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Integration of Social Emotional Learning (SEL) into Problem-Based Learning (PBL) to Improve Mathematical Representation

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Abstract. *This classroom action research aims to improve students' mathematical representation abilities by applying problem-based learning (PBL) combined with social-emotional learning (SEL). PBL emphasizes problem-based learning, while social-emotional learning is a learning method that supports the development of students' social and emotional competencies. This study consists of two cycles, each containing steps, namely, planning, action, observation, and reflection. The instrument of this study uses a teaching module with the material of a two-variable linear inequality system. This study used subjects of class X 2 students of SMA Negeri 5 Jember in the 2024/2025 Academic Year. The results showed that applying PBL and social-emotional learning (SEL) can improve students' mathematical representation in verbal, visual, and symbolic aspects by 22.5%, from 70.6% to 93.1%. In addition, students' social-emotional competence (SEC) also increased by 21.7%, from 68.8% to 90.4%. Therefore, the integration of SEL in PBL can be an effective strategy for improving students' mathematical representation as well as social-emotional competence (SEC).*

Keywords: *mathematical representation, PBL, SEL*

INTRODUCTION

Students' mathematical ability is the ability of students to solve a mathematical problem. Mathematical ability consists of several main aspects, namely, conceptual understanding, reasoning, problem-solving, communication, and mathematical representation. Conceptual understanding involves students' ability to understand and internalize mathematical ideas (Giriansyah et al., 2023), while mathematical reasoning includes the ability to make conclusions and logical arguments (Marfu'ah et al., 2022). Problem-solving is students' skills to apply mathematical knowledge in real situations (Riyanto et al., 2024). Mathematical communication involves students' ability to convey mathematical ideas effectively (Triana et al., 2019). Improving students' mathematical abilities will support the development of students' critical and creative thinking skills.

One of the mathematical abilities that students must have is mathematical representation ability. Mathematical representation ability is the ability of students to communicate mathematical ideas or concepts in a certain way (Hardianti & Effendi, 2021). One of the effective practices of teaching mathematics is to use and connect mathematical representations (NCTM, 2020). This mathematical representation ability is applied to find out how students understand mathematical concepts to present solutions to mathematical problems. Mathematical representation ability consists of verbal, visual, and symbolic representations. Verbal representation is related to students' ability to make mathematically reasonable explanations, then visual representation is related to students' ability to draw diagrams/pictures correctly. Symbolic representation is related to students' ability to find mathematical models and get solutions accurately and systematically (Supandi et al., 2018).

Based on in-depth analysis, most students at SMA Negeri 5 Jember face significant challenges in their mathematical representation skills. The data shows that 33.3% of students have difficulty explaining mathematical concepts related to the problems given. That situation reflects low mathematical literacy, so their learning results do not reach their optimal potential. Furthermore, around 45% of students show a minimum enthusiasm for following the learning process. They also have difficulty actively participating in class discussions and show independent learning skills that still need to be improved. Although teachers have made maximum efforts by implementing demonstration methods to facilitate understanding of concepts, 43% of students cannot represent solutions well in the context of mathematical problems. This problem also occurs in high schools in Tasikmalaya, where 41% of students cannot describe the model of a two-variable linear inequality system in a Cartesian diagram (Nurhayati & Ratnaningsih, 2023). Thus, the appropriate interventions become imperative to improve students' mathematical representation skills. This effort aims to help them understand the material better and increase their motivation and engagement in learning.

The problem-based learning (PBL) model is applied to determine the mathematical representation skills of students in learning activities. Problem-based

learning (PBL) is a model that connects learning activities with contextual problems so students can think actively and make conclusions (Sulistiana, 2022). Learning activities will be effective and meaningful if students have optimal social and emotional competencies. Social and emotional competencies come from social-emotional learning (SEL) through explicit instructions and student-centred learning approaches that help students to be involved in the learning process and develop analytical, communication, and collaborative skills (Widiastuti, 2022). The integration between PBL and SEL creates a holistic learning environment. Students develop not only cognitive skills but also social and emotional intelligence. They learn to analyze problems from multiple perspectives, communicate solutions clearly, and respect diverse viewpoints. As a result, their mathematical representation abilities improve not just technically but also meaningfully as they connect abstract concepts to real-life contexts through collaborative exploration. By adopting this integrated approach, educators can make mathematics more engaging and relevant (Lathifah et al., 2023). Learning shifts from rote memorization to an active process of discovery, teamwork, and personal growth, preparing students for academic and real-world challenges.

