PEMBELAJARAN STEM-*PROBLEM-BASED LEARNING* TOPIK PEMBUATAN BIODIESEL UNTUK MENGEMBANGKAN KETERAMPILAN PEMECAHAN MASALAH SISWA

STEM-PROBLEM-BASED LEARNING ON BIODIESEL PRODUCTION TO DEVELOP STUDENTS' PROBLEM-SOLVING SKILLS

May Ester [1], **Kelly Sinaga** [2*]

[1]*Program Studi Pendidikan Kimia, Fakultas Pendidikan, Universitas Pelita Harapan, Tangerang, Indonesia*
[2]*Program Studi Pendidikan Kimia, Fakultas Pendidikan, Universitas Pelita Harapan, Tangerang, Indonesia*
*Email : kelly.sinaga@uph.edu

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Abstrak

Pengembangan keterampilan pemecahan masalah dengan menggunakan pembelajaran problem-based learning (PBL) terintegrasi STEM (science, technology, engineering, mathematics) menjadi urgensi dalam menjawab tantangan abad ke-21. Data penelitian pada salah satu sekolah Kristen di Lampung kelas XI IPA menunjukkan kurangnya keterampilan pemecahan masalah. Diketahui ketika siswa diberikan latihan stoikiometri, mereka tidak mampu dalam menyelesaikan masalah yang diberikan. Pembelajaran ini menjadi solusi dari permasalahan dengan tujuan penulisan, yaitu memaparkan tentang kajian penerapan pembelajaran PBL terintegrasi STEM dapat mengembangkan keterampilan pemecahan masalah siswa. Metode penelitian yang digunakan kualitiatif deskriptif, dengan hasil pembelajaran ini dapat mengembangkan keterampilan pemecahan masalah. Penerapan pembelajaran ini menggunakan lima tahapan mendukung pengembangan keterampilan pemecahan masalah. Penilaian setiap indikator keterampilan pemecahan masalah dilihat melalui lembar kerja menggunakan rubrik yang dirancang. Perolehan kemampuan pemecahan masalah siswa secara rata-rata pada tiap indikator adalah memahami masalah 53,33% & 80,00%, menyusun cara penyelesaian masalah 57,14% & 70,00%, menyelesaikan masalah 60,00% & 85,00%, dan kesimpulan/evaluasi 82,00% & 83,00%. Penerapan pembelajaran ini dilakukan sebanyak tiga pertemuan. Hal tersebut memfasilitasi guru dalam menuntun siswa mengembangkan keterampilan pemecahan masalah dan menuntun mereka semakin menyadari tanggung jawabnya di hadapan Allah. Berdasarkan penerapan model ini, penulis menyarankan menggunakan waktu dengan baik dalam penerapan tahapan PBL untuk mencapai hasil yang baik.

Kata Kunci : *Keterampilan, Pembelajaran, STEM, PBL.*

Abstract

Developing problem solving skills using integrated problem-based learning (PBL) STEM (science, technology, engineering, mathematics) is an urgency in responding to the challenges of the 21st century. Research data from a Christian school in Lampung for class XI science shows a lack of problem solving skills. It is known that when students are given stoichiometry exercises, they are unable to solve the problems given. This learning is a solution to problems with the aim of writing, namely explaining the study of the application of STEM integrated PBL *learning to develop students' problem solving skills. The research method used is descriptive qualitative, with the results of this learning being able to develop problem solving skills. The application of this learning uses five stages to support the development of problem solving skills. The assessment of each indicator of problem solving skills is seen through a worksheet using a designed rubric. The students' average problem solving abilities for each indicator were understanding problems 53.33% & 80.00%, developing ways to solve problems 57.14% & 70.00%, solving problems 60.00% & 85.00% , and conclusion/evaluation 82.00% & 83.00%. The application of this learning was carried out in three meetings. This facilitates teachers in guiding students to develop problem-solving skills and leads them to become more aware of their responsibilities before God. Based on the application of this model, the author suggests using time well in implementing the PBL stages to achieve good results.*

Keywords : *Skills, Learning, STEM, PBL.*

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INTRODUCTION

The 21st century is also known as a century that is changing rapidly, one example is in the field of information technology. Information technology develops characterized by the dissemination of information that is so easily found by people. Behind the development of the times, of course, there are many demands in producing quality human resources. Of course, to produce quality human resources can be developed through education. 21st century skills include critical thinking and problem solving, collaboration, communication, creativity and innovation (Septikasari, 2018). Of course, the development of these skills can be done in all scientific disciplines. One of the skill developments that integrates high-level thinking with metacognitive processes is problem solving, which is one of the relevant skills in the 21st century (Zubaidah, 2020).

