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Implementation of STEM Integrated Problem Based Learning Model to Improve Problem Solving Skills and Learning Motivation of Grade X Vocational High School Students on the Material of Substances and Their Changes

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Abstract: This study aims to analyze significant differences in problem-solving ability and learning motivation simultaneously between experimental class students and control class students; problem-solving ability between experimental class students and control class students; learning motivation between experimental class students and control class students; analyze the effective contribution of learning using PBL-STEM to students' problem-solving ability and learning motivation simultaneously; analyze the effective contribution of learning using PBL-STEM to students' problem-solving ability; analyze the effective contribution of learning using the PBL-STEM model to students' problem-solving motivation. This study uses a quasi-experimental model with a posttest only design. The sample of this study consisted of two classes, namely the experimental class and the control class, by random sampling. The experimental class uses learning with PBL-STEM, while the control class uses learning with a scientific approach. Data collection on problem-solving ability was obtained from descriptive test data and learning motivation data through a questionnaire. The MANOVA test was used to analyze the differences in problem-solving ability and learning motivation of experimental and control class students simultaneously. The between subject effect test was used to analyze the differences in each dependent variable in the experimental class and the control class. The partial eta square test was used to analyze the effective contribution of PBL-STEM to the dependent variable. The results showed that there were differences in problem-solving ability and learning motivation simultaneously between students in the experimental group and the control group; there were significant differences in problem-solving ability between students in the experimental group and the control group; there were significant differences in learning motivation between students in the experimental group and the control group; the effective contribution of using PBL-STEM to problem-solving ability and learning motivation simultaneously was 24.6% (high); the effective contribution of using PBL-STEM to problem-solving ability was 19% (high); the effective contribution of using PBL-STEM to learning motivation was 15.7% (high).

Keywords: Learning motivation; PBL; Problem solving skills, STEM

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Introduction

Education is one of the most important factors in determining the quality of human resources and the progress of a nation. The educational process is always able to produce creative, innovative ideas in the dynamics of the development of the times. The 21st century is marked by many changes and challenges in various aspects, so that the educational process is no longer only considered as an effort to prepare students for the future, but also to enable them to live independently, wherever and whenever. Therefore, education must focus on the development of human potential as a whole, covering aspects such as intellectual, spiritual, emotional, social, and kinesthetic intelligence (Komariah et al., 2019).

In the world of education, learning is seen as a conscious and deliberate effort that is well designed to achieve educational goals. The learning process is essentially attempted so that students can develop their creativity and activities through various interactions and learning experiences. Another essence of learning is the planning or design prepared by teachers in an effort to teach students. Therefore, in the learning process, it is expected that the design or plan prepared will not only make students interact with the teacher as one of the learning resources, but also with all learning resources that can be used in an effort to achieve the desired learning objectives.

Education is always closely related to the curriculum. The curriculum acts as an instrument used to achieve educational goals, so it can be concluded that the curriculum is a guide for the implementation of education in Indonesia (Angga et al., 2022). This statement emphasizes that the curriculum is not just a document, but also a means and guideline used by education practitioners to carry out an optimal learning process in achieving educational goals. The government always pays serious attention to education because the progress of a country begins from education. One of the efforts made by the government to improve the quality of education is to perfect a sustainable curriculum through the implementation of the Merdeka Curriculum. The Merdeka Belajar policy rolled out by the Ministry of Education and Culture of the Republic of Indonesia (Kemendikbud RI) under the leadership of Nadiem Anwar Makarim, has a core concept of freedom in thinking patterns. This means that every school, teacher, and student is given the freedom to innovate in the learning process. The Merdeka Belajar policy is characterized by an emphasis on creativity, a learning approach that focuses on problem solving, adaptation of learning according to the needs of society in the global era, and a comprehensive evaluation approach (Saputri et al., 2022).