SEL application in history subjects that apply the culturally responsive teaching (CRT) method has encouraged students to be motivated and confident in expressing their opinions. However, the study has not had an in-depth analysis of more technical subjects, such as mathematics or science (Nasution et al., 2023). Previous studies using the PBL model have been able to increase student activity so that they can solve problems using mathematical concepts. However, the study has not integrated PBL with other learning methods to see its impact on students' mathematical representation abilities (Sari et al., 2023). In addition, the PBL model also has a good effect on social-emotional competence by supporting better communication interactions between students in science and science material (Amalia et al., 2024).

In addition, research on science learning integrated with social-emotional skills can improve intellectual and social-emotional abilities in students (Masyithah, 2021; Miranda et al., 2024). Further research by implementing a

project-based learning model (Project Based Learning or PjBL) integrated with SEC (Social Emotional competencies) techniques could improve student activity and learning results in Mathematics learning. However, in that study, there has been no analysis of how this model is integrated with PBL to achieve more optimal results (Ramayati et al., 2025). The PBL integrated with social-emotional learning (SEL) can increase student activity and critical thinking skills (Ruhmana et al., 2023; Setiawati et al., 2024), but this study has not discussed the mathematical representation abilities of students. Therefore, this study aims to improve students' mathematical representation abilities using the PBL model and social-emotional learning (SEL) on the material of two-variable linear inequality systems at SMA Negeri 5 Jember. The researcher chose that topic because learning about two-variable linear inequalities helps students connect math to real life. In Jember, where agriculture and small businesses are essential, these inequalities vividly illustrate real-life situations, like planning crop harvests or managing budgets for school events. This subject undeniably prepares students for advanced studies in economics, engineering, and science. Through collaborative problem-solving, they not only sharpen their math skills but also forge strong teamwork and critical thinking abilities that will serve them well in the future.

RESEARCH METHOD

This study uses Classroom Action Research (CAR). CAR is an activity carried out by teachers to improve or enhance the quality of learning (Manik et al., 2023). This study planned to conduct two cycles, consisting of four steps, namely, 1) planning, 2) action, 3) observation, and 4) reflection. In this study, the material used was a two-variable linear inequality system. The subjects in this study were 30 students of class X 2 from SMA Negeri 5 Jember in the 2024/2025 academic year.

In cycle I, the planning step, the researcher prepared learning devices consisting of the development of teaching modules, teaching materials, and LKPD for learning activities. At the action step, the researcher carried out offline learning with students according to the devices that had been prepared previously. Then, for

the observation step, the researcher observed the process of working on student worksheets that had been worked on by students at the action stage and conducted an attitude assessment according to social-emotional competence with the attitude assessment guidelines contained in Table 1. This attitude assessment measures the social-emotional competence (SEC) possessed by students.

Table 1. Attitude Assessment Guidelines

Score	Self-awareness	Self-management	Social awareness	Relationship skills	Responsible decision-making
4	Be orderly in activities and wear neat clothes when participating in learning activities.	Have initiative, critical thinking in class, and be independent.	Be enthusiastic and active in learning and be able to share understanding with friends.	Respect friends' opinions in discussions and creativity in presenting independent work results.	Dare to express their opinions in class and be responsible for their assignment.
3	Begin to be orderly in activities and wear neat clothes when participating in learning activities.	Begin to have initiative, critical thinking in class, and an independent attitude.	Begin to be enthusiastic and active in learning and can share understanding with friends.	Begin to appreciate friends' opinions in discussions and be creative in presenting independent work results.	Begin to dare express their opinions in class and are responsible for their assignment.
2	Not yet orderly in activities and does not wear neat clothes when participating in learning activities.	Not yet having initiative, critical thinking in class, and an independent attitude.	Not yet enthusiastic and active in learning and not yet able to share understanding with friends.	Not yet respecting friends' opinions in discussions and not yet having creativity in presenting independent work results.	Not yet daring to express their opinions in class and being responsible for their assignment.
1	Never orderly in activities and wear neat clothes when participating in learning activities.	Never having initiative, critical thinking in class, and an independent attitude.	Never enthusiastic and active in learning and unable to share understanding with friends.	Never respecting friends' opinions in discussions and creativity in presenting independent work results.	Never daring to express their opinions in class and being responsible for their assignment.

