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Application of Problem-Based Learning (PBL) on Hydrocarbon Compound Lesson to Increase Student Learning Outcomes

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Abstract
This study aims to improve the learning outcomes of 11th grade Science 4 state senior high school (SMAN) 3 Ambon on the subject material of hydrocarbon compounds by using the Problem-Based Learning model. This research was conducted with 37 11th-grade Science 4 students as the research sample. The data was collected by tests, observation sheets, and worksheets. Data were analyzed descriptively by percentage and n-gain with categories. The results of the research showed that the student's learning outcomes were achieved with different qualifications. There are 2 students (5.41%) who had very good qualifications, 27 students (72.97%) were in good qualifications, 5 students (13.51%) are in fair qualifications, and 3 students (8.11%) are in poor qualifications/failed. N-gain achievement of 28 (75.68%) students was in the high category and 9 (24. 32%) students were in the medium category. The results of the analysis of the average normalized gain score for all students are 0.77 which is in the high category. Therefore, the Problem-Based Learning (PBL) model can improve student learning outcomes.

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INTRODUCTION

The curriculum is a component that has been programmed, planned, and designed regularly and is used as a reference in the process of learning activities to achieve the goals of education. The 2013 curriculum is a curriculum that requires students to be successful in all aspects, both in the form of cognitive, affective, and psychomotor aspects. The 2013 curriculum is now widely used in several schools, one of which is in-class activities involving students to be more active, especially in the learning process. In the 2013 curriculum, subjects must be followed by all students in one educational unit at each unit or level of education (Kementrian Pendidikan dan Kebudayaan, 2012).

Student learning outcomes are one of the goals of the learning process in schools, for that, a teacher needs to know, study several teaching models, and practice them when teaching. To produce high student achievement (results) of learning, teachers are required to educate and teach students by using the learning model needed in the learning process in class (Mulyasa, 2010; Nasution, 2017).

Based on the results of observations at SMA Negeri 3 Ambon through interviews with chemistry subject teachers. It shows that one of the difficult subject materials for students is Hydrocarbon. Some students respond well, but some do not. The last is almost all students get grades below the cut score (KKM). That is the reason why I took the Ambon 3 Public High School in the material for hydrocarbon compounds, was because during the pandemic this school used an emergency curriculum, where the learning indicators that had to take place were

nine basic competencies (KD) to seven KD, one of the indicators that did not teach is the subject material of hydrocarbon compounds. When asked if the previous learning results could not be provided by the teacher at the school because this material on hydrocarbons had not been taught during the pandemic. So that the material for hydrocarbon compounds seems easy but many are still wrong in naming hydrocarbon compounds, determining or identifying the types of hydrocarbon compounds, and the reactions of hydrocarbon compounds. This problem has an impact on learning motivation and will affect student learning outcomes.

Hydrocarbon compounds are a subject material that is quite abstract but can also be found in everyday life. Hydrocarbon compounds are commonly found in everyday life, one of which is gasoline. In addition, many hydrocarbon compounds are found in goods used in everyday life, for example, plastic, charcoal, gas, and others. Hydrocarbon compounds are learning material in 11^{th} grade which explains carbon compounds that are closely related to everyday life such as carbohydrates, fats, combustion products, and others. Hydrocarbon compounds are considered difficult because in learning there are theoretical terms and carbon chain structures that are difficult for students to understand so in the end students get the wrong concept. Hydrocarbon material will be easy to understand if students are active in learning (Ernawati & Ikhsan, 2016; Khairini et al., 2021; Listari, 2013; Mashami & Khaeruman, 2020; Safira & Effendi, 2022; Zakir et al., 2021).

One effort to overcome these problems is to use the PBL model because this model is a learning model based on the structure of real problems with everyday life and is related to the material concepts to be studied. In addition, because this model is centered on students, they are required to play an active role in exploring and developing their understanding of the concepts being studied. Problem-based learning is a learning model that presents real problems in students' daily lives (contextual problems) to stimulate students to learn. PBL challenges students to work in groups to find solutions to real-world problems. The problems given are used to help students' curiosity in the intended learning. Through the PBL model which is taught on hydrocarbon material, students are brought to contextual problems, such as in the problem orientation stage, students' critical thinking skills are built in formulating real problems (Graaff & Kolmos, 2003; Silver-Hmelo, 2004).