Based on the results of a survey related to the secondary education system in the world in 2018 issued by PISA (Program for International Student Assessment) in 2019, it shows that Indonesia is in a low position, namely 74th out of 79 other countries, so it can be seen that Indonesia is in the 6th lowest position compared to other countries. This illustrates that student literacy in Indonesia, including problem-solving skills, is still very low (Hidayatulloh et al., 2020). Meanwhile, the results of the 2022 PISA show that the literacy, mathematics (numeracy), and science skills of Indonesian students are still relatively low despite an increase in ranking. The literacy ability ranking of Indonesian students in 2022 was in 71st position. The mathematics ability ranking was in 70th position. Meanwhile, the science ability ranking was in 67th position. In 2022, there were 81 countries included in the PISA ranking (OECD, 2023). It should be understood that the lack of progress in PISA scores may reflect deeper challenges in the Indonesian education system. This includes the need for reform in the learning approach and curriculum development, to place more emphasis on critical thinking aspects and 21st century skills needed in the modern world.

The success of education can be seen from the quality of students, one of the benchmarks is the student learning process. Efforts to improve the quality of learning can actually be known through information about the success of teachers and students in interacting to achieve the learning objectives that have been set, while the learning process is the main activity, so that student success depends on the learning process itself. Efforts to create a good learning process include using a learning model. The use of learning models is adjusted to learning objectives. The learning process must also be considered so that the learning objectives are focused and can help students use their intellectual power. Low learning outcomes can be caused by various factors, and one of them is learning motivation. Motivation is an internal and external drive that encourages students who are learning to make better behavioral changes (Mardani et al., 2021). Each individual has a different level of motivation from each other. Motivation has the ability to increase the goals and targets to be achieved in learning outcomes. Students who have high motivation will use all their energy, feel happy and enthusiastic when following the learning process, which in turn will result in superior learning achievements. Conversely, students with low learning motivation can affect their activeness in learning, are not serious about learning, easily give up in solving problems, and have an impact on achieving less than satisfactory learning outcomes. Given the importance of motivation in helping students achieve the desired learning outcomes, the role of teachers is very significant in triggering the emergence of this motivation.

Based on the results of interviews and observations conducted with several educators at SMKN 4 Tarakan, chemistry/science learning still does not explore and develop students' abilities in solving problems related to the material being studied. Initial data shows that the average result of students' daily tests on the material of substances and their changes in the 2022/2023 school year was only 64.32. The low learning outcomes and students' problem-solving abilities and learning motivation are caused by several factors, including: students' current chemistry/science learning is only involved in simple tasks that do not explore their critical thinking skills for problem solving and applying them in everyday life. The learning process is less active where the teacher delivers the material, students memorize concepts, take notes, and listen. This can result in low student activity and low learning motivation. Based on the results of the field study, it is necessary to apply a learning model that can make learning more student-centered, improve students' ability to solve problems and be able to increase students' learning motivation. Based on this, it is necessary to apply student-centered learning, activate students and be able to improve students' problem-solving abilities and learning motivation.

The Independent Curriculum implemented in Indonesia emphasizes a more flexible and student-centered approach, which is in line with the principles of constructivism theory. Constructivism theory, pioneered by Jean Piaget and Lev Vygotsky, states that learning is an active process in which students construct their own understanding based on experiences and interactions with the environment. One learning model that can activate students is the PBL model. PBL is a learning model that confronts students with practical problem situations or begins with the presentation of problems related to the real world. This problem-based learning model is also in line with the principles of constructivism (Kartamiharja et al., 2020). In addition to demanding student-centered learning, learning is expected to be in accordance with the characteristics of the 21st century. One of the student-centered learning models that is in accordance with the characteristics of 21st century education, in accordance with the 4C's concept, namely creative thinking and innovation, critical thinking and problem solving, communication, and collaboration is the problem-based learning model (Saputri et al., 2022).

PBL has three types of learning, namely cognitive, collaborative, and content learning. The focus of cognitive learning is critical, creative, and innovative thinking skills. Communication and teamwork skills are the main focus of collaborative learning. Cross-disciplinary knowledge in science, technology, engineering, and mathematics (STEM) is the main focus of content learning. STEM is a learning approach that integrates science, technology, engineering, and mathematics to develop students' creativity through solving everyday problems. STEM focuses on connecting interdisciplinary knowledge that is not enough if done separately (Wahdaniyah et al., 2023). STEM is a cross-disciplinary learning approach that brings together the four fields of science, technology, engineering, and mathematics and breaks down the barriers that previously separated them (Smith et al., 2022).