(Widiastuti, 2022)

The attitude assessment criteria can be seen in Table 2. The last step is reflection. At this step, the researcher records all findings during and after the learning process. The researcher now analyzes the observation results and what was and was not accomplished before to improve in cycle II.

Table 2. Attitude Assessment Categories

Percentage of Achievement	Category
$86 - 100$	Exemplary
$76 - 85$	Proficient
$60 - 75$	Developing
$55 - 59$	Emerging
< 54	Beginning

Cycle II has the same flow as the step in Cycle I, but in Cycle II, the planning step refinement to the learning results obtained by students previously in Cycle I. Cycle II is the end of this study. The researchers use the scoring guidelines in Table 3 (Supandi et al., 2018).

Table 3. Mathematical Representation Ability Scoring Guidelines

Score	Verbal Representation	Visual Representation	Symbolic Representation
4	The explanation is mathematically sound, clear, and logically structured.	Describe diagrams/pictures completely, correctly, and systematically.	Finds mathematical models correctly and performs calculations or obtains solutions accurately and systematically.
3	The explanation is reasonable and correct. However, it is not logically structured, and there are slight language errors.	Describe a diagram/picture, but the answer is incomplete and inaccurate.	Finds the mathematical model correctly and gets the solution but is wrong in the calculation.
2	The mathematical explanation is understandable and correct but only partially complete and correct.	Describe a diagram/picture that lacks explanation.	Finding the mathematical model correctly, but is wrong in obtaining the solution.
1	Only a few explanations are correct.	Only a few pictures/diagrams are correct.	Only a few of the correct mathematical models.
0	No answers, and even if there are, they only show a lack of understanding of the concept, so the information provided is meaningless.		

(Supandi et al., 2018)

To get the percentage of students' mathematical representation ability, the researcher used the formula in equation (1) as follows. (Pahleviannur, 2022).

$$RM = \frac{Score}{Maximum\ score} \times 100\% \quad (1)$$

Note :

RM: Percentage of students' mathematical representation ability

The calculation results of the percentage of students' mathematical abilities will be grouped into a category based on Table 4.

Table 4. Mathematical Representation Ability Assessment Category

Percentage of Achievement (%)	Category
$90 \leq RM \leq 100$	Excellent
$78 \leq RM < 90$	Developing
$55 \leq RM < 78$	Satisfactory
$40 \leq RM < 55$	Need Improvement
$RM < 40$	Unsatisfactory

This research is said to be successful if students' learning results and attitude assessment results increase in cycle II. Besides that, all of the results must reach more than 78 because the success indicators for learning results and attitude assessments are that students obtain scores that reach the KKM, namely ≥ 78, with the percentage of students completing the KKM.

RESULT AND DISCUSSION

Cycle I

The planning stage in cycle I begins with preparing learning tools, such as teaching modules and LKPD, along with assessment instruments by the PBL model integrated with SEL. Then, in the action stage, the researcher carried out learning activities by implementing social-emotional learning, which has five competencies. Learning activities begin by implementing self-awareness competency in preliminary activities, and the teacher will apply self-management competency, social awareness, and relationship skills, as well as responsible decision-making by conducting discussions and working on the assigned tasks. The mathematical problem-solving in cycle I of one of the students (AF) can be seen in Figure 1. The student's answer was selected for its unique qualities that defied effective verbal and visual representation, highlighting its depth and originality.

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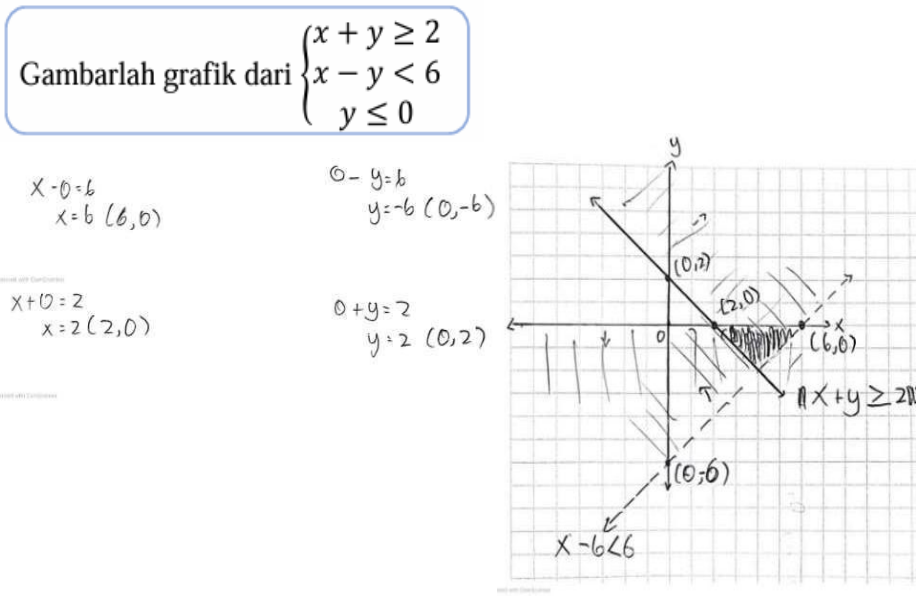

