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The implementation of the PBL model to improve the eleventh-grade students' mathematics learning outcomes at SMA IT Al-Fityah Pekanbaru

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Abstract
This research was carried out because it was triggered by the low learning outcomes of eleventh-grade students at SMA IT Al-Fityah Pekanbaru. Classroom action research using the Problem-Based Learning (PBL) model was applied to enhance mathematical learning outcomes and the learning process. The study comprised two action cycles, progressing through four stages: planning, acting, observing, and reflecting. Conducted during the odd semesters of the 2023/2024 school year, the research involved 27 students in the eleventh grade at Al-Fityah SMA IT Pekanbaru. The research instruments included learning tools (such as syllabi, lesson plans, and student worksheets) and data collection instruments in the form of teacher-student activity sheets. These were analyzed descriptively narratively, along with student mathematics learning outcome tests, which were analyzed descriptively statistically. Data analysis revealed that the learning process, when applying the Problem-Based Learning model, consistently achieved expected progress in each meeting. The results indicated an increase in the number of students reaching the minimum achievement criteria (KKM). Before implementing the action, 44.44% of students achieved minimum achievement criteria (KKM) in the knowledge aspect. This percentage rose to 55.55% in cycle I and further increased to 77.78% in cycle II. Similarly, in terms of skill competency, the percentage of students reaching KKM was 55.25% in Cycle I and increased to 74.07% in Cycle II. Overall, the application of the PBL model positively impacted the learning process for eleventh-grade students at SMA IT Al-Fityah Pekanbaru.

Keywords: Mathematics learning outcomes, Classroom action research, Problem based learning

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Introduction

The standard guidelines for the educational process set the objectives of learning mathematics, namely that students can understand mathematical concepts, understand the relationships between concepts, and apply these concepts to solve problems related to mathematics lessons (Permendikbud Nomor 22, 2016) The objectives of learning mathematics serve as guidelines for assessing whether a mathematics learning process has been successfully implemented. These objectives play a crucial role because they encompass descriptions of the knowledge, skills, and attitudes that students acquire after engaging in mathematics education.

Whether or not a learning objective is achieved can be seen from the results of students' mathematics learning (Rahmawati et al., 2020). Learning outcomes serve as a measure of how well students have mastered the subject matter. This is indicated by changes in student behavior seen at the end/after the learning process has taken place (Surya, 2017). It is hoped that this change will be a process of improving behavior in a better direction than before (Purnamasari et al., 2017). The measurement guidelines for student learning outcomes are known as the Minimum Achievement Criteria (KKM). KKM represents a competency standard established by the school, taking into account various factors such as student characteristics, subject matter, and the school's environment (Permendikbud Nomor 23, 2016). The school establishes the Minimum Achievement Criteria (KKM), which categorizes students as having achieved learning completion if they meet the specified criteria. The determination of whether Minimum Achievement Criteria (KKM) is attained for each basic competency relies on test analysis conducted by the teacher.

The collection of cycle test result data was conducted to determine students who achieved the Minimum Achievement Criteria (KKM) in the eleventh-grade IPA students of SMA IT Al-Fityah Pekanbaru. According to information collected from mathematics subject teachers, the school sets the Minimum Achievement Criteria (KKM) for mathematics subjects at 70 for class XI. The daily mathematics test scores for the Mathematics Induction material in the odd semester of 2023/2024 showed that the percentage of students achieving the Minimum Achievement Criteria (KKM) was 44.44%, which is still relatively low, which is below 50%. Based on this, observations and interviews were conducted to identify the factors that caused the low mathematics learning outcomes of students in the class.

Based on observations, it appears that the teacher has not communicated a clear set of learning objectives during the initial activities and has failed to motivate students regarding the subject matter. Throughout the learning sessions, the teacher assumes an active role (teacher-centered), with students merely receiving information and lacking opportunities for independent development. Additionally, the teacher does not engage in activities to summarize lessons with students at the end of the class.

The results of the conducted interviews revealed that students generally dislike mathematics due to the perceived difficulty of the material. They explained that when faced with practice questions involving contextual problems, they struggled to understand the given problems, which in turn hindered their problem-solving abilities. Consequently, students tended to be passive in their learning, lacking active participation.