Problem solving skills become a skill in helping a person to face various complex real-life challenges. Problem solving skills are a person's ability to understand correlations, reason, make choices, compile, analyze and express in solving a problem (Jayadiningrat & Ati, 2018). Through this understanding, it states that problem solving skills require students to be able to think and analyze a problem at hand. Of course, not only that, students can also connect learning with their daily lives.

Problem-solving skills are one of the key abilities required in today's global education. In an era filled with complex challenges, such as climate change, health crises, and rapid technological development, the ability to solve problems creatively and innovatively is crucial. Problem solving not only helps individuals solve problems effectively, but also encourages them to think critically and act based on relevant data and facts (OECD, 2019). STEM (Science, Technology, Engineering, and Mathematics) based education offers an interdisciplinary approach that allows students to develop problem-solving skills in a real-world context. Through STEM learning, students are trained to identify problems, analyze data and come up with innovative solutions. This not only improves their academic competence, but also shapes a mindset that is ready to face the challenges of the 21st century (Bybee, 2020).

Problem-solving skills also play an important role in creating socially responsible individuals. With a collaborative and solution-oriented approach, students are encouraged to think about the impact of their decisions on society and the environment. Problem solving done with openness, empathy and collaboration contributes greatly to creating a more inclusive and sustainable world (Kim et al., 2021). Through the development of problem-solving skills, global education seeks to shape a generation that is not only able to overcome challenges, but also has the ability to create innovative and impactful solutions. Thus, STEM-based education plays an important role in preparing students to become adaptive, creative and responsible future leaders.

In Indonesia, problem solving skills are still in the low category. This is shown by the results of TIMMS (Trends International Mathematics and Science) which measures student cognition through facts, concepts and solving simple problems to high reasoning. Through this test, a score of 397 was obtained in 2015, in which Indonesia occupied the fourth smallest score out of 64 countries (Sumiantari, Suardana, & Selamet, 2019). The same problem was also found by the author in class XI IPA students in one of the schools in Lampung. The fact that the author found in the classroom was that some students could not complete problem solving on the topic of stoichiometry given by the teacher. The low ability in solving students' problems gives urgency to teachers to develop problem-solving skills through the learning process in the classroom.

Of course, developing students' problem-solving skills through the learning process requires a strategy. One of the good strategies in developing students' problem-solving skills is the use of the STEM-integrated problem-based learning (PBL) model. This learning is a strategy that exposes students to problems that need to be solved conceptually through learning (Redhana, 2019). The incorporation of STEM-integrated PBL learning directs learning that provides students with a project to solve problems based on STEM aspects, namely science, technology, engineering, and mathematics (Erlinawati, Bektiarso, & Maryani, 2019). Through this model, teachers organise learning activities that can improve problem solving skills in groups.

Through the above explanation, the objective of this paper is to explain the study on the application of STEM-integrated PBL learning to develop students' problem-solving skills. This objective will answer the problem formulation of the writing, namely "How can STEM-integrated PBL learning develop the problem solving skills of students in class XI IPA? The method used in this paper is descriptive qualitative method.

METHODS

The method used by the author is descriptive qualitative using observation sheets, lesson plans and mentor feedback, teaching reflections, student worksheets, and assessment rubrics as data sources.