Figure 1. Mathematics Problems and Solutions Cycle I

In Figure 1, the solutions are obtained without mathematical explanation and arranged systematically and logically to determine the intersection points and shaded areas in the graph. The graph in Figure 1 is also not yet equipped with a scale on the x and y axes. In the observation step on cycle I, the researchers found that students' SEC achievement in the Developing category of responsible decision-making competency obtained the lowest achievement, namely 66.3%, while self-management competency achieved the highest achievement, namely 72.5%

Table 5. Social Emotional Competence Achievement Cycle I

Competence	Achievement (%)	Category
Self-awareness	67.1	Developing
Self-management	72.5	Developing
Social awareness	67.9	Developing
Relationship skills	70	Developing
Responsible decision-making	66.3	Developing

In cycle I, students were given a mathematical problem to draw the result area of a two-variable linear inequality system. The learning results in cycle I can be seen in Figure 2. According to the school's KKM, which is 78, 80% of students have not finished it, which is coloured red in Figure 2, whereas 20% of students have done so because their scores are higher than the KKM. The lowest score in

this cycle is 50, and the highest value is 83.3, with the average score of students in cycle I being 68.1. The learning results in Figure 2, when grouped based on mathematical representation abilities, are in Table 6. The achievement of verbal and visual representation is in the Satisfactory category, and symbolic representation is in the high category with a percentage of 81.7%.