Furthermore, students speculated that their inconsistent and low mathematics scores were directly related to the challenging nature of the subject matter. Classroom observations and interviews with the eleventh-grade IPA students at SMA IT AL-Fityah Pekanbaru also highlighted additional factors contributing to low mathematics learning outcomes. These factors include students' passivity during the learning process, a tendency to rely solely on material delivery by the teacher, difficulties in grasping concepts, and struggles in solving contextual problems.

In addressing the challenges related to learning outcomes, several efforts are necessary to be made. These include improving the learning process, encouraging active student participation, enhancing their understanding of essential mathematical concepts, and enabling them to solve real-world problems related to mathematical material. To tackle these issues, one

effective step is to adopt the Problem-Based Learning (PBL) model. PBL, as described by Tan, is an innovative approach that empowers educators to continuously develop students' thinking skills through collaborative teamwork. By implementing PBL, educators can foster a dynamic learning environment that promotes problem-solving abilities and deeper understanding. (Hidayat et al., 2019) The PBL model is defined as a learning model that is based on constructivism and accommodates students to be involved in contextual problem solving, understand the provisions and methods of critical thinking and problem solving, and use real problems to construct knowledge about the subject matter (Endriani & Rakhmawati, 2019).

PBL is a learning model by applies problems in everyday life. This allows students to learn concepts from the subject matter and learn how to think critically and solve problems (Anwar & Jurotun, 2019). In problem-oriented learning situations, the PBL model helps students improve their mindset and achieve a higher level of independence. Sastrawadi & Rusdi stated that the PBL model can change the learning process, especially regarding the role of teachers. Teachers do not only teach students and help solve problems (Pamungkas et al., 2019).

According to Putra, the PBL model has several advantages, namely, students are more likely to be able to explore concepts in related material because they independently construct knowledge, students are actively involved in finding alternative solutions to solving problems, and students can experience the positive benefits of learning because the problems solved are related to everyday life (Sriwati, 2021). Several characteristics of PBL differentiate it from other learning models, such as (1) implementing an authentic learning process, (2) motivating students to learn and participate actively through the presentation of problems, (3) learning by integrity or being motivated by unlimited problems, (4) active participation of students, (5) working in groups, and (6) skills and experience possessed by students. (Fauzia, 2018)

Classroom learning in the PBL model follows five practical steps or syntax, namely: student orientation to problems, organizing students to learn, guiding individual and group investigations, developing and presenting work results, and analyzing and evaluating the problem-solving process (Hapudin, 2021). The PBL model is considered effective in improving the learning process and directing students' mathematics learning outcomes to a better level through the implementation of structured and interactive stages. This is in line with previous research by (Widiyana, 2021) which shows that the learning outcomes of students from before the action was carried out until after the action of using the PBL model was carried out there was an increase. These results show that the use of the PBL model can influence the mathematics learning outcomes of students in a better direction.

Linear programming is one of the mathematical materials studied in Senior High School (SMA). Linear programming is authentic material for learning mathematics (Sadiah et al., 2023). The reason why it is important to master linear programming material is because it can be applied to various relevant situations. The main point of linear programming material is to achieve a single result, such as minimizing or maximizing profits. Idris said that linear programming is one of the most difficult mathematics topics for students to understand, as seen from the learning situation and conditions (Simbolon et al., 2023).

The ability of high school students to understand and implement linear programming concepts is still relatively low. This is in line with research by (Ahmad et al., 2018), which explains that students have difficulty understanding problems, difficulty in writing down things that are known and asked, and making examples, which causes students to be constrained in

working on the next steps. According to a mathematics teacher at SMA IT Al-Fityah Pekanbaru, students have many difficulties understanding linear programming material. This is based on his experience in teaching in the eleventh-grade IPA students, problems in linear programming material are usually in the form of story problems and sometimes require a long solution process. and a long time, this makes students overwhelmed and difficult to understand problems related to linear programming material. Based on these reasons, linear programming material was chosen for this study because linear programming material is included in the material that has been difficult to understand by some of the eleventh-grade IPA students at SMA IT Al-Fityah Pekanbaru.

Based on the description of the low learning outcomes of students, the PBL model, and linear programming material, a study was conducted by applying the PBL model. The purpose of the study was to improve the learning process and improve the mathematics learning outcomes of the eleventh-grade IPA students at SMA IT Al-Fityah in Pekanbaru in 2023/2024 on KD 3.2 Explaining two-variable linear programs and their solution methods using contextual problems and KD 4.2 Solving contextual problems related to two-variable linear programs.