The integrated problem based learning (PBL) learning model of Science, Technology, Engineering, Mathematics (PBL-STEM) is an innovation in education because it actively involves students in a structured group or team process, thus optimizing their thinking skills. This allows students to develop, test, and improve their thinking skills continuously, as well as demonstrate effective communication skills by communicating information to others (Andriani et al., 2021). PBL is a model that prioritizes the suitability of learning with things found in students' daily lives. The application of the PBL model can produce many desired abilities in the world of education (Nuswowati et al., 2017). PBL presents contextual questions and makes learning more meaningful for students, while STEM can provide profound benefits for students because they can solve problems through critical thinking processes and provide an overview of what they are doing (Rosiningtias et al., 2023). STEM education certainly not only equips students with concepts but also answers the need for human resources in Indonesia (Nuraziza et al., 2018). As a trend that is currently being widely echoed in the world of education, STEM is an approach to solving real-world problems by guiding students' mindsets to become problem solvers, inventors, innovators, building independence, logical thinking, technology literacy, and being able to connect STEM education with the world of work (Mulyani, 2019).

The results of research conducted by Sabora et al. (2022), revealed that learning using the problem based learning model in class X SMAT Wira Bakti in general has a significant effect on improving students' problem-solving abilities on the subject of basic chemical laws significantly. In line with this, the research (Mardani et al., 2021), PBL model can increase students' learning motivation. He also explained that motivation can move students to be more enthusiastic in receiving learning. In line with this research, research conducted by Rosiningtias et al. (2023), related to the implementation of the PBL-STEM model revealed that learning with the STEM approach integrated with the PBL model makes students more active in learning because the problems discussed come from the surrounding environment. In the implementation of PBL-STEM, in learning students gain experimental understanding based on facts in everyday life, provide comprehensive interpretations and can be used in everyday life because the skills obtained can be used in society besides that students are required to participate actively, learn to use their own ideas and initiatives, direct students to the desired goals, students will be motivated more optimally to learn. In addition, students are invited to have creativity and be able to utilize and be able to master technology.

Method

This study is a quasi-experimental study using a post-test only control group design. This study used one control group and one experimental group. In learning activities, students in the experimental group will be given treatment using the problem based learning (PBL) model, integrated with STEM, while in the control group will be given treatment using a scientific approach because learning activities at the school where the study was conducted are accustomed to using a scientific approach, although its application has not been maximized. The quasi-experimental post-test only research design is shown in Table 1.

Table 1. Research Design

Group	Treatment	Final test
Experiment	X1	Y1i, Y2i
Control	-	Y1j, Y2j

Information:
X1 : PBL-STEM Model
- : Scientific approach
Y1i : Experimental class problem solving ability
Y2i : Motivation to learn of experimental class
Y1j : Control class problem solving ability
Y2j : Motivation to learn of control class

The population of this study was students of class X of State Vocational High Schools in Tarakan City with the research sample being students from 2 classes of X of State Vocational High School 4 Tarakan which were divided into experimental class and control class. The sample in this study was obtained using random sampling technique on the class. The experimental class is a class that uses the PBL-STEM model and the control class is a class that uses a scientific approach. The data used in this study were collected using a problem-solving ability test instrument in the form of a descriptive test of 9 questions on the material of mixture separation techniques and a learning motivation questionnaire of 26 statements. The instruments used were first validated theoretically by experts and empirically validated to students. The descriptive problem-solving ability test instrument was compiled based on the problem-solving ability indicators put forward by Polya including: (1) understanding the problem; (2) planning a solution; (3) solving the problem according to plan; and (4) rechecking all steps (Kurniawati et al., 2019). Meanwhile, the learning motivation questionnaire instrument was compiled based on learning motivation indicators which include: (1) having a desire and desire to succeed; (2) having a drive and need in learning; (3) the existence of hopes and ideals; (4) the existence of appreciation in learning; (5) the existence of interesting activities in learning; and (6) the existence of a conducive learning environment (Uno, 2014). The post-test in the form of a descriptive test of problem-solving abilities and a learning motivation questionnaire was given to students at the end of the meeting. The data obtained were then analyzed using the Multivariate Analysis of Variance (MANOVA) test with the help of SPSS 26 software and Microsoft Excel. Before the Manova test was carried out, the Manova prerequisite test was carried out first.