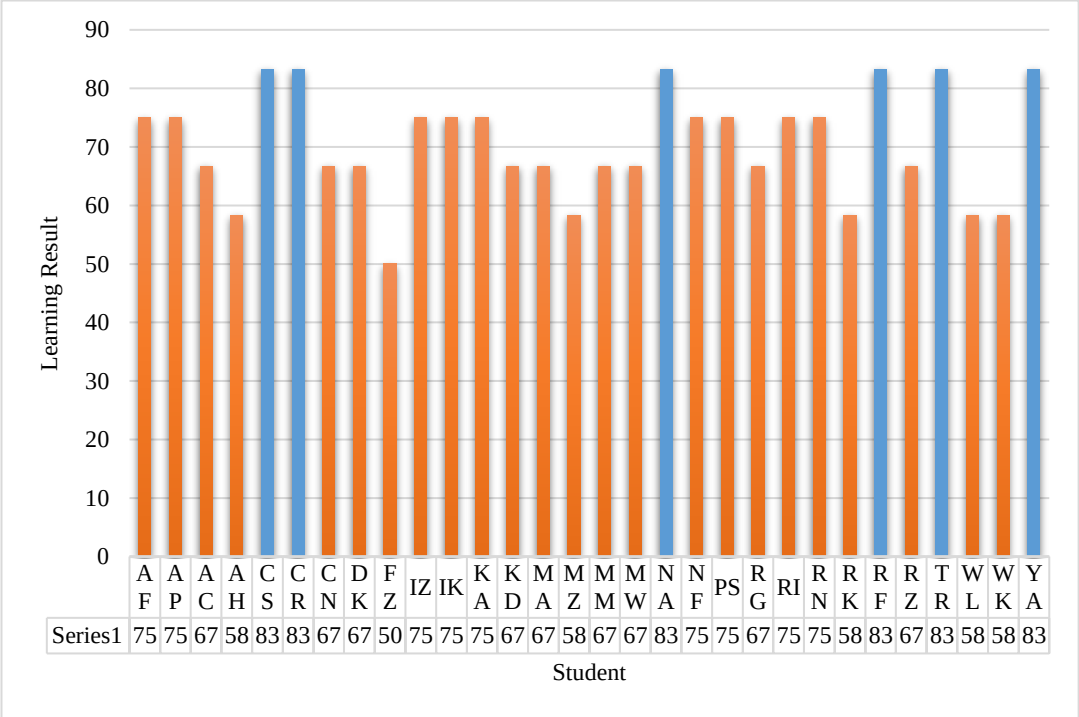

Figure 2. Learning Results in Cycle I

In the reflection step in cycle I, the mathematical representation abilities of students obtained an average of 70.6%, which means it is still in the moderate category. Students could perform calculations or obtain solutions accurately and systematically, so their achievements are in the high category in the symbolic representation aspect. However, in the verbal and visual representation aspects, the percentage has not yet reached the KKM. This result is because students find it hard to provide mathematically reasonable explanations, clearly and logically arranged and to describe diagrams/pictures completely, correctly, and systematically. Therefore, 80% of students have not completed it because they have learning results that have not reached the KKM.

Table 6. Achievement of Mathematical Representation Ability Cycle I

Mathematical Representation	Achievement (%)	Kategori
Verbal Representation	60.8	Satisfactory
Visual Representation	69.2	Satisfactory
Symbolic Representation	81.7	Good

Based on data analysis and observation of SEC achievement in Table 5. students are in the Developing category ≤ 78%. Responsible decision-making competency has the lowest achievement of 66.3%, which means that students begin to dare to express their opinions in front of the class and are responsible for what they do. The result of self-awareness and social competency also needs to be improved with the aim that students are orderly enough to participate in learning activities and wear neat clothes when participating in learning activities. In addition, students begin to be enthusiastic and active in learning and can share understanding with friends. For this reason, in cycle II, students will be more guided in learning activities in the section on developing and presenting work results and analyzing and evaluating the problem-solving process. That aims to make students more courageous in expressing their opinions in front of the class and being responsible for what they do. In addition, other SEC will improve so that students' learning results are optimal so that they can increase students' mathematical representation abilities.

Cycle II

The learning activity tools in cycle II improved based on the learning results of cycle I, which only 20% of the 30 students completed. Similar to cycle I, cycle II began with the planning step based on the reflection stage that the researcher had carried out in consultation with the supervising teacher and field supervisor. Furthermore, the researcher carried out the previously revised learning activities for the action step. The mathematical problems and their solutions for cycle II of one student (AF) can be seen in Figure 3. The student's answer was selected for its remarkable development and depth of insight.

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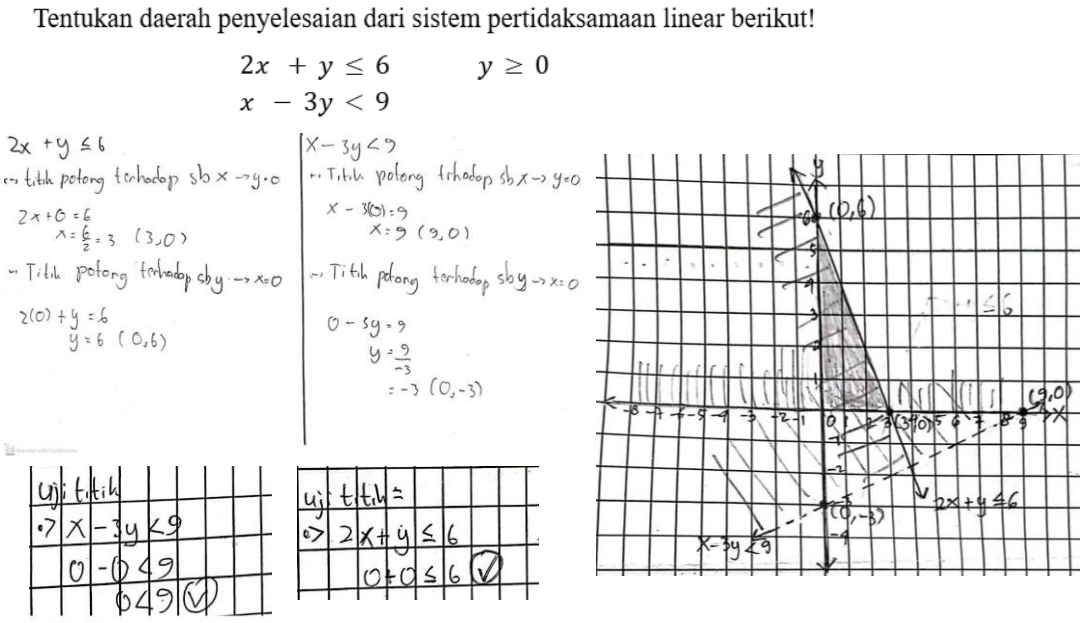