RESULT AND DISCUSSION

The 21st century is a digital era that experiences rapid development of technology and information. Of course, facing the 21st century era requires various skills, known as the 4Cs (creativity and innovation, critical thinking and problem solving, collaboration, and communication) that must be mastered by students (Septikasari, 2018). This is a challenge for education, because it must improve quality human resources in accordance with the demands of the times. Therefore, this research focuses on improving students' problem-solving skills through in-class chemistry learning. Problem solving skills are needed by students to train in dealing with various problems that occur in the real world.

To improve students' problem solving skills, a lesson is needed to achieve these skills through the learning process in the classroom. In this study, teachers used STEM-integrated PBL learning applied to the XI-IPA class in one of the Christian schools in Lampung. The combination of STEM with problem-based learning can help students in solving problems. The application of STEM learning can encourage students to improve their higher-order thinking skills and the use of technology as a medium or learning resource and science as a source in solving the problems faced. Teaching practice using this learning was carried out for three meetings with the topic of stoichiometry with the sub-topic of the design of making biodiesel from vegetable oil. In meeting 1, the design of biodiesel from vegetable oil was related to the content of substances in the mixture. In meeting 2, the design of biodiesel from vegetable oil was related to the content of substances in the mixture. In meeting 3 students made group presentations.

The core competencies (KI) and basic competencies (KD) that teachers use can be seen in Table 4.

TABEL 4. CORE COMPETENCIES AND BASIC COMPETENCIES

Core Competencies		Basic Competencies	
3.	Understand, apply, and analyse factual, conceptual, procedural, and metacognitive knowledge based on their curiosity about science, technology, arts, culture,	3.10	Apply the basic laws of chemistry, the concept of relative molecular mass, chemical equations, the concept of mole, and substance content to solve

	and humanities with insights into humanity, nationality, state, and civilisation related to the causes of phenomena and events, and apply procedural knowledge in specific fields of study in accordance with their talents and interests to solve problems.		chemical calculations.
4.	Processing, reasoning, and presenting in the concrete and abstract domains related to the development of what is learned at school independently, acting effectively and creatively, and being able to use methods according to scientific principles.	4.10	Analyse experimental data using the basic laws of quantitative chemistry.

Through the Core Competencies and Basic Competencies in table 4, the indicators achieved by students at the previous meeting were that students were able to understand the concept of moles. Students are also able to understand the empirical formula and molecular formula in a compound. The indicators that students will achieve in the application of STEM-integrated PBL learning are that students are able to identify the levels of substances in the mixture, understand the concept of mass percentage; volume percentage; parts per million or part million (bpj/bpm); molarity; molality and mole fraction. Students are also able to integrate substance levels in mixtures in everyday life through functions, uses, purposes and so on.

Through the application of STEM integrated learning, there are several components that students will achieve through group work. The STEM components in the Biodiesel learning topic can be seen in Table 5.

TABEL 5. KOMPONEN STEM

STEM Component	Description
Science	Stoichiometry, Hydrocarbons, Organic Reactions and Biochemistry.
Technology	Biodiesel manufacturing technology
Engineering	Design of biodiesel production from vegetable oil including the type of materials used, composition, and manufacturing process.
Mathematics	Calculation of the composition used in biodiesel from vegetable oil.

The learning process that occurs in class XI-IPA with the application of STEM-integrated PBL learning uses the following five stages:

a. Problem Orientation

This stage aims to stimulate students to think at a higher level that will help them in solving problems according to the desired results. Students are given a video about the process of the formation of petroleum and natural gas and news about the depletion of petroleum and natural gas in Indonesia. The aim is to provide an initial introduction to the process of the formation of petroleum and natural gas which comes from the fossils of living things where the process takes place over millions of years. Providing videos can help students to understand the concept of the problem more easily because the animation in the video makes students able to see the process that occurs as if in a real context.

Through the problems that occur, students are expected to be able to design a substitute for petroleum as a vehicle fuel, known as biodiesel. The teacher introduces biodiesel to the students through the Student Worksheet. Through the Student Worksheet questions, students will understand the problems given and get to know about biodiesel. So that students will be much easier to design and explore the context of the problem given. Without realising it, through this activity students have formed an indicator of problem solving skills, namely understanding the problem (KPM-1).

b. Organize Students for Learning.