This research provides benefits for students by enhancing their understanding of the subject, offering fresh insights to teachers for developing effective teaching methods, and supporting schools in elevating overall learning quality. The Problem-Based Learning (PBL) model fosters student engagement in learning mathematics and enhances their comprehension of concepts related to linear programming materials, enabling them to solve real-life problems. The application of the PBL model serves as an alternative approach or reference for teachers during classroom instruction. It can be absorbed and integrated into efforts aimed at enhancing the mathematics learning process for eleventh-grade IPA students at SMA IT Al-Fityah Pekanbaru. Furthermore, it is expected to deepen teachers' insights and skills regarding the application of the PBL model to improve students' mathematics learning outcomes.

Methods

The conducted research involves collaborative Classroom Action Research (CAR), where the researcher collaborates with the mathematics subject teacher during the implementation process. This study aims to enhance mathematics learning outcomes and improve the teaching and learning process in the classroom. This research action took place from September 18, 2023, to October 11, 2023, which was carried out in the odd semester of the 2023/2024 academic year in the eleventh-grade IPA students of SMA IT Al-Fityah Pekanbaru. This study involved 27 students (9 males and 18 females) from the eleventh-grade IPA students of SMA IT Al-Fityah Pekanbaru who had heterogeneous ability levels.

The research was conducted in 2 cycles consisting of four stages, namely planning, acting, observing, and reflecting. The following are activities carried out during each cycle: (1) Planning, planning is carried out by compiling research instruments such as learning devices and data collection instruments. Compilation of learning devices consisting of syllabus, lesson implementation plan (RPP), and student worksheets (LKPD) for each of the four meetings. Learning devices are compiled based on the revised 2013 curriculum. Data collection instruments consist of observation sheets of teacher and student activities during four meetings,

as well as mathematics learning outcome test sheets with alternative answers. The planning stage also determines the division of individuals into heterogeneous groups based on basic values. In the first cycle, students' basic values were calculated from daily test scores; (2) Acting, is the application of the planning stage. Actions taken during the learning process are based on the learning devices that have been prepared. The learning devices used are adjusted to the steps of the PBL model and provide worksheets (LKPD) to students at each learning meeting; (3) Observing, Observation is carried out during the implementation of the action, to see whether or not the action is carried out following the learning scenario that has been created. Another aim of this stage is to pay attention to how teachers and students interact during learning in the classroom and to determine the optimality of the action. Observation is carried out along with the action being carried out. The results of the observation are used as a basis for reflection. The results of the observation must be able to describe the actual situation; and (4) Reflecting, Reflection has an evaluation aspect. Collaborative activities or cooperation with the teacher as an observer are needed to evaluate how the action is carried out. After the action in each cycle, reflection is carried out. Data obtained from the observation sheet will be processed at this stage. The results of the reflection are used to make improvements for the next cycle.

The data collection techniques used are observation and testing. Observation sheets function as observation guides for the implementation of learning models and teacher and student activities in the classroom. This sheet includes a description of indicators that of course refer to the steps of the PBL model. Filling out the observation sheet is done by writing comments and suggestions according to the actual picture of what is happening in the classroom. The results of the observations must be described in detail regarding the initial, core, and final activities on the observation sheet.

The data of students' mathematics learning outcomes were obtained through a written test (Cycle Test) conducted twice, namely in the first cycle after going through two meetings, and in the second cycle after going through two meetings. The Cycle Test was conducted to measure students' knowledge and skills. The examination of students' mathematics learning outcomes was based on alternative answers. Alternative answers were used as a scoring guideline to measure knowledge abilities, and the assessment rubric was used to measure skill abilities. The questions will be arranged in the form of descriptions based on the grids created to achieve problem-solving indicators that are adjusted to the main material of the linear program.

Observation sheets and learning outcome tests conducted will then be analyzed descriptively and narratively. The purpose of data analysis on both instruments is to measure and describe teacher activities and student behavior in mathematics learning of the eleventh-grade IPA students at SMA IT Al-Fityah Pekanbaru. Data analysis on both instruments is also expected to be able to describe the maximum or not of the actions that have been carried out. The stages of this analysis include: (1) reducing data, which is an activity to summarize the results of observations in the instrument without changing the information or descriptions of the data; (2) presenting data, to simplify the process of understanding the situation, planning the next steps based on understanding. Data presentation is presented in the form of systematic narrative text so that it is easier to conclude; and (3) drawing conclusions, an effort to provide an assessment based on structured data reduction and presentation, starting to draw temporary

conclusions at the end of cycle I and ending in cycle II. If the learning steps have a quality that is getting better at each meeting, then learning is improved.