Figure 3. Mathematics Problems and Solutions Cycle II

In Figure 3, the solutions have a mathematical explanation and are arranged systematically and logically to determine the intersection points and shaded areas on the graph. The graph in Figure 3 was completed with a scale on the x and y axes. At the observation step, there is an attitude assessment based on social-emotional competence, the results are illustrated in Table 7. The attitude assessment in cycle II experienced an increase of 21.7%, where initially all students were in the Developing category, then in cycle II, all students were in the Exemplary category.

Table 7. Social Emotional Competence Achievement Cycle II

Competence	Achievement (%)	Category
Self-awareness	91.7	Exemplary
Self-management	92.9	Exemplary
Social awareness	90.4	Exemplary
Relationship skills	89.2	Exemplary
Responsible decision-making	87.9	Exemplary

In cycle II, students were given mathematical problems related to determining the area of the results of a two-variable linear inequality system. Then, they were given instructions to solve the problem. The results of the work based on

mathematical representation abilities can be seen in Figure 4. All students have successfully achieved the KKM. There were 46.6% of students who obtained the maximum score of 100, while there were 3% of students who obtained the minimum score of 78, and the average student score was 89.8.

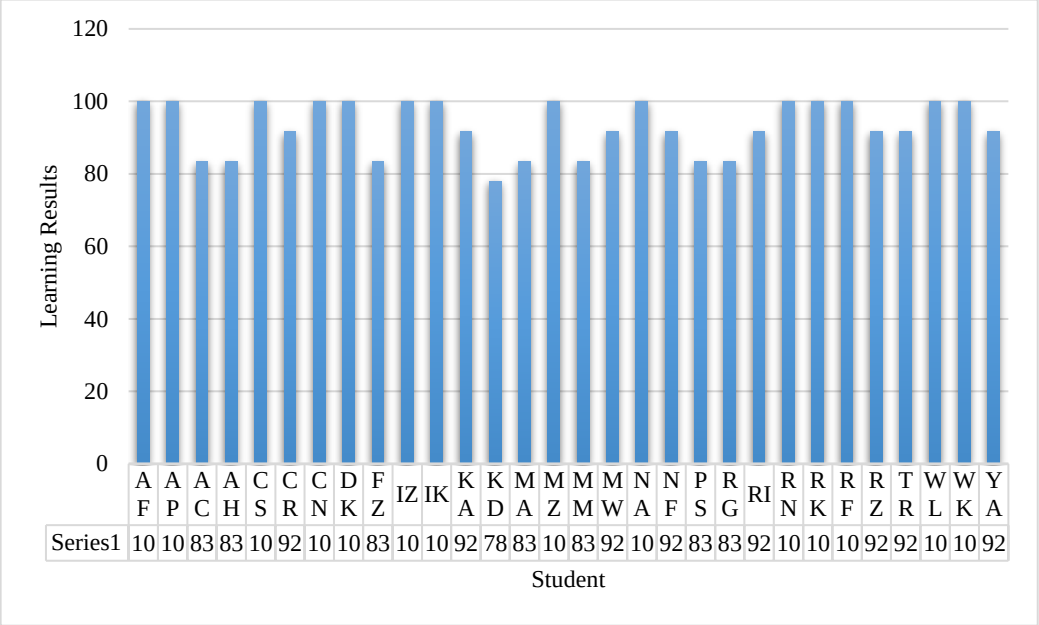

Figure 4. Learning Results in Cycle II

The students' learning results in Figure 4, when grouped based on mathematical representation ability, are shown in Table 8. Based on the table, the verbal representation achievement was in the Good category, while symbolic and visual representation were in the Excellent category with a percentage of 100%.

