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Student Problem-Solving Ability in Views of Self-Directed Learning on Problem Based Learning Assisted by Module

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Abstract

This research described the required module patterns for the students based on the self-directed learning types to improve their problem-solving skills taught by problem-based learning. The applied design was qualitative descriptive. Thus, the research described the observed events qualitatively and quantitatively. The subjects consisted of 35 students of XI Science 4 at Senior High School Grabag, the academic year 2021/2022. The researchers took the data source with a purposive sampling technique by considering certain objectives. Then, the researchers collected the data with a self-directed learning questionnaire, problem-solving skill test, observation, and interview. The researchers analyzed the data qualitatively. The researchers also used N-gain analysis to determine the improvement. The results showed that (1) students with high self-directed learning applied the first module pattern in the form of a scaffolding technique to model the behaviors and provide an explanation, (2) students with moderate self-directed learning applied the second module pattern in the form of scaffolding technique to invite the participation of other students and to share the keywords; (3) studentss with low self-directed learning applied the third module pattern in the form of scaffolding to model the behavior, present explanation, participate, and invite other students by providing keywords; (4) improved problem-solving skills; and (5) reaching the minimum standard mastery for learning taught by problem-based learning assisted by module.

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INTRODUCTION

Permendiknas No. 22 Year 2006 explains that mathematics lesson is important for Senior High School students to learn. The lesson prepares the students to solve problems by having the capabilities to understand the problem, design the mathematics model, complete the model, and interpret the obtained solutions. Phonapichat et al., (2014) also explain that mathematics is a mean to train students to solve problems and to construct advanced cognitive processes to solve non-mathematics problems.

NCTM (2000) formulates the mathematics learning objectives to improve the mathematics power, such as: (1) learning to mathematically communicate, 92) learning to mathematically reason, (3) learning to mathematically solve problems, (4) learning to mathematically connect ideas, and (5) learning to represent. From the formulation, problem-solving skill is an important aspect for students to master.

One of the skills of mathematics power, demanded by TIMSS and PISA, is a problem-solving skill. TIMSS explains that problem-solving skill covers the cognitive assessment domain, starting from cognition, implementation, and reasoning. The relevant problem-solving skill by TIMSS and PISA demand in this research is Polya-based problem-solving. This problem-solving skill refers to mathematics problem-solving skills by finding answers based on some stages. They are (1) understanding problems, (2) planning the solution and strategy, (3) executing the solution with the planned strategy, and (4) rechecking the obtained answer correctness.

Based on the preliminary study, the researchers found the students' problem-solving skills were not optimum. Most students were confused and doubt to plan the solution stages for the mathematics questions. They were less active to ask during classroom learning. These poor mathematics problem-solving skills influenced the learning quality.

Teachers have important roles to support the future 2045 generation. Therefore, education should not only transfer knowledge but also develop the students' characters. The applied character development should begin immediately. Excellent characters lead to a strong mentality so that the next generation could advance the nation greatly and in a dignified manner (Darman, 2017; Manullang, 2013).

Perpres No. 87 Year 2017 explains one of the characteristics is self-directed learning. Self-directed learning requires a self-directed learning strategy, effective feedback for learning, and motivation dependency (Zimmerman, 1990). Self-directed learning is important for students to improve so that they can solve problems without teachers' assistance (Amalia & Sukestiyarno, 2021). (Brookfield, 2000; Kamaruddin et al., 2012; Knowles, 1975; Lowry, 1991) defines self-directed learning as an individual process. This process consists of: (1) learning initiation without other individual assistance, (2) diagnosing learning necessities and formulating the learning objectives independently, (3) identifying learning sources to use, (4) having and determining learning strategies, and (5) evaluating learning outcomes. Sumarni & Sumarmo, (2016) explain self-directed learning as an excellent tendency, supervising skill, evaluating skill, directedness, and cognitive and behavioral control of students. Students with self-directed learning could perform excellently both individually and collectively.