Result and Discussion

Manova Test

The MANOVA test was conducted based on the results of the prerequisite tests that had been met. The first hypothesis tested whether or not there were differences in problem-solving abilities and learning motivation simultaneously between students in the experimental and control classes. The MANOVA test was used to determine whether or not there were differences between the experimental and control groups. The MANOVA results in this study are shown in Table 2.

Table 2. MANOVA (Hotelling's Trace) Test Results

	Effect	Value	F	Sig.	Description
Model	Hotelling's Trace	0.326	10.266[b]	0.000	There is a difference

The significance value based on the MANOVA (Hotelling's Trace) test is 0.000. These results indicate that Ho is rejected because the multivariate test produces a significance value smaller than 0.05 so that it can be concluded that there is a difference in problem-solving ability and learning motivation of students in classes using STEM-integrated PBL learning with classes using scientific learning.

To find out whether there is a difference in problem-solving ability between students in the experimental class and students in the control class and learning motivation between students in the experimental class and students in the control class can be seen based on the results of the test of between-subject effect analysis shown in Tables 3 and 4.

Table 3. Results of the Test of Between-Subject Effect on Problem Solving Ability

Dependent Variable	Df	Mean Square	F	Sig.
Problem Solving Skills	1	1202.152	15.059	0.000

Based on the results of the Test of Between-Subject Effect, the significance value for the problem-solving ability variable is 0.000, which means that the significance value is less than 0.05 (Sig.<0.05), so H_0 is rejected. Thus, it can be concluded that there is a difference in problem-solving ability between students in the experimental class and the control class.

Table 4. Results of the Test of Between-Subject Effect on Learning Motivation

Dependent Variable	Df	Mean Square	F	Sig.
Learning Motivation	1	1202.152	15.059	0.001

Based on the results of the Test of Between-Subject Effect, the significance value for the learning motivation variable was 0.001, which means that the significance value is less than 0.05 (Sig.<0.05), so H0 is rejected. Thus, it can be concluded that there is a difference in learning motivation between students in the experimental class and the control class.

The magnitude of the effective contribution of the PBL-STEM model to students' problem-solving abilities and learning motivation simultaneously can be seen from Hotelling's Trace in the partial eta square section. Based on Table 5, the partial eta square value is 0.246, which shows that 24.6% of the application of the PBL-STEM model provides an effective contribution to students' problem-solving abilities and learning motivation simultaneously.

Table 5. Results of Test of Between-Subject Effect

	Value	F	Hypothesis df	Sig.	Partial Eta Squared
Model	0.326	10.266^b	2.000	0.000	0.246

Furthermore, to analyze the effective contribution of the PBL-STEM model to students' problem-solving abilities on the material of substances and their changes, it can be seen from Hotelling's Trace in the partial eta squared section in Table 6.

Table 6. Results of the Test of Between-Subject Effect for Problem Solving Ability

Dependent Variable	Df	Mean Square	F	Sig.	Partial Eta Square
Problem Solving Skills	1	1202.152	15.059	0.000	0.190

The collected data shows a partial eta square value of 0.190. This means that the effective contribution of the PBL-STEM model to problem-solving ability is 19%. The effective contribution of the PBL-STEM model to students' learning motivation on the material of substances and their changes can be seen from Hotelling's Trace in the partial eta square column in Table 7.