Whether or not the Minimum Achievement Criteria (KKM) has been achieved is analyzed by comparing the percentage of students who have achieved the Minimum Achievement Criteria (KKM) on the basic score before and after the implementation of the action. This analysis aims to describe the achievement of each indicator by each student. Data on students' mathematics learning outcomes will be analyzed using descriptive statistics. Data on mathematics learning outcomes before and after the action to students are then presented or represented in the form of a frequency distribution table to obtain a concise and clear description of student learning outcomes. The formation of this frequency distribution table is also used to determine whether or not there is an increase or decrease in student learning outcomes before and after the action is carried out. Learning outcomes will increase if the percentage of students who meet the Minimum Achievement Criteria (KKM) on the cycle test after the action is higher than the percentage of students who achieve the Minimum Achievement Criteria (KKM) on the daily test before the action.

Classroom action research is said to be successful if the problems studied are increasingly narrowed down or if the problems are increasingly solved during each cycle. If the situation after the action becomes better or there is an improvement in the process and results of students' mathematics learning after the application of the PBL model, then it can be said that the action was successful, but if it is worse or even no different, the action has not been successful or is considered a failure.

The classification or interpretation of the success of this research action is: (1) there is a transformation of the learning process towards a better direction based on the results of the reflection of the learning process. This can be seen through the observation sheets of teacher and student activities. The category of the implementation of learning process improvements occurs if the implementation of learning is seen to be moving towards a positive direction and of course, based on the implementation of the PBL model in learning; and (2) The results of the analysis of the achievement of Minimum Achievement Criteria (KKM) and the analysis of frequency distribution data can show that the mathematics learning outcomes of students have increased. If there is a change in the frequency of students who are in a lower value interval (<70) to a higher value interval (≥ 70) from before the action to after the implementation of the action (Cycle I Test and Cycle II Test), then it can be concluded that the learning outcomes of students have increased. If in cycles I and II there is an increase in the learning process and mathematics learning outcomes of students, it can be concluded that the application of the PBL model can improve the learning process and mathematics learning outcomes of students in the eleventh-grade IPA students of SMA IT Al-Fityah Pekanbaru.

Results

In cycle I, the research instruments were prepared, namely learning devices (syllabus, RPP (Lesson Plan), LKPD (Worksheets)) which were designed by implementing the PBL model. Data collection instruments were also prepared (observation sheets for teacher-student activities, and mathematics learning outcome tests). Observations were made during the implementation stage of the action. Learning activities began with preparing students

physically and mentally, explaining learning objectives, and providing motivation, and apperception. In the core activity, forming students into groups and carrying out learning activities according to the PBL phase. In the closing activity, together with students, they concluded the learning material, reflected on what had been learned, gave formative tests, and homework, and informed the material for the next meeting. In the learning process of cycle II, the research instruments were no longer prepared because they had been carried out at the planning stage in cycle I. In cycle II, the steps were still implemented from cycle I, correcting deficiencies and weaknesses based on reflections from cycle I. Activities began with an introduction, core, and closing, but in each activity, there were certainly improvements from the deficiencies found in cycle I.

In the phase of organizing learning activities, students have been able to identify problems and students are active in expressing their opinions, in the phase of guiding group investigations, students are used to working together in their groups and actively asking questions if they find difficulties in working on LKPD, in the phase of developing and presenting the results of students' work, they are enthusiastic about submitting themselves to convey the results of group discussions and in the phase of analyzing and evaluating students also dare to comment and provide responses. The application of the PBL model carried out by researchers has a positive impact on the implementation of the learning process, namely, students actively participate in the learning process such as asking questions, answering questions from teachers and friends, and being able to submit themselves in learning by appearing in front of the class, so that learning is not centered on the teacher. Students do not only receive lesson materials from the teacher but also explore and develop their knowledge.