The observation results at Public Senior High School 1 Grabag found that the students had low self-directed learning. The evidence was - most students did not initiate learning autonomously. Most students relied on their peers to work on the given assignment. Some of them even copied their friends' works. They also rarely accessed the internet to get learning materials. Thus, they required learning innovation to positively influence their self-directed learning.

The promoted classroom learning by teachers influenced the problem-solving skill and self-directed learning indicator achievements. One of the learnings to improve the problem-solving skill is mathematics problem-solving skills with problem-based learning (Sumartini, 2016). (Ismawati et al., 2017; Sariningsih & Purwasih, 2017; Yuliasari, 2017) also, explain that problem-based learning could improve the mathematics skills of students. Students must be skillful in the learning process so they could successfully learn during the PBL. Thus, PBL is strongly dependent on external sources to improve

the students' self-directedness (Aulia et al., 2019). This model could improve the self-directed learning of the students and their problem-solving skills improvements.

PBL provides an excellent problem-solving plot and presents contextual problems. Thus, students will have the motivation to learn and improve their problem-solving skills (Vendiagrys et al., 2015; Wardono & Waluya, 2018). Yusri (2018) explains that problem-based learning design begins with real problem structure dealing with mathematics concepts. Thus, students do not only receive information from the teachers. In this model, teachers must motivate and direct the students to participate in the learning process.

PBL implementation requires accurate media to improve students' problem-solving skills and self-directed learning. One of the media is a module, a teaching material instrument set. The arrangement of this teaching material is systematic so that students can study with and without teachers (Depdiknas, 2008). Any innovative and creative developed module makes students motivated to learn (Prastowo, 2014). Module implementation facilitates students to learn the given materials (Fathonah et al., 2019). Module habituates students to study autonomously (Maliya et al., 2019).

Module development should also consider students' characters (Nasution, 2016). For teachers, a module is useful to alter the teachers' roles into facilitators. Students can autonomously learn modules in which the teachers facilitate and guide all activities for the students to follow. Thus, the learning activities will be more effective and interactive through discussion. The module is applicable to determine the students' self-directed learning (Saputra R. A. K., Sukestiyarno, 2020).

From the explanation, the researchers found no researchers analyzed the required module patterns by the students based on self-directed learning to improve the problem-solving skills during the implementation of problem-based learning. A module is important to prepare the students before getting into the classroom learning session. A correct module implementation to provide preemptive learning can be a strategy to habituate the students. Thus, they can learn autonomously and improve their problem-solving skills.

METHOD

This qualitative method applied descriptive qualitative design to the required module patterns by the students based on their self-directed learning types. This research descriptively analyzed the quality of problem-based learning assisted by a module. This descriptive analysis of the required module applied Miles & Huberman analysis stages, starting from data reduction, display, and verification (Sugiyono, 2016). The research subjects consisted of the eleventh graders of XI IPA 4 at Public Senior High School 1 Grabag in the academic year 2021/2022, 35 students. The researchers determined the data source with purposive sampling based on certain considerations and objectives. The promoted learning for the experimental class was with PBL assisted by a module implementation for five meetings. Then, the researchers collected the data by observing, interviewing, testing, and documenting. The applied observation technique, participative observation, required the researchers to observe the self-directed learning characteristics and problem-solving skills. The researchers observed these dimensions with observational guidelines of self-directed learning character and problem-solving skills for five meetings. The interview technique was an in-depth interview to collect the self-directed learning character and problem-solving skill data from the students. The applied test method was essay problem-solving skill test questions. The applied material for the learning was SPLTV or linear equation system for three variables. The applied documentation method was useful to collect written data and figures, such as the student's name list, the number of students, the photographs of the students' activities, and other related data with the research.

RESULTS AND DISCUSSIONS

The researchers analyzed the observation and interview results to determine the required module pattern for each self-directed learning type. In this research, the module pattern is comprehended based on the scaffolding technique. Cantlon (Bikmaz et al., 2010) explains five scaffolding techniques. They are modeling certain behaviors, explaining, inviting student participation, verifying, and clarifying student understanding, and sharing hints. For each technique, the researchers categorized the students into high, moderate, and low self-directed learning levels.