This stage begins with organising students into groups of three to four. The division of groups given by the teacher is homogeneous. The organisation of each group is given a memorandum that likens the group to the RnD team at PT Jhonlin Agro Raya. Giving this memorandum is to bring students in a real context. The importance of bringing students in a real context is to introduce problems that occur in real life. Positioning the group as an RnD team to bring students to work together in conducting research and development on the design of biodiesel from vegetable oils.

Then the teacher gives questions to students in the form of student worksheets. Questions are given to stimulate students' cognition in developing problem-solving strategies. Students utilise technology in finding information from various sources with the aim of finding the components of vegetable oil biodiesel. This context requires students to be able to analyse information found from various sources. Thus students can determine the parameters needed when making biodiesel from vegetable oil. Students will form an indicator of problem-solving skills, namely composing ways to solve problems (KPM-2).

c. Guiding Individual and Group Observation

This stage encourages students to discuss in groups through teacher guidance. The discussion that occurs in the group is looking for information about biodiesel from various sources. Group discussions will form communication and interaction skills that students do through giving opinions and listening to the opinions of group mates. In addition, students will also find new knowledge experiences through the opinions of group mates and through information from various sources found by students.

Teacher provides student worksheet questions to guide students discussion in group. The questions help students to develop cognitive in designing the process of biodiesel formation. In addition, students will also develop their ideas in making the design. Through this process, students will form a problem-solving indicator, namely developing ways to solve problems (KPM-2).

d. Develop and Present Results

At this stage students review the results that have been designed by continuing the literature study by digging up various information through various sources on the internet. This aims to ensure and improve and improve the design of solutions that have been done by students. Students in the group will assess whether the solution that has been done can answer the problem. In addition, students can also improve the parts that still need improvement, so that students can revise the solution to improve better results.

Then each group presents the results that have been done in class. This aims to provide information to other groups about the results of the biodiesel design that the group has designed. The achievement of problem-solving skills indicators formed through this stage is problem solving (KPM-3).

e. Reflection and Evaluation of Problem Solving Results

At this stage each group reflects on the things the group has gone through in solving the problem. Then the group reflects on things that must be improved in the future and if given the opportunity what things will be improved. This aims to encourage students to evaluate every ability they already have and improve the abilities that are still lacking. So that students will produce indicators of problem solving skills, namely conclusions/evaluation (KPM-4).

ada tahap ini setiap kelompok merefleksikan hal-hal yang sudah kelompok lalui dalam menyelesaikan pemecahan masalah. Kemudian kelompok merenungkan hal-hal yang harus ditingkatkan kedepannya dan jika diberi kesempatan hal-hal apa yang akan diperbaiki. Hal ini bertujuan untuk mendorong siswa untuk mengevaluasi setiap kemampuan yang sudah dimiliki dan meningkatkan kemampuan yang masih kurang. Sehingga siswa akan menghasilkan indikator keterampilan pemecahan masalah yaitu kesimpulan/evaluasi(KPM-4).

The results obtained in this study were analysed by comparing the categories of achievement of problem solving skills indicators by Sarumaha (2022). A description of the level or category of achievement of problem solving skills can be seen in Table 6.

TABLE 6. CATEGORY OF ACHIEVEMENT OF PROBLEM SOLVING ABILITY

Persentase Pencapaian	Kategori
81,00% - 100%	Very Good
61,00% - 80,00%	Good
41,00% - 60,00%	Enough
21,00% - 40,00%	Less
00% - 20,00%	Very Less

The achievement of problem solving indicators during the learning process using STEM-integrated PBL learning can be seen in figure 1.

