ISSN 2987-4270
PLE
Physics Learning and Education
Vol. 1 No. 2 (2023), page 81-90

Enhancing Student's Skills: Need Analysis To Develop E-Modul Integrated Problem-Based Learning Model On Smartphone-Based

Melfa Rahmayani[1], Asrizal[1*]

Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia
Corresponding author: asrizal@fmipa.unp.ac.id

ABSTRACT

The development of Science and Technology is a feature of the 21st century which requires students to have critical thinking, creative thinking, communication, and collaboration skills. This study aims to need analysis to develop an e-module for a renewable energy-integrated PBL model based on a smartphone to improve students' creative thinking and communication skills. The objects of this study were three high school physics teachers, 70 class X high school students, and teacher documents in the form of learning objectives, teaching modules, and documents on the student's midterm assessment results. Data collection techniques used in this study were questionnaires, documentation, and tests of student's creative thinking and communication skills. Data collected were analyzed using quantitative descriptive statistical analysis techniques. Based on data analysis, the study results include: 1) the use of ICT in physics learning is in the sufficient category, this is not in line with the significant potential use of technology in schools, especially the use of smartphones, 2) students characteristics seen from the components of background, interest in learning, learning motivation, learning styles, and students' attitudes are in a good category, but the value of knowledge and creative thinking skills and students' communication is still low, 3) the learning objectives carried out by the teacher as seen from the flow analysis of the learning objectives of three teachers are in the category sufficient, 4) the learning arrangements carried out by the teacher by looking at the teaching modules of three teachers are in the sufficient category.

Keywords: *E-modul, Problem-Based Learning, Smartphone, Creative Thinking Skills, Communication Skills*

I. INTRODUCTION

The development of science and technology in education has produced many innovations to support the learning process [1]. The rapid development of science and technology has changed the paradigm of learning in the world of education, shift in digital learning marks the development of science and technology, requiring individuals to have 21st-century skills. Development Science and technology characterize the 21st-century and influence the global order of life. The pace of science and technology development has indirectly required prerequisites for the human ability to obtain opportunities to participate in it [2][3]. In order to cope with the advancements in science and technology individuals are expected to possess relevant skills in the 21st century to cope with the advancements in science and technology.

The 21st-century skills are skills that a person needs to successfully face increasingly complex challenges, especially to achieve success in life [4][5]. The 21st-century is marked as the century of openness or globalization. In the 21st-century human life is experiencing fundamental changes that are different from the order of life in the previous century. The 21st century demands student skills to be ready to face existing challenges [3][6]. 21st-century skills have become basic skills that students must have today. Four skills are essential for students to master, known as the 4C skills. These skills consist of critical thinking, creative thinking, communication, and collaboration skills [7][8]. The importance of 4C skills in the 21st-century is due to increasingly fierce competition for human resources, one of which is the mastery of various competencies.

One of the skills students must have is creative thinking skills. The assignments given to students, especially those that contain various everyday problems, require students to apply creative thinking skills in analyzing problems, finding ideas, and arguing [8]. In line with creative thinking skills, students must also have communication skills. Communication skills are skills possessed by a person to convey new thoughts, ideas, knowledge, and information to others through speech, writing, symbols, pictures, graphics, or numbers [9].

Through the skills of creative thinking and communication that owned, it hoped to achieve educational goals by the demands of the independent curriculum.

The independent learning curriculum answers the intense competition for human resources globally in the 21st century [10][11]. Education has a strategic role in forming qualified, creative, and competitive human resources. The presence of the independent learning curriculum is the government's effort to improve the quality and quality of education in a better direction. Learning in the era of independent learning involves independent conditions in fulfilling the goals, methods, materials and evaluation of learning for both teachers and students [10]. The concept of independent learning that has developed into a curriculum has relevance to 21st-century learning because it is more concerned with the needs of students. Thus, the independent learning curriculum is one of the curricula that can overcome the educational crisis and adapt to the times [11].

In essence, educational efforts are an investment in the future of a nation for the progress of the Indonesian nation through sustainable development. One aspect that needs to get full attention in sustainable development is the environmental and energy aspects [12]. The problems Indonesia faces in the environmental and energy fields are dependence on dwindling fossil energy reserves, limited access to energy for the community, and the development of renewable energy constrained by technological mastery and low financing. The problem of limited access to energy requires an effort to reduce dependence on fossil energy, for example, by developing renewable energy sources or changing our behaviour in using energy, which is the responsibility of the world of education in preparing students to have intelligent behaviour in consuming energy [13]. The curriculum is vital in awakening students to care more about the environment. One of the subject matter that studies energy and the environment is physics.

Physics learning is learning by developing reasoning and analysis, so that almost all issues related to nature can be understood [14][15]. The physics learning process provides direct experience in developing competencies to explore and understand the natural surroundings scientifically. Physics learning is developed based on the principle of active learning, which provides opportunities for students to develop their potential [16]. Physics learning is needed in everyday life to meet human needs through problem-solving. Solving problems requires a relevant learning model called the Problem-Based Learning model [17]. Physics learning can work by using teaching materials that can guide students in the learning process, such as e-module. Based on previous research, to make it easier for students to learn independently about renewable energy so that students can become people who drive change and fight for clean and affordable energy for all, they need teaching materials in the form of e-modules which can be carried anytime and anywhere [18].