Table 4.1 shows the categorization of self-directed learning.

Table 4.1 the categorization of self-directed learning

Self-Directed Learning Categories	Achieved Scores	Number of the Students	Percentage
Low	$x < 93$	10	29%
Moderate	$93 \leq x \leq 105$	14	40%
High	$x > 105$	11	31%

The table shows that the students with high self-directed learning 28%, consisting of 10 students out of 35 students. Then, students with moderate self-directed learning consist of 14 students, 40%. The last category, students with low self-directed learning consist of 11 students, 31%.

The Scaffolding Technique for Students with Low Self-Directed Learning

From the self-directed learning questionnaire and interview results, the researchers found 11 students with low self-directed learning type. The observation showed that the implementation of the scaffolding technique for eleven students with low self-directed learning required more than one technique. However, the implementation of these techniques could not be done at once. Table 4.2 shows the distribution of each scaffolding technique type for students with low self-directed learning.

Table 4.2 the scaffolding technique of students with low self-directed learning

S	Students with low self-directed learning										
										0	1

Remarks

TS : scaffolding technique

A : behavioral modeling technique

B : explanatory technique

C : a technique of inviting to participate

D : verifying and clarifying techniques

E : sharing hint technique

From the table, the implementation of scaffolding techniques for students with low self-directed learning does not only focus on certain techniques. The technique of inviting to participate applies to all students. However, besides this technique, the researchers found other tendentious techniques of different scaffolding techniques. They were verifying and clarifying techniques and the sharing hint technique explanatory technique, and behavioral modeling technique and explanatory technique.

By grouping the students' capabilities into high, moderate, and low, the students seemed to mostly apply verification and clarification techniques and sharing hint techniques at minimum levels. These findings were observable on R3, R6, R7, and R10. Thus, the researchers took the two best subjects with moderate self-directed learning to comprehend. They could also use verification and clarifying techniques to share hints however R10 was not active to participate. R9 subject had the lowest skill. By considering these matters, the researchers chose the students with the lowest self-directed learning to be R8 and R10.

The results showed that R10 required personal scaffolding. The subject is rarely initiated by explaining and modeling the behavior. The subject instead applied a technique of inviting others to participate, sharing hints, and verifying techniques. Of these techniques, the most frequently applied technique was sharing hints.

The interview results showed that the pattern orders of the applied scaffolding techniques were based on the students' skills. The students with excellent scaffolding techniques tended to be constant. On the other hand, students with low skills seemed to have random patterns. The results showed that the implementation of the scaffolding technique was based on the students' skills.

The Applied Scaffolding Technique by Students with Moderate Self-Directed Learning

The questionnaire showed 14 students with a moderate self-directed learning category. The observation results showed that the realized implementation of scaffolding for these students was

more than one technique. The subjects event applied some techniques at once.

Table 4.3 the applied scaffolding technique of students with moderate self-directed learning

S	Students with moderate self-directed learning													
									0	1	2	3	4	

The table shows that the applied scaffolding technique by the subjects depended on certain techniques. This finding indicated the same matter as found in the students with low self-directed learning. However, the researchers found two tendencies of implementing different scaffolding techniques. They were verifying and clarifying techniques, sharing hints, explanatory, and behavioral modeling techniques.

By grouping the students' capabilities into high, moderate, and low, the high and moderate category students seemed to mostly apply verification and clarification techniques and sharing hint techniques. These findings were observable on S2. S3. S4. S5. S8. S9. S11. S12. and S13. For low-category students, S1. S6. S10. and S14. they applied the explanatory technique and the modeling technique to implement the scaffolding technique. The researchers took some research subjects to comprehend the findings. S1 was the subject with the lowest skill in this group. For the common subjects with excellent skills, they had to apply explanatory techniques and modeling techniques while sharing their scaffolding technique personally. S8 and S9 had better skills but they needed the technique. The S8 subject had better skills than S9. Thus, the researchers chose S8 as the subject. By considering these matters, the researchers chose the students with moderate self-directed learning to be S1 and S8.