Analysis of data describing the Minimum Achievement Criteria (KKM) was carried out by comparing the total percentage of students who met the Minimum Achievement Criteria (KKM) on the basic score before and after the implementation of the PBL model, namely the Cycle I Test score and Cycle II Test score. The school sets the Minimum Achievement Criteria (KKM) for mathematics learning at 70. Students are considered to have completed it if the KKM set by the school is achieved, or in other words, their learning outcomes in mathematics learning are at a value of ≥70. Figure 1 below shows the percentage of achievement of the KKM for students' mathematics learning outcomes.

Based on Figure 1, it can be seen that the total number of students who achieved the KKM in the Cycle I Test was 59.26%, an increase of 14.82% from the basic score. In the Cycle II Test, the total number of students who achieved the Minimum Achievement Criteria (KKM) was 77.78%, an increase of 33.34% from the basic score and an increase of 18.25% from the Cycle I Test. From this data, it can be seen that the achievement of the Minimum Achievement Criteria (KKM) of students increased by 14.82% from the basic score. Students who achieved the Minimum Achievement Criteria (KKM) of knowledge competency in the Cycle I Test increased by 3 people from the basic score with an increase of 11.11%, and in the Cycle II Test, many students who successfully met the Minimum Achievement Criteria (KKM)of knowledge competency increased by 6 people from the basic score with an increase of 22.23%. This shows that the achievement of the Minimum Achievement Criteria (KKM) of students' knowledge competency increased from before the action rather than after the action. The achievement of KKM competency skills of students has increased by 18.52%, with as many as 5 people from

Test Cycle I to Test Cycle II. Thus, it can be said that the achievement of the Minimum Achievement Criteria (KKM) in competency skills of students has increased.

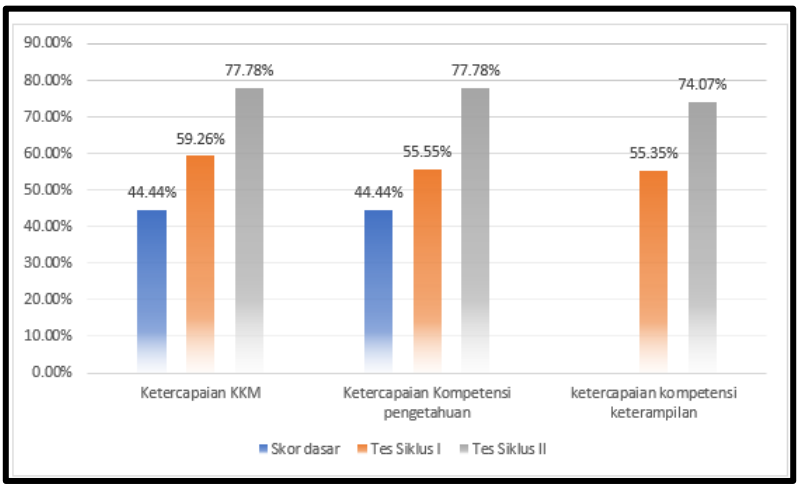

Figure 1. The Percentage of Students Achieving the Minimum Achievement Criteria (KKM) in Mathematics Learning Outcomes

Individual analysis was conducted to show the improvement of students' mathematics learning outcomes. These results were then presented in the form of a frequency distribution. The frequency distribution table was created based on the KKM interval reference guidelines. Table 1 below shows the frequency distribution as a description of students' mathematics learning outcomes.

Table 1. The Distribution Frequency of Students' Mathematics Learning Outcomes

Interval	Students' Frequency			Criteria
	Basic Score	Cycle 1 Test	Cycle II Test	
0-9	-	-	-	Not Good (Score<70)
10-19	-	-	-	
20-29	-	-	-	
30-39	-	-	-	
40-49	-	-	-	
50-59	3	4	1	
60-69	12	7	5	
70-80	3	8	6	Fair
81-90	7	5	11	Good
91-100	2	3	4	Very Good
$\sum f$	27	27	27	

Based on Table 1, in the basic score, 15 students had not reached the KKM. In the Cycle I Test, it decreased to 11 students, then decreased again to 6 students in the Cycle II Test. On the other hand, the number of students who achieved the KKM increased, from 12 students (44.44%) in the basic score, to 16 students (59.25%) in the Cycle I Test and 21 students (77.78%) in the Cycle II Test. Furthermore, in the basic score, the highest score of students was in the "Very Good" criteria as many as 2 students, then in the Cycle I Test it increased to 3 students, and the frequency for the "Very Good" criteria in the Cycle II Test increased again. In the Cycle II Test, the number of students who obtained the lowest score interval of 60-69 decreased from the basic score and the Cycle I Test.