Table 7. Results of the Test of Between-Subject Effect on Learning Motivation

Dependent Variable	Df	Mean Square	F	Sig.	Partial Eta Squared
Learning Motivation	1	339.682	11.921	0.001	0.157

The collected data shows a partial eta square value of 0.157. This means that the effective contribution of the PBL-STEM model to learning motivation is 15.7%.

This study aims to determine whether or not there are differences in problem-solving abilities and learning motivation between experimental class students using the PBL-STEM learning model compared to control class students through a scientific approach. This study also aims to analyze the effective contribution of the PBL-STEM learning model to the material of substances and their changes. Data on differences in problem-solving abilities were obtained through tests, while learning motivation was obtained from questionnaires. The following is a discussion of the problem-solving abilities and learning motivation of the experimental and control classes.

The difference in problem-solving ability in this study was measured through a posttest conducted at the end of the learning process. The posttest questions consisted of 12 descriptive questions. The posttest questions had gone through a theoretical validation stage by asking for consideration from 2 expert judgments who were lecturers in Chemistry Education from Yogyakarta State University (UNY). Empirical validation was tested on 34 students of grade XI of SMK Negeri 4 Tarakan. The results of the empirical validation obtained 9 valid questions and were suitable for use in the study. The analysis of whether or not there was a difference in problem-solving ability and learning motivation between students in the experimental class and the control class was carried out using the MANOVA test (Hotteling's Trace test). The data on problem-solving ability and learning motivation that had been obtained were analyzed using the MANOVA analysis technique after meeting the MANOVA prerequisite test. The results of the multivariate test obtained a significance value of 0.000. The significance value is smaller than 0.05, which means that there is a difference in problem-solving ability and motivation simultaneously between students in the experimental class and the control class. This is in line with research conducted by Andriyati et al. (2023) which states that giving contextual and complex problems will train students' problem-solving abilities, where in the STEM-integrated PBL model students are trained to analyze problems that exist in the lives of students. Another study by Septiani et al. (2020) stated that students' understanding of a material will increase students' learning motivation. The results of this study are also in line with research conducted by Prastika et al. (2022) which shows that the use of the STEM-integrated PBL model can improve student learning outcomes. Thus, based on the three studies, it can be concluded that the PBL-STEM model trains students to analyze contextual problems so that they can answer various questions and create better student learning motivation.

The results of the multivariate test obtained a significance value of 0.000. The significance value is smaller than 0.05, which means that there is a difference in problem-solving ability between students in the experimental class and the control class. Based on the results of the posttest that has been carried out, there is a difference in the average value of problem-solving ability between students in the experimental class and the control class. Students in the experimental class obtained an average posttest score of 86.29 while the control class was 77.74 as shown in Figure 1. Thus, it can be concluded that the experimental class has a deeper problem-solving ability regarding the concept of matter and its changes.

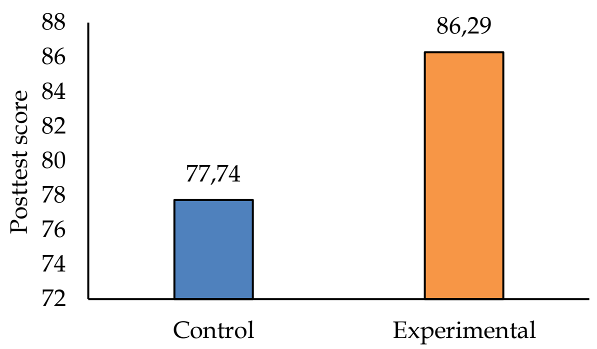

Figure 1. Problem solving ability posttest results

This is due to the difference in the models given, where the experimental class uses the PBL-STEM model while the experimental class uses a scientific approach. Learning with the PBL-STEM model is presented by providing examples of activities or phenomena around students' lives, namely in Tarakan City which are connected to STEM, which makes students more enthusiastic in learning it. This causes students to be better able to explain and find out things related to the phenomenon. In addition, STEM-integrated learning helps students to be able to determine what parts are in the phenomenon being studied. This is different from the control class which learns with a scientific approach where the learning is not linked to STEM.