The interview results showed that both subjects applied explanatory, behavioral modeling, and inviting participation techniques. However, they had specific different implementations. S1, a subject with low skill, applied the explanatory technique for the basic concept. On the other hand, S8, s subject with moderate skill, applied the scaffolding technique on minimally applied questions. From the findings, the researchers found that scaffolding technique implementations were at an average level based on the students' skills.

The Scaffolding Technique for Students with High Self-Directed Learning

From the self-directed learning questionnaire and interview results, the researchers found 10 students with a high self-directed learning type. The observation results showed that the realized implementation of scaffolding for these students was more than one technique. The subjects event applied some techniques at once.

Table 4.4 the applied scaffolding technique of students with high self-directed learning

S	Students with high self-directed learning									
										0

The table shows that the applied scaffolding technique for high self-directed learning was not only based on certain techniques. However, besides this technique, the researchers found other tendentious techniques of different scaffolding techniques. They were verifying and clarifying techniques and the sharing hint technique, behavioral modeling technique and explanatory technique.

By grouping the students' capabilities into high, moderate, and low, the moderate category students seemed to mostly apply verification and clarification techniques and sharing hint techniques. These findings were observable on S3. T1. T3. T4. T5. T6. T8, and T9. For low-category students, T2, T7, T8, and T10, they applied the explanatory technique and the modeling technique to implement the scaffolding technique. The researchers attempted to comprehend this finding by taking the research subjects.

The observation showed that the T8 subject seemed to be the lowest while T5 was the moderate-

skill subject. The questionnaire results showed that T5 had a high self-directed learning category. Thus, the researchers took T5 and T8 subjects. From the findings, the researchers found that scaffolding technique implementations were at an average level based on the students' skills.

From the findings, the researchers concluded the implementation of scaffolding techniques. They were (1) personal scaffolding technique implementation was not backgrounded by different types of self-directed learning but instead the students' skills; (2) personal scaffolding technique order was not backgrounded by the types of self-directed learning but students' skills. The researchers grouped two types of scaffolding techniques. They were (a) the first group technique - consisting of explaining and modeling behavior, (b) the second group technique - inviting the students' participation, verifying, and sharing hints; (3) during the interaction, the researchers found some scaffolding implementation process, such as (a) the teacher-students interaction for each self-directed learning type ran excellently; (b) the peer-student interaction did not apply specific patter to support the given scaffolding technique by the teacher; and (4) the process of scaffolding indicated that students with low self-directed learning were easily interrupted by inconvenient responses.

The implications of the conclusions in this research plan included: (1) teachers had to consider the students' skills in selecting scaffolding techniques, including the scaffolding implementation; (2) teachers had to consider the students' skills to apply the types of scaffolding technique; and (3) the interaction of scaffolding process indicated the initiation of the teachers to interact with high category students. Thus, the group selection should be based on the self-directed learning categories so that teachers had to carefully respond.

The Required Module Patterns for the Students based on the Self-Directed Learning Types

The researchers prepared the module to use for scaffolding implementation. Cantlon (Bikmaz et al., 2010) explains five scaffolding techniques. They are modeling certain behaviors, explaining, inviting student participation, verifying and clarifying student understanding, and sharing hints. In this research, the researchers could not use the verifying and clarifying technique for the module. Thus, the researchers only used four scaffolding techniques.

The type I module applied certain behavioral modeling techniques and explanatory techniques. The type II module applied to share hint technique and participation invitation technique. The type III module applied four scaffolding techniques at once. For each module type, the researchers comprehended the results based on the self-directed learning types: low, moderate, and high.