Based on previous research that the PBL learning model can improve student learning outcomes (Fauziah et al., 2016; Herlina, 2020; Listari, 2013). This was proven in research that the application of the PBL learning model contributed 28.34% to student learning outcomes from the preliminary study, amounting to 10.32% since the pretest was carried out (Lusiyana et al., 2019). Based on the results of the study it can be concluded that the Problem-Based Learning (PBL) learning model on compound nomenclature material is effective in student learning outcomes of class X MAN in Banjarbaru City. This can be seen from the difference in the average pretest and posttest learning outcomes of students, as evidenced by the calculation of the Wilcoxon test where the sig value (0.001) is smaller than the α value (0.05).

Further study (Mautia, 2020) on the application of Problem-Based Learning to the hydrocarbon compounds subject material can improve the chemistry learning outcomes of 10^{th}-grade TKR students at SMK Muhammadiyah I Banda Aceh (Meutia, 2020). At the end of the cycle I, students who achieved learning mastery were 47.37% (9 people), and students who had not completed were 52.63% (10 people), while in cycle II, students who achieved learning mastery were 84 .21% (18 people), and students who have not completed as much as 15.79% (3 people). With an average grade in cycle I of 46, and an average in cycle II of 79. In another study conducted (Herlina, 2020), problem-based learning can improve student learning outcomes in hydrocarbon material. This can be seen from the results of the posttest in cycles I and II, which increased from 69.47 to 78. Based on this description, the researcher was interested in researching the application of the Problem-Based Learning (PBL) model on hydrocarbon

compound lessons on increasing learning outcomes of 11th-grade Science 4 students of state senior high school (SMAN) 3 Ambon.

METHOD

The type of research used is descriptive quantitative research which aims to describe student learning outcomes by applying problem-based learning models. In this case, the results of student learning are seen after taking lessons using the problem-based learning model. The population in this study were 145 11th-grade science students at SMAN 3 Ambon, the academic year 2022/2023 which is divided into four classes. The sample for this study was taken purposively with a total sample of 37 students of 11th grade Science 4 students of SMAN 3 Ambon. Research Instruments consist of tests and observation sheets. The test in the form of an initial test (pre-test) and a final test (post-test) consists of multiple choice and description questions to measure students' cognitive abilities. Observation sheets consist of affective and psychomotor observation sheets and student worksheets (LKPD). Data were analyzed quantitatively using the percentage formula to describe student initial proficiency (Pre-test), cognitive, affective, and psychomotor performance during learning, and final proficiency. Data describe 4 qualifications of proficiency, very good (85 – 100), good (76 – 84), fair (72 – 75), and poor (<72). *The n-gain* formula was carried out to describe student enhancement expressed in the high (**g > 0.7)**, medium (**0.3<g≤0.7)**, and low (**g ≤ 0.3)** categories (Sugiyono, 2010).

RESULTS AND DISCUSSION

The purpose of this study was to determine the increase in student learning outcomes after the learning process was carried out using the Problem-Based Learning model. This research was conducted in three meetings on the material of hydrocarbon compounds. The class used as the sample was class XI IPA 4 SMA Negeri 3 Ambon with a total of 37 students. Based on the research conducted, the results of the research will be described as follows:

Initial Test (Pre-Test) of Students

Before carrying out the teaching and learning process in class, students are given an initial test (pre-test). This test was carried out to know the extent of students' readiness and initial knowledge of the material to be taught. The initial test consisted of 10 PG questions and 5 essay questions which were arranged based on the material being taught, namely hydrocarbon compounds (alkanes, alkenes, and alkynes), physical properties, types of isomers, and simple reactions of alkanes, alkenes, and alkynes. Preliminary test results data are shown in Table 1 below.