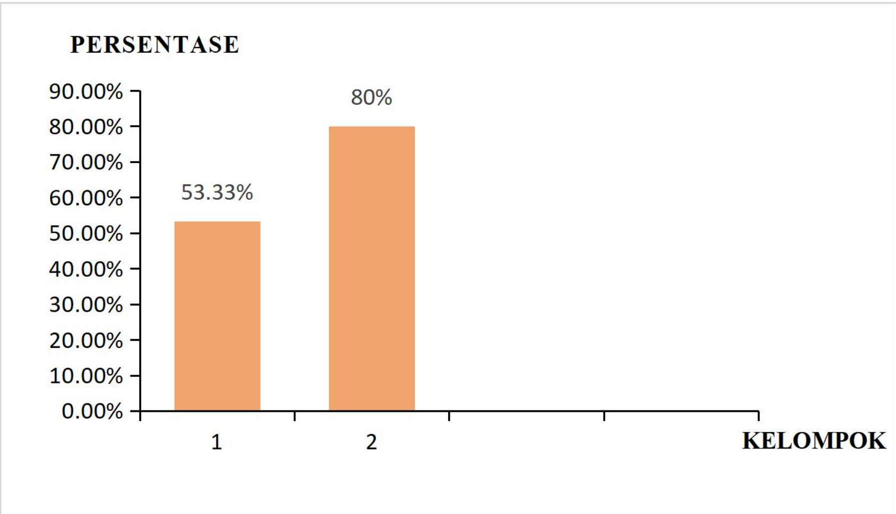

FIGURE 1. INDICATOR OUTCOME UNDERSTANDING THE PROBLEM (KPM-1)

Through the diagram data above, it can be seen the comparison of achievement between each indicator in group 1 and group 2. Each indicator in the group is declared successful but the teacher still needs to evaluate students to further improve each indicator that must be achieved by students in developing problem solving skills. The indicator of understanding the problem obtained a percentage of 53.33% in group 1 and 80% in group 2. Through this percentage it can be concluded that the indicator of understanding the problem is good in group 2. However, the indicator of understanding the problem must continue to be trained and developed for students to get much better results. It can be seen that the success of the indicators in group 1 is still categorised as sufficient. This needs to be an evaluation for teachers and students of what factors cause students to be lacking in understanding problems.

Furthermore, the achievement of the indicator of developing ways to solve problems during the learning process can be seen in Figure 2.

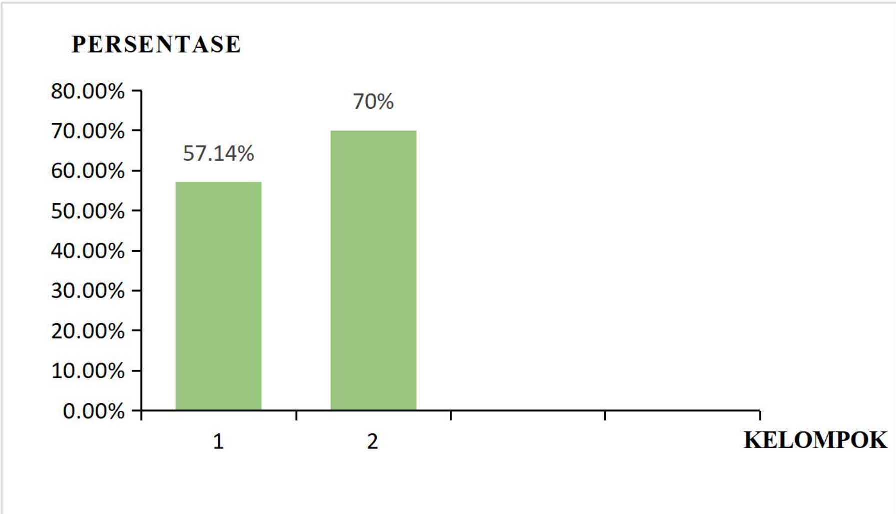

FIGURE 2. INDICATOR OUTCOME DEVELOPING PROBLEM SOLVING METHODS (KPM-2)

The indicator of compiling ways to solve problems obtained a percentage of 57.14% in group 1 and 70% in group 2. Through this percentage, it can be concluded that the indicator of compiling ways to solve problems in group 2 is good. However, in group 1 the indicator of the achievement of this indicator is still classified as sufficient. This was influenced by the fact that when students searched for information with literature studies in groups, it was found that students still had difficulty in digesting the information they had found through the internet. This can be seen from the answers to the students' LKS that have the wrong concept (attachment 8). Therefore, it is necessary to improve in understanding the concept, because students still have difficulty in understanding the concept if it is not explained repeatedly. According to research from Erin Febri Astuti, Suweken, & Waluyo (2019) in their journal said that understanding concepts is important as a foundation in thinking to solve problems in real life.