The Module Pattern for Students with Low Self-Directed Learning

Based on the interview, questionnaire, and observation, the researchers found 11 students with low self-directed learning type. From the three offered modules, the researchers found the most preferable module by students with low self-directed learning.

Table 4.5 the module pattern for students with low self-directed learning

M	Students with low self-directed learning									
									0	1
I										
II										

Remarks

TM : Module Type

I : a module with behavioral modeling and explanatory techniques

II : a module with participation invitations and sharing hint techniques

III : a module with behavioral modeling, sharing hints, and participation invitation techniques

The researchers found that the scaffolding technique for students with low self-directed learning was not based on certain techniques. The researchers also found two tendencies of applying different scaffolding techniques. They were the verification and clarification technique and sharing hint technique, and explanatory and behavioral modeling technique.

Students with low skills, such as R1, R2, R4, R5, R8, R9, and R11 applied the scaffolding techniques in the forms of explanatory, behavioral modeling, and participation invitation techniques.

The module selection as shown in the table revealed that these students chose the type III module, a module with behavioral modeling, explanatory, participation invitation, and sharing hint techniques. They chose the type III module because their skills were low. Thus, the module could help them understand the materials by having detailed explanations.

Students with moderate self-directed learning, such as R3 and R6, could use all scaffolding techniques. These subjects also chose the type III module. The other subjects, R7 and R10, also chose the type III module although these subjects applied participation invitation, verifying, and sharing hint techniques.

The researchers took some research subjects to comprehend the findings. The researchers found the interesting findings were on students with moderate self-directed learning, the researchers chose R7 and R10 as the subjects. These subjects had better skills than the other students with moderate self-directed learning.

The results showed that the module selection of students with low self-directed learning was - the type III module. The module consisted of four scaffolding techniques. They were behavioral modeling, explanatory, participation invitation, and sharing hint techniques. However, the researchers found a different result of the scaffolding technique to promote personal scaffolding. In this finding, the researchers also found learning skills did not influence the module selection. The evidence was R7 and R10 as the subjects with moderate self-directed learning. The subjects chose the type III module.

The Module Pattern for Students with Moderate Self-Directed Learning

Based on the interview, questionnaire, and observation, the researchers found 14 students with moderate self-directed learning type. From the three offered modules, the researchers found the most preferable module by students with moderate self-directed learning.

Table 4.6 the module pattern for students with moderate self-directed learning

M	Students with moderate self-directed learning													
											0	1	2	3	4
I															
II															

The researchers found that the scaffolding technique for students with moderate self-directed learning was not based on certain techniques. However, the researchers found two tendencies of implementing different scaffolding techniques. They were verifying and clarifying techniques, sharing hints, explanatory techniques, and behavioral modeling techniques.

The subjects with lower skills, such as S1, S6, S7, S10, and S14, chose the type II module. The interesting findings were students with moderate skills, such as s2, S4, S5, S8, S9, S11, S12, and S13, also chose the type III module. These subjects also chose the type I module. S3 subject even also chose the type I module. When the teacher provided the scaffolding technique for S3, the applied technique was inviting the participant, verifying, and sharing hints.

The researchers took some research subjects to comprehend the findings. The researchers also found interesting findings on students with high and moderate skills. The S3 subject was the students with high skills in this group. Thus, the researchers took S3 as the research subject. On the other hand, from the moderate self-directed learning group, S8 had the best skill. By considering these matters, the researchers chose the students with moderate self-directed learning to be S3 and S8.

The results showed that the module selection of the moderate self-directed learning group was the type II module. The module selection was different from the personal scaffolding technique implementation. In this finding, the researchers also found learning skills did not influence the module selection. S3 subject, the subject with high skill, and S8, the subject with moderate skill, remained to choose the type II module.

The Module Pattern for Students with High Self-Directed Learning

Based on the interview, questionnaire, and observation, the researchers found 10 students with high self-directed learning type. From the three offered modules, the researchers found the most

preferable module by students with high self-directed learning.