Table 1. Student achievement data in the initial test (pre-test)

Intervals	F	FR%	Qualification
85 - 100	-	-	very good
76 - 84	-	-	good
72 - 75	-	-	fair
< 72	37	100	poor
Total	37	100	

Based on Table 1, it can be seen that the initial test scores obtained by students are low which is evidenced by the results of the initial test of students who are in poor qualification/failed. The result is due to initial knowledge of compound material. These hydrocarbons are still minimal and the lack of readiness of students to take part in the learning process. The students'

scores which are classified as poor for this material of hydrocarbon compounds can be understood because the material has never been taught to students before. Basic knowledge (cognitive) or the most basic aspects of this knowledge have not been mastered by students.

Student Learning Outcomes During the Learning Process

After the initial test process has been carried out or has been carried out, it is continued with the learning process. The learning process using the PBL model is carried out in three meetings. During the learning process, students will be assessed through cognitive aspects, affective aspects, and psychomotor aspects.

Student Cognitive Proficiency

Student cognitive assessment data can be obtained from the results of assessing students' cognitive processes in working on student worksheets (LKPD). The LKPD provided aims to determine students' understanding of the material for hydrocarbon compounds and which lasted for three meetings. The data obtained can be seen in Table 2 below.

Table 2. Data on students' cognitive abilities at each meeting

Intervals	Meeting I		Meeting II		Meeting III		Qualification
	F	FR(%)	F	FR(%)	F	FR(%)	
85 -100	30	81.08	22	59,46	14	37,84	very good
76 - 84	7	18,92	15	40,54	23	62,16	good
72 - 75	-	-	-	-	-	-	fair
< 72	-	-	-	-	-	-	poor
Amount	37	100	37	100	37	100	

Based on the data in Table 2, it can be seen the cognitive abilities of students at each meeting. Cognitive Assessment was assessed in groups. At the first meeting (I), almost all students could answer the questions on the worksheet, even though the results of each group were different but almost all students were able to achieve very good qualifications. The achievement of cognitive learning outcomes of students with very good qualifications is also triggered by the ability of students to understand indicators, namely the uniqueness of carbon atoms, the types of carbon atoms based on the number of C atoms attached to carbon chains, and the classification of carbon compounds taught by the teacher. so that students can solve the problems that exist in the worksheets given by the teacher to be solved starting from students being able to provide orientation on the problems given. Students are shown pictures and narratives related to indicators of the uniqueness of carbon atoms. The next where students can present the results they have done very well and discuss the objections of each group.

The teacher's strategy in applying the learning model (PBL) is balanced with what the teacher teaches during the learning process so that what is taught by the teacher can be properly recorded by students. and up to the stage where students can present the results they have done very well and can answer objections from each group. The teacher's strategy in applying the learning model (PBL) is balanced with what the teacher teaches during the learning process so that what is taught by the teacher can be properly recorded by students. and up to the stage where students can present the results they have done very well and can answer objections from each group. The teacher's strategy in applying the learning model (PBL) is balanced with what the teacher teaches during the learning process so that what is taught by the teacher can be properly recorded by students (Khery et al., 2013; Purwanto & Siregar, 2016).

The achievement of student scores began to change at the second meeting (II), it can be seen clearly in Table 4.2, there were 22 students (59.46%) with very good qualifications, 17 students (40.54%) with good qualifications, and there are no students with fair and poor qualifications or fail. This is because the types of learning outcomes began to be developed, starting from the

type of knowledge results (C1), to the types of learning outcomes for understanding (C2), application (C3), and analysis (C4), so that the questions the students worked on changed the level of difficulty. Even so, students still achieve very good and good qualifications. This achievement was because these students were able to work on all the core stages, from determining the problem to working on the questions or assignments provided in the worksheet.

