The mistakes they make in problem solving are due to misinterpreting the results that have been obtained because they do not check again whether the results obtained are correct or not.

Most of the medium AQ when they encounter difficulties, they stop and give up more. Students with this

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level have quite good fighting power before they find difficulties. They still try to find a solution to the problem. But if they still don't find a solution either they will just stop and give up without wanting to know the appropriate solution.

In problem solving, lack of accuracy is a deficiency that is often seen, because they are more quickly satisfied with the results that have been obtained and want to immediately submit the results without checking the answers again. They tried to solve the given problem but the results did not match the illustrations they made. This shows the lack of accuracy of medium AQ students in rechecking the results that have been obtained. However, there are also some of them who have the ability to continue to struggle and solve the problems by utilizing most of their potential. This AQ is a transition from medium and high. They have mixed traits of high and medium AQ. This transitional type of high and medium AQ has the traits of both high and medium AQ at certain times (Septianingtyas & Jusra, 2020). Medium-high transitional AQ students continue to try to solve the problem until they are able to find the right solution, this is a trait of high AQ. However, they still have the trait of moderate AQ which is not through, this can be seen from the way they illustrate the results with the answers that have been obtained.

Students with low AQ have less fighting power. They have a nature that gives up easily. When in learning, if faced with difficulties, they tend not to want to continue the learning. Even if they want to, they don't understand what they are doing. They still try to explain using their own language without knowing whether it is correct or not.

They prefer to avoid and look for ways that are considered easier because they see the given problem as something too difficult, so they do not try to solve it. Lack of self-control is one of the factors that cause them to lose their fighting spirit when facing problems (Chadha, 2021). This attitude not only blocks their development, but also makes them fail to solve problems and lose the opportunity to improve their problem-solving skills. Students with this level of AQ are passive and silent. Most of them are cool with their own world, so they are less focused on learning.

The increase in mathematical problem solving ability was seen across all AQ levels. The improvement of high AQ is able to better solve problems and get the best results compared to medium, and low AQ. Medium AQ is also the same, when compared to low AQ, they experience better improvement. This result is in line with research from Rahmi et al., (2021) which shows that AQ levels have different mathematical problem solving ability. In addition, high AQ has better learning achievement in problem solving than students who have medium, and low AQ (Dewanto, Budiyo, & Pratiwi, 2019).

There is No Interaction Effect between Learning Model and AQ on Mathematical Problem Solving Ability

In this research, The students' KPMM who obtained STEM-PjBL was always better in all AQ categories of high, medium, and low compared to scientific learning. It shows that there is no interaction effect between the learning model and AQ on students' KPMM. These results show that direct students' direct involvement in solving problems through STEM-PjBL has a

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positive effect for better results compared to the scientific learning. This is in line with research Han et al., (2016) and Ramdhani et al., (2017) that the application of the STEM-PjBL model and the scientific approach has shown positive results in improving geometry skills and students have a better understanding of geometry concepts.

The application of the STEM-PjBL model is more recommended in learning that focuses on contextual problem solving on circle material because it has a stronger influence than the scientific approach for all levels of AQ, whether high, medium or low. Apart from the application of the PjBL model, the STEM approach also has a role in improving students' mathematical problem solving ability, because this learning approach emphasizes interdisciplinary problem solving and combines concepts from all four aspects of STEM. On the other hand, the scientific approach is more likely to focus on scientific processes and exploration in one scientific discipline. Both the STEM approach and the scientific approach reflect ZPD principles to varying degrees. However, the STEM-PjBL model has a stronger connection with ZPD because collaboration between students and teachers is key to achieving the best project results.

The effect of the learning model on students' mathematical problem solving ability also does not depend on the level of AQ because both students in the STEM-PjBL and Scientific models have high confidence in solving problems especially in high AQ and most of the medium AQ. The confident students are more motivated to learn and succeed in the classroom. Students' self-confidence is related to self-control,

where students feel confident and believe they will succeed with their abilities (Suryadi & Santoso, 2017). This is related to the control dimension of AQ which indicates how confident a person is able to influence things positively (Chadha, 2021). Furthermore, self-efficacy and AQ have an important role in student success in learning, the higher self-efficacy and adversity quotient of students, the better their learning achievement (Suryadi & Santoso, 2017).

This belief makes them continue to struggle in the midst of the difficulties they are facing. While most of the low AQ have doubts in solving problems. This happens because students who have doubts because they do not master the material tested. In addition, the application of scientific approach encourages students to be active and critical in overcoming problems, as well as strengthening confidence in their abilities so that they can find the right solution (Ramdhani et al., 2017).

CONCLUSION AND SUGGESTION

The application of project-based learning model with STEM approach has a positive effect on students' mathematical problem solving ability by obtaining better improvement than the scientific approach which obtained n-gain values of 0.48 and 0.35, which means that there was an improvement in KPMM with a quite good category. AQ has a positive effect on mathematical problem solving ability at all AQ levels. Students who have high AQ obtained better mathematical problem solving ability improvement with medium AQ, and medium AQ obtained better mathematical problem solving ability improvement with low AQ. There is no interaction effect between learning

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model and AQ on students' mathematical problem solving ability. In learning, teachers need to pay attention to each level of AQ possessed by each student in order to direct students according to their respective potential. It is expected that students who have high AQ can continue to maintain an unyielding attitude in order to continue to struggle, medium AQ can be more thorough in solving problems, and low AQ strive to continue to improve their abilities.

The suggestions for future research are expected to focus more on increasing AQ in each student in applying the STEM-PjBL model for KPMM. By focusing on increasing AQ, the future research can complement this research in terms of the direct impact of using the STEM-PjBL model in solving a problem.

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