Table 4.7 the module pattern for high self-directed learning group

	Students with high self-directed learning									
S										0
I										
II										

The table shows that the implementation of the scaffolding technique for students with high self-directed learning was not based on certain techniques. However, the researchers found two tendencies of implementing different scaffolding techniques. They were verifying and clarifying techniques and sharing hints, explanatory techniques and behavioral modeling techniques.

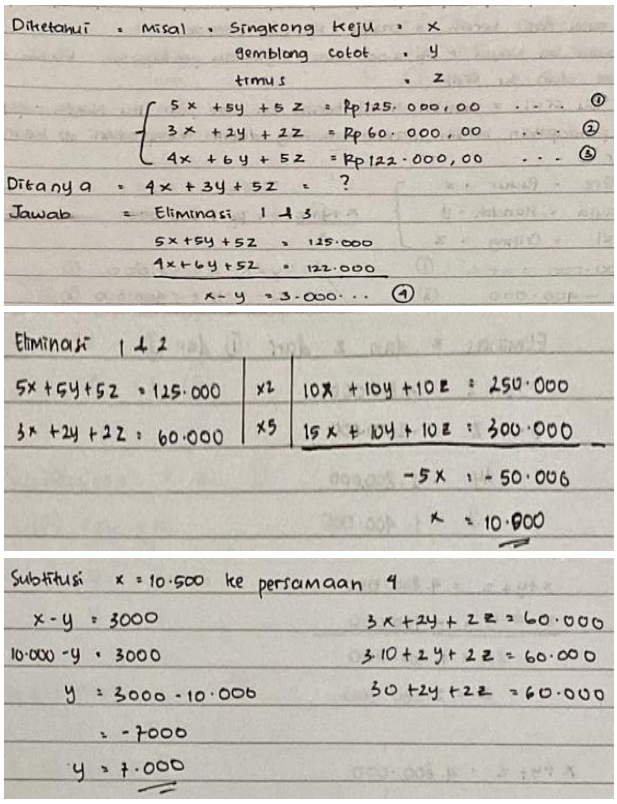
The researchers found students with moderate skills, such as T1, T3, T4, T5, T6, and T9; and students with low skills, such as T2, T7, T8, and T10, chose the type I module.

The findings showed that the module selection of high self-directed learning group was the type I module. This finding was different from the scaffolding implementation technique in a personal manner. The background differences did not influence the module selection. The subjects with moderate and low skills remained to choose the type I module.

The findings from the three groups showed that generally, the type II module was the most acceptable module for all types of students with various skill backgrounds. They thought that the module was clearer and more complete. These matters indicated that they needed a module with an easy explanation. The finding was in line with the objective of a module, to facilitate the self-directed learning of the students with minimum assistance from the teachers. The type I module provided materials and examples completely with explanatory and behavioral modeling techniques. Thus, the students could easily the materials autonomously.

The results concluded that the required module for each self-directed learning type was varied. Students with high self-directed learning chose the type I module with participation invitation and sharing hint techniques. Students with moderate self-directed learning chose the type II module with behavioral modeling and explanatory techniques. Students with low self-directed learning chose the type III module with behavioral modeling, explanatory, participation invitation, and sharing hint techniques.

R9 subject's skills kept improving on the third meeting. However, the skills decreased at the fourth meeting. However, the R9's skills in the fifth meeting and the first meeting were significantly different. R10's problem-solving skill was improved based on the studied materials. S1 problem-solving skills also fluctuated. However, the problem-solving skill of the subject was high. The problem-solving skills of S8 also fluctuated based on the studied materials. The same fluctuations and findings were also observable on T5. T8 received intensive guidance because the subject could not understand problems, plan the solution, execute the plan, and recheck the results. After giving guidance, the subject's problem-solving skills fluctuated. Figure 2 shows the stages of the subjects' work. The figure shows that the subjects applied Polya's problem-solving skill stages. Thus, the subjects already had problem-solving skills.