At the third meeting (III) there were 14 students (37.84%) with very good qualifications, 23 students (62.16%) with good qualifications, and no students with fair and poor qualifications or failed. Table 4.2 explains that: there is a decrease in cognitive learning outcomes when compared to the second meeting (II). The decrease in learning outcomes in the third meeting (III) was since in the third meeting (III) the level of difficulty was in determining the types of isomers and predicting simple reactions of hydrocarbon (alkanes, alkenes, and alkynes).

Student Affective Proficiency

The effective assessment of students is assessed from every learning process in the class at meeting I, up to meeting III. Target affective aspects include persistence, thoroughness, and the ability to solve logical and systematic problems. This aspect is a realm shown by behavior dealing with emotional matters such as feelings, values, interests, concerns, motivations, and attitudes. Affective assessment (attitude) is shown in Table 3.

Table 3 Data on students' affective abilities at each meeting

Intervals	Meeting I		Meeting II		Meeting III		Qualification
	F	FR (%)	F	FR(%)	F	FR(%)	
85 -100	27	72.97	24	64,86	27	72.97	very good
76 - 84	10	27.03	13	35,14	10	27.03	good
72 - 75	-	-	-	-	-	-	fair
< 72	-	-	-	-	-	-	poor
Amount	37	100	37	100	37	100	

Based on Table 3, it can be seen that at the meeting I, II, and III all students were in very good and good qualifications and there were no students who were in fair or poor qualifications or failed. This is because students pay attention to the material that is conveyed properly and seriously in group discussions and students who can explain also to students who still do not understand the material. The ability of students at each meeting is in varying qualifications and has also increased to very good and good qualifications indicating that students can receive very well and well. These results were obtained from the sum of each student's positive affective value which was assessed in terms of responsibility, teamwork, discipline, respect for friends, and honesty. The application of problem-based learning is able to make students have better attitude on science learning (Fauziah et al., 2016; Khery et al., 2013; Khoiriyah & Husamah, 2018; Purwanto & Siregar, 2016)

Student Psychomotor Proficiency

Assessment of the psychomotor aspects of students is carried out to find out what skills are mastered by students. These results were retrieved using psychomotor assessment sheets for each learning process in the class at meeting I, meeting II and meeting III. Psychomotor assessment is shown in Table 4.

The data in Table 4 shows the results of the psychomotor achievement of students. At meetings I, II, and III, all students were in very good and good qualifications and there were no students who were in fair and poor qualifications/failed. This is because each student is able to be enthusiastic about answering, explaining, presenting, and being accountable for their work. The enthusiasm of students is triggered by the PBL model which requires all students to be actively

involved in the learning process and takes responsibility for what has been done on the work sheet together.

Table 4. Data on students' psychomotor abilities at each meeting

Intervals	Meeting I		Meeting II		Meeting III		Qualification
	F	FR(%)	F	FR(%)	F	FR (%)	
85 -100	22	59,46	24	64,86	29	78,38	very good
76 - 84	15	40,54	13	35,14	8	21,62	good
72 - 75	-	-	-	-	-	-	fair
< 72	-	-	-	-	-	-	poor
Amount	37	100	37	100	37	100	

Assessment of the learning process for psychomotor aspects for each learning process carried out, obtained from the activeness of students in learning. Almost all students get the opportunity to answer, explain orally, write down and explain what they do and understand. This is used as a psychomotor value, not only the knowledge that is dominated but also the extent to which students are brave in expressing what they know.

This psychomotor assessment is related to the model used in the learning process, namely the PBL model. Judging from the results obtained, each meeting has a different frequency, starting from the first meeting to the third meeting which has increased, where this problem-solving learning model has begun to be developed and understood by students at each meeting to solve every problem in the LKPD shared. Problem-solving can develop critical thinking skills and the ability to adapt to new knowledge from students (Khery, 2013).

Student Learning Outcomes in The Final Test

The final test is carried out after the students take part in learning using the PBL (Problem-Based Learning) model. The final test questions given are 10 multiple-choice questions and 5 essay questions. In contrast to the initial test (almost all students did not fill in the answers to questions: 1-5), for essay questions in the final test all students answered/filled in each question asked, whereas for the selected PG questions there was a change when compared to the initial test. Student final test results can be seen in Table 5.