The results of the multivariate test obtained a significance value of 0.001. The significance value is smaller than 0.05, which means that there is a difference in learning motivation between students in the experimental class and the control class. Based on the results of the posttest that has been carried out, there is a difference in the average value of learning motivation between students in the experimental class and the control class. Students in the experimental class obtained an average posttest score of 77.77 while the control class was 73.23 as shown in Figure 2. Thus, it can be concluded that the experimental class has a deeper learning motivation regarding the concept of matter and its changes.

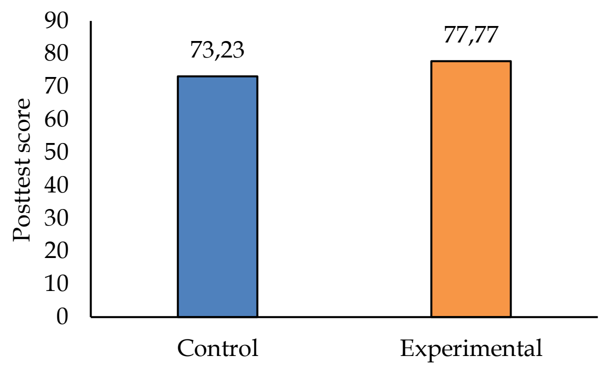

Figure 2. Results of the learning motivation posttest

The STEM-integrated PBL model can be an important learning experience for students to increase their confidence in their abilities and motivation to learn (LaForce et al., 2017). STEM learning can make students produce products from a learning, so that students can face future challenges and help students solve problems much more comprehensively if integrated (Hilyana et al., 2021; Jihannita et al., 2023). This is in line with research conducted by Reis et al. (2023) which states that the STEM approach can increase the complexity of students' cognitive structures. Thus, it can be concluded that the STEM-integrated PBL model can improve problem-solving skills, complexity of thinking, and learning motivation.

The results of the study showed a partial eta square value of 0.246 based on the results of the Test of Between Subjects Effects. This shows that the application of the PBL-STEM model provides a simultaneous contribution of 24.6% to problem-solving ability and learning motivation, including the high category. Problem-Based Learning (PBL)-STEM was carried out through 3 meetings. The first meeting focused on problem orientation by presenting six topics. In this early stage, students also developed their problem-solving skills in the learning process. The topics presented include: residents use dirty water for daily needs (topic 1), utilization of sea water (topic 2), processing of eucalyptus oil in the kenawai bird factory (topic 3), use of dyes in processed cassava foods (topic 4), making instant tiwul (topic 5) and utilization of coconut into VCO (topic 6). Furthermore, students collect relevant information to identify and solve existing problems for each topic. In addition, at this first meeting, students are asked to connect problems with existing sources and integrate STEM into the learning materials being studied, including science (writing chemical/science theories or basic scientific facts), technology (determining the underlying and developed technology), engineering (a series of tools), and mathematics (writing comparisons of substances, calculations, percentages, and others).

The activities in the second meeting were to create a presentation design and then review/improve it with the teacher. This activity began with designing a project according to the chosen topic. The process includes: (1) analyzing the answers to questions with problems including the separation techniques used; (2) literature studies including sources, working principles, and working methods; (3) conducting simple experiments on separating mixtures including objectives, tools, materials, and working methods; and (4) creating an infographic design with the final result in the form of an infographic storyboard image. Furthermore, the product that has been designed is then consulted with the teacher to get suggestions, input, and criticism. After receiving suggestions and input from the teacher, the students and their groups then improve it based on the results of the teacher's input.

The third meeting is presenting the results of the work. This activity includes explaining the work that has been made, conveying experiences gained during learning, and telling the obstacles/limitations faced, and improving them based on suggestions and input from friends/other groups. Explaining the results of this student's work helps improve students' problem-solving abilities at the conceptual level. Furthermore, analyzing and evaluating the problem-solving process. Students reflect and draw conclusions through discussions with friends and under the guidance of teachers. This stage is based on arguments based on evidence and communication of information to reach conclusions and evaluate deficiencies during the research (Adiwiguna et al., 2019).