The achievement of problem-solving indicators can be seen through Figure 3 below, which is measured during the learning process.

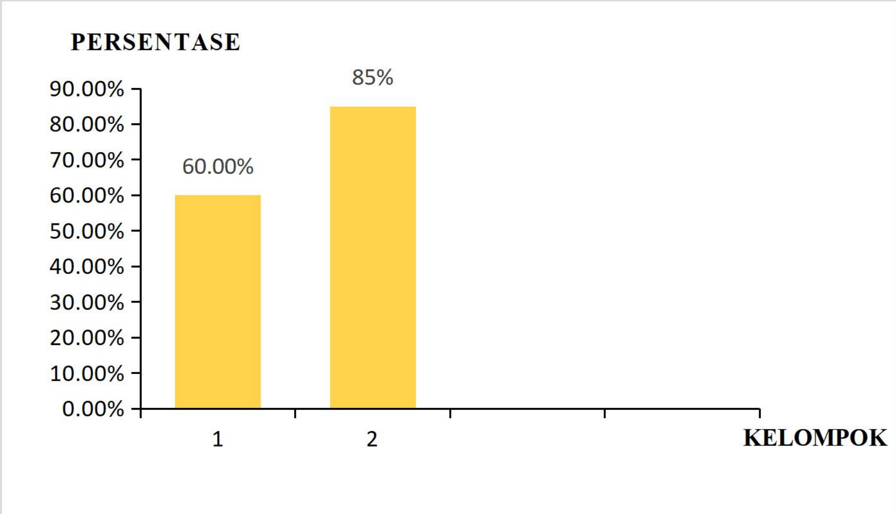

FIGURE 3. ACHIEVEMENT OF PROBLEM SOLVING INDICATOR (KPM-3)

The indicator of solving problems obtained a percentage of 60% in group 1 and 85% in group 2. The percentage of indicators of solving problems in group 2 shows a very good category. Meanwhile, group 1 showed an adequate category. This can be seen when the group completed the problem solving and presented the presentation, students did not show a clear and complete design for making biodiesel from vegetable oil. So, the teacher needs to evaluate in improving the indicators of problem solving in students who have not reached the good category. Of course, increasing students' experience in problem solving requires repeated application so that they are accustomed to being faced with contextual problems.

Furthermore, the achievement of the conclusion/evaluation indicator during the learning process using STEM-integrated PBL learning can be seen in Figure 4.

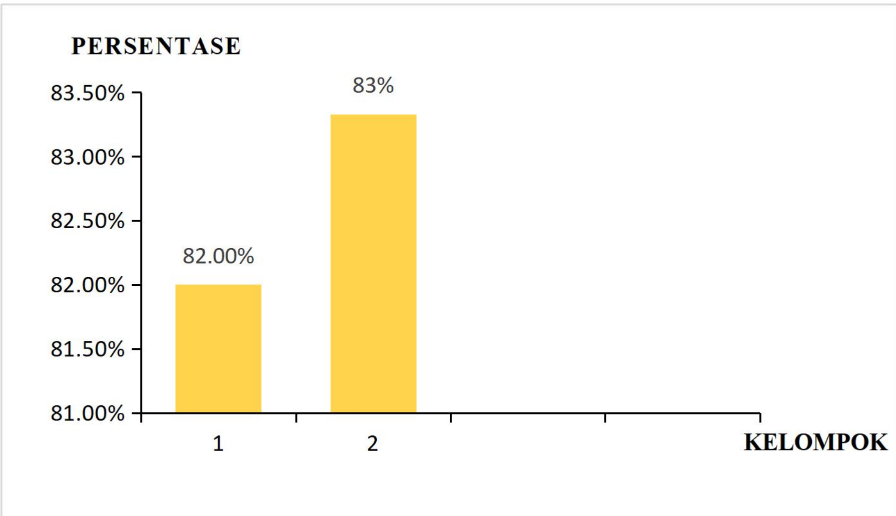

FIGURE 4. ACHIEVEMENT OF CONCLUSION/EVALUATION INDICATOR (KMP-4)

The KPM-4 indicator obtained a percentage of 82% in group 1 and 83% in group 2. The conclusion/evaluation percentage in group 1 and group 2 was categorised as very good. When solving problems in groups, students have been trained in analytical skills so that the ability to make conclusions becomes better.