Table 5. Student achievement data in the final test (post-test)

Intervals	F	FR (%)	Qualification
85 - 100	2	5,41	very good
76 - 84	27	72.97	good
72 - 75	5	13.51	fair
< 72	3	8,11	poor
Amount	37	100	

The data in Table 5 shows that the achievement of students' final test results is 2 (5.41%) students with very good qualifications, 27 (72.97%) students with good qualifications, 5 (13.51%) students with fair qualifications, and 3 (8.11) students are in poor/failed. This is because along with the enthusiastic learning process, students began to be directed. It is clear that the difference in the final test results is much better than the initial test even though there are still 3 (8.11) students who are poor qualified or fail, this is because students cannot work on the test questions that have been given by the researcher. Students who are very good qualifications because solving questions, 29 of these students can do well and correctly.

The success of students in achieving learning mastery in this study was also because the teacher had carried out the learning process using the PBL model which was also supported by cognitive, affective, and psychomotor assessments. The result is that students can answer each

question and can achieve the assessment criteria for each aspect. From these data, it can be said that all students can achieve KKM after following the learning process using the Problem-Based Learning (PBL) model. Thus, the use of the PBL model in the learning process is effective in achieving student learning mastery.

N-gain Value Data

Improved student learning outcomes can be seen by using the N-gain formula. N-gain is the difference between the pretest and posttest scores, the gain shows an increase in students' understanding or mastery of concepts after learning is carried out by the teacher (Arikunto, 2016). The pre-test and post-test were analyzed using the n-gain technique to find out the increase in student learning outcomes after the PBL learning model was applied, the results of which can be seen in Table 6.

Table 6. N-gain score calculation results

Interval	F	FR(100%)	Criteria
$g > 0.7$	28	75,68	high
$0.3<g\leq0.7$	9	24,32	medium
$g \leq 0.3$	-	-	low
Amount	37	100	

The data in Table 4.6 shows that the increase in student learning outcomes in the material for hydrocarbon compounds is that 28 (75.68%) students are in the high category and 9 (24.32%) students are in the medium category. From the description of the N-gain data, it can be said that overall, there is an increase in student learning outcomes in the material of hydrocarbon compounds with the criteria for achieving an N-gain of 0.7 included in the high category.

With the success of students in the learning process, of course, there is a contribution from the learning models. The Problem-Based Learning (PBL) model, problem-based learning models can solve problems can stimulate students' ability to find new knowledge for students, problem-solving can increase student learning activities, problem-solving can also help students to apply their knowledge in everyday life which is related to the material being taught, namely hydrocarbon material, which these chemical compounds are most commonly encountered in everyday life, and problem-solving can help students develop their knowledge (Arends, 2008; Ersoy & Başer, 2014; Khoiriyah & Husamah, 2018; Silver-Hmelo, 2004; Surya et al., 2017; Yuliati et al., 2018). Problem-solving can train students to think in dealing with something and can be used as a self-evaluation of the results and the learning process.

The Problem-Based Learning (PBL) model applied to the material of hydrocarbon compounds can increase the activeness of students in learning and develop students' thinking processes in solving problems given by the teacher individually or in groups (Awang & Ramly, 2008; Khery et al., 2013; Khoiriyah & Husamah, 2018). Thus students in the learning process are more active so the teacher is only a motivator and facilitator for students in the classroom. Students can also understand the material of hydrocarbon compounds correctly and can improve learning outcomes in the lessons taught by the teacher.

CONCLUSION

From the research results it can be concluded that the learning outcomes of students are as many as 2 students (5.41%) who are in very good qualifications, 27 students (72.97%) are in good qualifications, 5 students (13.51%) are in fair qualifications, and 3 students (8.11%) are in poor/failed. The results of the analysis of the average normalized gain score for all students are 0.77 which is in the high category, this indicates that there is an increase in learning outcomes in the material of hydrocarbon compounds.

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