Table 8. Achievement of Mathematical Representation Ability Cycle II

Mathematical Representation	Achievement (%)	Category
Verbal Representation	85.8	Good
Visual Representation	93.3	Excellent
Symbolic Representation	100	Excellent

In the reflection stage in cycle II, the mathematical representation ability of students, the average was 93.1%, which means it is in the Excellent category, so there was an increase of 22.5% from cycle I. Students have achievements that are included in the Good category in the verbal representation aspect, where students can provide mathematically reasonable explanations clearly and logically arranged.

In the visual and symbolic representation aspect, students can describe diagrams/pictures completely, correctly, and systematically, perform calculations or obtain solutions accurately and systematically. For this reason, 100% of students have completed it because they have learning results that reach the KKM. Based on data analysis and observation, the achievement of SEC in Table 7, students are in the Exemplary category ≥ 78% while mathematical representation ability is in the Good and Excellent categories. For this reason, this study can be stopped in cycle II because the achievement of SEC and learning results reach the KKM. Furthermore, comparing the improvements that occur in the achievement of SEC and mathematical representation ability.

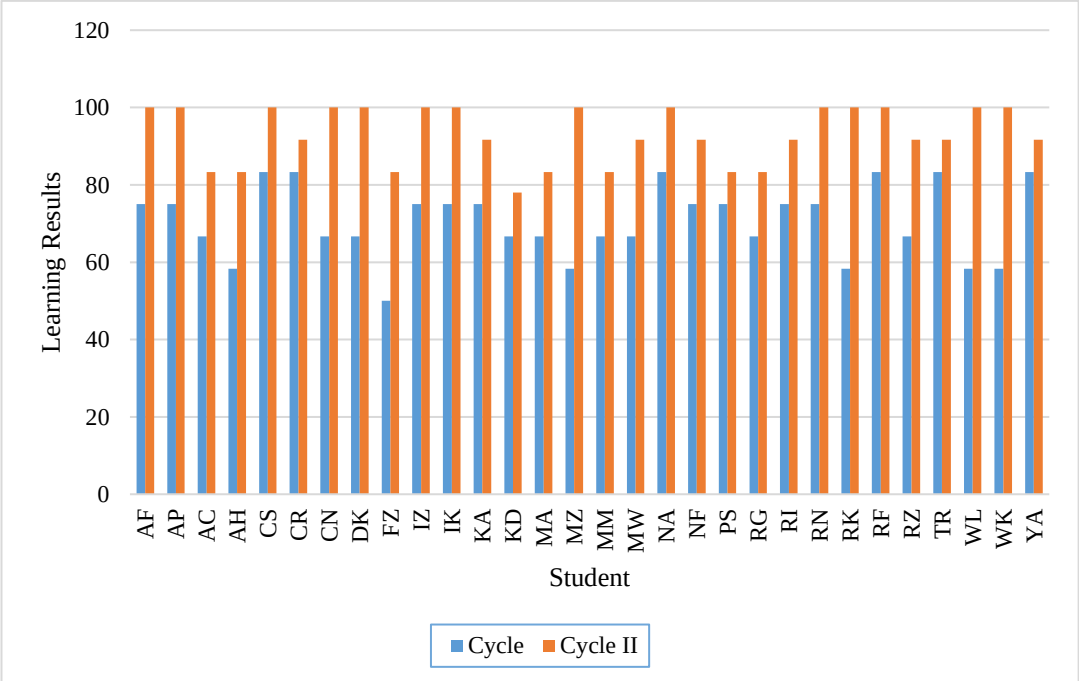

Figure 5. Comparison of Learning Results

Figure 5 compares the learning results of the students. The learning results for the students improved; whereas only 20% of them finished Cycle I, 100% of them did so in Cycle II, and 46.6% of them even received the highest possible score. According to earlier research by Nur Fadhil et al. (2023), pupils' increased social-emotional competence is directly correlated with their increased mathematical representation ability.