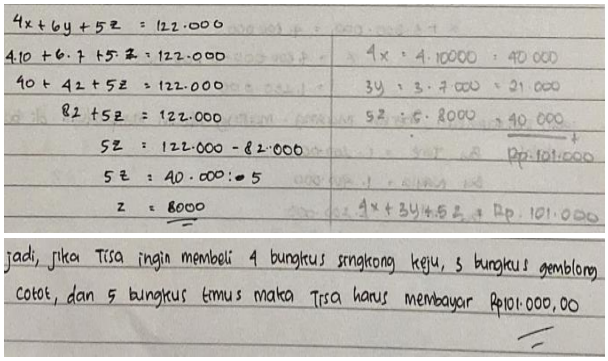


Figure 1 the problem-solving skill stages of the students

The high category problem-solving skill improvements, with N-gain index on the first until fifth meeting for R9, R10, S1, S8, T5, and T8 were 0,94; 0,85; 0,80; 0,87; 0,87; and 0,87 consecutively. Here are the N-gain change in the subjects' problem-solving skills.

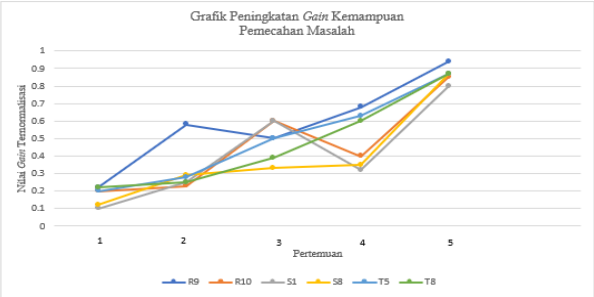


Figure 2. The N-gain change graphic of the subjects' problem-solving skills

Based on the description of the improved problem-solving skills, all subjects showed that problem-based learning assisted with module supported the improvement of students' problem-solving skills. This finding happened because the applied PBL, assisted by the module, met the types of students' self-directed learning categories. Amaliyah & Sukestiyarno (2021) explain that modules are useful to provide self-directed learning enhancement and to support the students' problem-solving skills.

In this research, the students were deemed to have achieved the completion if they met the minimum standard mastery. The applied minimum standard mastery was 67 for all individual completion and 75% for classical completion. From the problem-solving skill test, the obtained data showed that six subjects had higher scores than 67. Thus, all subjects individually reached the completion. The students of the experimental group consisted of 35 students. 29 students of the group obtained scores higher than the individual minimum standard mastery. Thus, the classical completion was 82.9%. The fact showed that problem-based learning implementation for mathematics, under the material of SPLTV - linear equation system for three variables, showed six subjects could reach the individual and classical completions.

Wulandari & Sukestiyarno (2013) also found that characters and problem-solving skills could improve by improving the behaviors as shown in the character indicators. Thus, the students could develop from the unseen stage into a stage of early development and early civilized stage. On the other hand, the students' problem-solving skills could reach the minimum applied completion. Arifin & Hidayah (2019) found that the applied learning to develop problem-solving skills was problem-based learning.

CONCLUSION

From the results and discussion, the researchers concluded that: (1) students with high self-directed learning applied the type I module with behavioral modeling and explanatory techniques; (2) students with moderate self-directed learning applied the type II module with participation invitation and sharing hint technique; (3) students with low self-directed learning applied the type III module with behavioral modeling, explanatory, participation invitation, and sharing hint techniques; and (4) problem-based learning assisted by module could improve the students' problem-solving skills. The high category of problem-solving skill improvements, based on the N-gain index from the first until the fifth meeting, consisted of R9, R10, S1, S8, T5, and T8. The obtained gain scores were 0,94; 0,85; 0,80; 0,87; 0,87; and 0,87 consecutively. The last conclusion, fifth conclusion, problem-solving skills with problem-based learning assisted by a module could reach the minimum applied criteria. The problem-solving skill test scores of R9, R10, S1, S8, T5, and T8 were 83,2; 87,6; 93,3; 100; and 100 consecutively.

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