In its application in this study, the steps of PBL-STEM learning activities show that learning activities by implementing the PBL-STEM model are very well implemented, where the learning design is made fun and associated with problems that are directly related to everyday life so that students are very active and enthusiastic in learning activities. PBL-STEM is able to create a more effective and meaningful learning process. This also makes the problem-solving ability and learning motivation of students better compared to the control class that follows learning with a scientific approach.

Thus, learning with the PBL-STEM model can improve students' problem-solving abilities and learning motivation. This is in line with research showing that the PBL model can improve students' communication skills, especially the ability to ask questions, express opinions, and communicate discussion results (Langitasari et al., 2021). Furthermore, STEM can challenge students critically, creatively and innovatively in applying science, technology, engineering, and mathematics in solving real problems (Sumartati, 2020). In addition, the application of PBL has a positive effect on learning outcomes including cognitive and affective (Kartamiharja et al., 2020). PBL-STEM helps encourage students to actively implement engineering and science aspects, as well as gain in-depth knowledge of science and mathematics to improve students' skills and experience in applying their knowledge in everyday life.

The implementation of learning using the PBL-STEM model has an effective contribution to the problem-solving ability variable of 19%, including the high category. Through PBL-STEM learning, students are taught to construct their own knowledge, develop problem-solving skills, become independent, and increase self-confidence and influence learning motivation. By providing authentic problems, students can assimilate the meaning of the subject matter through the learning process and their memory, so that it can be reapplied in the future (Ningsih, 2020). This is in line with Riswari et al. (2020) which states that problem solving requires design and implementation of various steps to achieve the expected goals and the role of teachers as instructors during learning in the classroom is one of the important things to know the problem-solving abilities of students.

The implementation of problem-based learning (PBL) integrated with the STEM approach is carried out by forming several study groups. In this method, students are given experimental experiences to produce an understanding of the facts obtained, then provide a comprehensive interpretation that can be applied in everyday life. The skills obtained from this learning can be used practically in society. In addition, students are encouraged to participate actively, use their own ideas and initiatives, and are directed towards the desired learning goals. This encourages students to learn more optimally. This method also encourages students to develop their creativity and improve their ability to master, utilize technology, and increase student motivation.

The implementation of learning with the PBL-STEM model has an effective contribution to the learning motivation variable of 15.7%, including the high category. The innovation of implementing the STEM-oriented PBL model is used to attract students' learning motivation to improve problem-solving abilities. The problems presented in the LKPD can influence students' responses where the LKPD uses life problems around students so that student motivation can increase because students learn directly the meaning and benefits of the material being studied in relation to real-life implementation. The purpose of this learning is to provide meaningful experiences for students, where teachers can observe the extent of students' understanding and wisdom, as well as how they respond and respond to challenges faced in the learning process. Therefore, learning with the PBL-STEM model is an alternative learning approach that has the potential to develop 21st century skills, where content mastery is developed through the provision of skills based on positive attitudes, characters, and habits (Halim et al., 2021).

Conclusion

Based on the results of the analysis, data processing and discussion, the author can draw the following conclusions: There is a significant difference in problem-solving abilities between students who follow the PBL-STEM learning model and students who follow the scientific approach learning on the material of substances and their changes. There is a significant difference in problem-solving abilities between students who use the PBL-STEM model and students who follow scientific approach learning on the material of substances and their changes. There is a significant difference in learning motivation between students who use the PBL-STEM model and students who follow the scientific approach to learning on the material of substances and their changes. The effective contribution of the application of the PBL-STEM model to problem-solving skills and learning motivation simultaneously on the material of substances and their changes is 24.6%, which is included in the high category. The effective contribution of the application of the PBL-STEM model to problem-solving skills on the material of substances and their changes is 19%, which is included in the high category. The effective contribution of the application of the PBL-STEM model to learning motivation on the material of substances and their changes is 15.7%, which is included in the high category.

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Author Contributions

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Conflicts of Interest

All author declares that there is no conflict of interest.

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