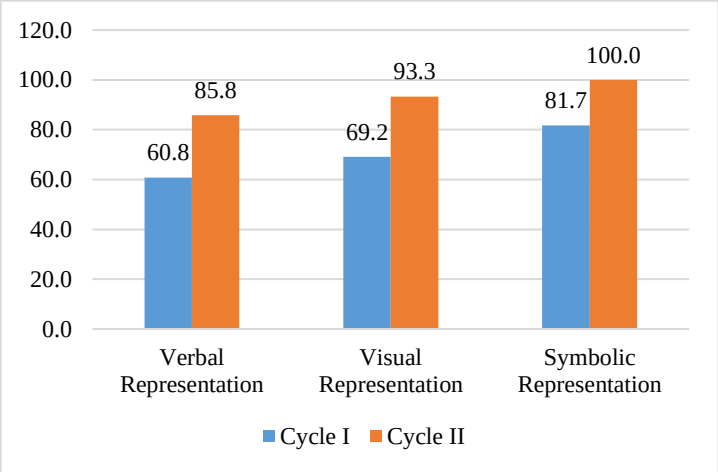

Figure 6. Comparison of Mathematical Representation Ability

Figure 6 shows that the mathematical representation ability in cycles I and II experienced an increase of 22.5% overall from the three aspects of mathematical representation ability. The verbal representation aspect had the highest increase of 25% compared to the other two aspects. That result means students try hard to provide mathematically reasonable, clear, and logically structured explanations in working on the given mathematical problems.

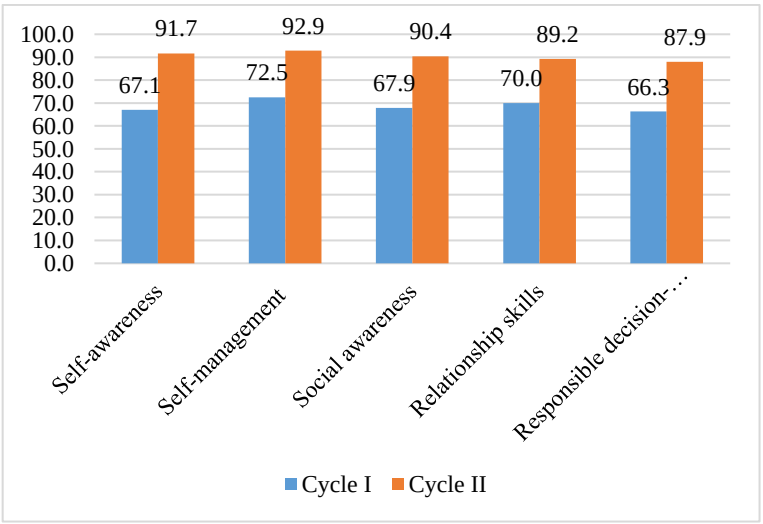

Figure 7. Comparison of Social-Emotional Competencies

Figure 7 illustrates an increase of 21.7% for the overall social-emotional competency. Self-awareness competency obtained the highest increase of 24.6% compared to the other four competencies. This result means that students try hard

to be orderly in activities and wear neat clothes when participating in learning activities. These results are by the application of social-emotional learning, which will increase SEC (Nengah et al., 2025; Setiawati et al., 2024).

When combined with problem-based learning (PBL), social-emotional learning (SEL) enables students to think critically to solve issues, generate ideas, and reach conclusions. These activities are classified from the Constructivism Theory, which emphasizes active learning experiences (Arafah et al., 2023). Based on this theory, knowledge is formed through construction carried out by humans on the reality they face. Over time, this theory has been influenced by the discipline of psychology, especially the cognitive psychology proposed by Piaget, which is concerned with the psychological mechanisms that drive the process of knowledge formation (Wahab & Rosnawati, 2021).

Students who get encouragement for the knowledge process can solve mathematical problems with one of the mathematical abilities, which is mathematical representation. For this reason, the mathematical representation abilities increase by implementing social-emotional learning (SEL) with the PBL model based on Constructivism Theory. These results are by previous research by Ruhmana et al. (2023) that the PBL model integrated with SEC can encourage students to improve their critical thinking and learning results.

This study highlights opportunities for further development of PBL and SEL integration. Future research should expand the sample size and diversity, test the approach on other mathematical topics, and assess its long-term impact on students' social-emotional skills and academic performance. Additionally, mixed-methods research could provide deeper insights into teacher and student perceptions. These explorations would strengthen the foundation for more holistic learning approaches.

CONCLUSION

Integration of the PBL model and social-emotional learning (SEL) on the material of two-variable linear inequality systems of class X 2 SMA Negeri 5 Jember can improve students' mathematical representation abilities. This result can be seen from the achievement of learning results in cycle I increased in cycle II by

22.5% overall in verbal, visual, and symbolic representation. The increase in mathematical representation ability is directly proportional to the increase in students' social-emotional competence by 21.7%. Therefore, social-emotional competence (SEC) can help improve students' mathematical representation abilities by applying the PBL model and social-emotional learning (SEL).

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