The data above shows that the learning outcomes of students increased after the action was taken, namely the learning outcomes changed towards a better direction, indicated by an increase in the frequency of students at intervals below the KKM from the basic score to the Cycle I Test and Cycle II Test or an increase in the frequency of students at intervals above the KKM from the basic score to the Cycle I Test and Cycle II Test. So, it can be said that the mathematics learning outcomes of students increased.

Discussion

The PBL model applied by researchers in the implementation of learning has a positive impact. Analysis of teacher and student activities during the implementation of the PBL model shows that during the learning process, the desired progress has been achieved, with narrative descriptions showing how intense interactions between teachers and students encourage creative problem-solving, productive collaboration, and significant improvements in understanding concepts and relevant practical skills. Most students are actively involved in the learning process, resulting in learning no longer being centered on the teacher, students not only receive lesson material from the teacher but also explore and develop their knowledge (Muhartini et al., 2023). In line with Sastrawadi & Rusdi's claim that by using the PBL model, the learning process can be changed, especially concerning the role of the teacher (Pamungkas et al., 2019). In addition, PBL is a learning model that applies problems in everyday life as a context for students to gain knowledge (Anwar & Jurotun, 2019). This will make students accustomed to working on contextual questions (daily life) so that learning becomes more meaningful and sticks in students' memories.

The mathematics learning outcomes data, shows an increase, in many students who meet the Minimum Achievement Criteria (KKM) standard in the knowledge and skills aspects. Students who meet the KKM standard in the knowledge aspect before the implementation of the action were 44.44% (12 students) in cycle I, increasing to 55.55% (15 students) in cycle I, and increasing again to 77.78% (21 students) in cycle II. Students who achieved Minimum Achievement Criteria (KKM) in skills competency in Cycle I were 55.25% (15 students) and increased to 74.07% (20 students) in Cycle II. These results show that there is an increase in students' mathematics learning outcomes with the application of the PBL model. In line with the research conducted by (Widiyana, 2021) in tenth-grade IPS 3 students at SMAN 4 Pekanbaru. Before the implementation of the PBL model, students' learning outcomes were relatively low, after the researcher implemented the PBL model as an effort to improve the learning outcomes of students at SMA 4 Pekanbaru in the tenth-grade IPS 3 students. The average student learning outcomes increased from before the action to after the action. Research conducted by (Sihotang & Sihombing, 2018) also proved that students' mathematics learning outcomes increased when the PBL model was applied.

Based on the explanation above, it can be said that the efforts or actions taken have been successful. According to the opinion expressed by Sanjaya (in his book entitled "Learning Strategy Oriented to Educational Process Standards"), if the problems discussed are increasingly narrowed down or through the actions of each cycle the problems are increasingly solved and there is an increase in learning outcomes obtained by students from cycle I to cycle

II, it can be concluded that the classroom action research conducted has been successful (Anjastin et al., 2018).

Conclusion

The presentation of the research results and discussion shows that the implementation of the PBL model can improve the learning process and increase the mathematics learning outcomes of the eleventh-grade IPA students at SMA IT Al-Fityah Pekanbaru on the main material of Linear Programs in the odd semester of the 2023/2024 school year. Through the research that has been conducted, suggestions are given for the PBL model in mathematics learning. This model can be considered one of the better learning models to be applied in mathematics learning because it can trigger active participation of students and improve their understanding of concepts. After all, the questions are related to everyday life. To ensure that each stage of learning runs according to the learning implementation plan and achieves learning objectives, teachers who apply this learning model must pay more attention to time management and class guidance during the learning process.

Declarations

Author Contribution	:	AMF: Writing-Original Draft. YR: Writing-Review & Editing. AM: Writing-Review & Editing.
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	The research ethics board of this institution consists of a panel responsible for granting permission to researchers to proceed with their studies within the school environment. Since this research involves educational aspects and activities at the school, the author has obtained permission from relevant parties, including the school principal and the local education office. To maintain privacy and confidentiality, all responses from research participants will be protected through the use of pseudonyms, ensuring that their identities remain concealed.

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