Through the discussion above, it is necessary to review group 1 because it is still categorised as lacking in problem solving after the application of STEM integrated PBL learning. Teachers need to evaluate what factors influence the non-achievement of KPM-1, KPM-2, and KPM-3 indicators in groups that have not reached the good category. Teachers can also review through the homogeneity of the groups divided by the teacher. It should be realised that group homogeneity still has many shortcomings, because no matter how many similarities each student has, there must still be a degree of heterogeneity. Groups are divided based on learning outcomes so that they are reviewed based on student knowledge. This does not guarantee that students can achieve good problem solving skills. Of course, each student also has their own differences. In addition, the lack of time in implementing this learning must still be considered. Developing a skill in students requires various stages and depends on how quickly they understand a concept from the material. The cognition of each student is different, this can also be one of the factors that group 1 has not yet reached the good category in achieving indicators KPM-1, KPM-2 and KPM-3.

Through the implementation of problem-based learning (PBL) integrated with STEM, students get a holistic learning experience. This approach not only focuses on academic learning objectives, but also aims to improve various 21st century skills, one of which is critical thinking and problem solving skills. In PBL-based STEM learning, students are invited to solve problems relevant to the real world, involving analysis, decision-making and reflection. This gives them the opportunity to develop in-depth critical thinking skills, which are important in the current era of globalisation (Hmelo-Silver, 2019).

Problem-based learning also gives students the space to develop their creativity. Students are trained to design innovative solutions to real challenges, such as environmental or technological issues, that are relevant to local and global contexts. In the context of global education, the development of these skills not only helps students to become lifelong learners, but also prepares them to become responsible and competitive global citizens (Larmer & Mergendoller, 2015).

The STEM-integrated PBL learning process focuses on developing problem-solving skills that bring students to meaningful learning experiences. When students are faced with complex real-world problems, they learn to work collaboratively, analyse data and come up with creative and relevant solutions. Thus, students not only gain new knowledge, but also improve their critical thinking skills and sense of responsibility towards society and the environment (OECD, 2019). STEM-integrated PBL also encourages students to understand that creativity, collaboration and timely decision-making are important elements in solving problems. STEM education based on problem-based learning provides students with an understanding that solutions to global challenges require careful thinking and an interdisciplinary approach. With this approach, students are not only equipped with academic skills, but also with values that support sustainability and global well-being (Kim et al., 2021).

CONCLUSION

The learning process used problem-based learning. The context of the problem given is to design biodiesel from vegetable oil. STEM-integrated PBL learning can be applied to develop students' problem-solving skills. STEM-integrated PBL learning uses five stages. The first stage is problem orientation, students are introduced to the problem through a video. The second stage is organising students, conducting homogeneous grouping, providing illustrations in the form of memoranda and providing LKS. The third stage is guiding individual and group observations, the teacher guides the group discussion process in finding information about biodiesel from various sources. The fourth stage is developing and presenting results, students review the results that have been designed by continuing the literature study to explore internet sources. The fifth stage is reflection and evaluation of the results of problem solving, the group reflects on the things that the group has gone through in solving the problem.

Through the above stages, STEM-integrated PBL learning can be applied to develop problem-solving skills. The average results of each student problem solving indicator are understanding the problem 53.33% & 80%, for the indicator Arranging ways to solve the problem 57.14% & 70%, solving the problem 60% & 85%, and conclusion / evaluation 82% & 83%. Through problem solving skills, humans increasingly recognise and see the nature of God through learning. The application of STEM-integrated PBL learning is a solution for teachers as facilitators in developing problem-solving skills while bringing students to get to know the real world.

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