The efforts made by the government, schools, teachers and other parties did not break the fact that the conditions in the field needed to reflect the expected conditions. For this reason, a preliminary study was carried out to see the problems in the field. The preliminary study was carried out to assess students' creative thinking and communication skills, as evidenced by tests measuring their abilities in these areas using the problem-based learning model. The results of student's creative thinking and communication skills in one of the public high schools in the city of Padang were in the lower category with an average of 56.07 and 55.24. These results differ from the demands of the 21st century, which require students to have creative thinking and communication skills in every day life.

The initial study was also supported by analyzing three journals regarding physics e-modules to improve students' creative thinking and communication skills. According to the first relevant research, based on the results of the initial test giving questions to students, it was found that the student's creative thinking skills had an average score of 52.79 in the less category. It can be seen from the students' answers stating that students still needed diverse and creative answers [19]. According to the second relevant research, the profile of students' creative thinking skills, namely 55.38%, is included in the sufficient category. It is due to the need for companion books that hone creative thinking [20]. According to the third relevant research, based on interview results, it was found that only a few students had good communication skills when learning physics took place in each class. It is influenced by physics learning activities that still need to follow what they should be, and practicum activities are only carried out on some deemed necessary material [21].

Starting from the ideal and actual conditions described, it found problems with students' creative thinking and communication skills. It is essential to make efforts to overcome this problem. One solution to this problem is to develop an e-module renewable energy integrated problem-based problem-based learning model on smartphone-based enhancetudents' creative thinking and communication skills. One of the learning materials that require e-modules is renewable energy because physics teaching materials that contain this material are still limited [22]. This material is essential to make students aware of using energy properly and caring for the

environment. This solution follows the independent learning curriculum design, which states that the physics learning process is adapted to the learning outcomes of each phase.

The research has three theoretical studies: e-modules, smartphones, problem-based learning models and students' creative thinking and communication skills. The first theory, E-module is an electronic version of the module with user access via electronic devices such as computers, laptops, tablets or even smartphones. E-modules can make it easier for students to learn independently and help them understand the material concept, whether or not there is a teacher [23]. E-modules are modules in digital form, consisting of text, images, or both, which contain digital electronic material accompanied by simulations that can and are appropriate for use in learning [24]. One way to make e-modules is to use the Flip PDF Professional application. Flip PDF Professional is a feature-rich flipbook maker with a page edit function to create interactive book pages by including multimedia such as images, video, audio, hyperlinks, and others [14].

The second theoretical study is about the problem-based learning model, the PBL model. The PBL model is a learning model that can develop students' mindsets and make students active and creative [25][26]. The PBL model allows students to take an active role in seeking information, solving existing problems, being responsible for the assignments given and associating a physics concept with events in their lives. Through problem-based learning, students experience a learning process by actively solving problems through structured stages and at the end of learning, students are expected to produce a particular product [17]. The problem-based learning model will make learning activities more enjoyable, increase learning interactions, and students become directly involved in mastering the material. Student involvement in learning increases students' creative thinking and communication skills [27].

The third theoretical study is about smartphones as a tool used in the learning process. A smartphone *or* smartphone is a mobile phone that can use and function like a computer. The smartphone is a type of media that can distribute information quickly through its internet facilities [1][28]. Smartphones can connect humans to one another over long distances with supporting facilities such as SMS, chat, telephone, and viber (telephone using internet data package facilities). The function of *a* smartphone is not only for texting and calling, but users can freely add applications, add functions or change according to the user's wishes. Smartphones also benefit students because they are multimedia learning media, which they can use for various purposes, including technology-based learning resources [24].

Based on the contextual background of the described issues, preliminary research analyzes the need to develop an e-module renewable energy integrated problem-based learning model on smartphone-based to enhance students' creative thinking and communication skills. The purpose of the study was to analyze the use of ICT in teaching physics in schools, student characteristics, teacher learning objectives from the ATP, and teacher learning arrangements from the teaching module.

II. METHOD

The research conducted is a type of quantitative descriptive research that is oriented towards the development of a product. Descriptive research is research with a method of describing and interpreting objects according to what they are. In general, descriptive research is carried out with two main objectives: systematically describing the facts and characteristics of the object being studied accurately [6][29]. Quantitative descriptive research is a method for describing, researching, and explaining something studied as it is and drawing conclusions from the phenomena that are observed using numbers [14].

Needs analysis In this initial study, there were three objects investigated. The objects investigated were three high school physics teachers at a state high school in Padang city, 70 high school students in class X, and teacher documents in the form of ATP, teaching modules, and documents on the results of student midterm assessments. High school physics teachers are used to get information about the use of ICT in learning physics. High school class X students are objects for obtaining information about student characteristics during learning and viewing creative thinking and communication skills. On the other hand, documents in the form of ATP and teacher teaching modules are used to obtain information on the learning objectives designed by the teacher and the learning arrangements carried out by the teacher. The midterm assessment document is used to see students' knowledge in learning physics.

Data was collected through appropriate instruments and analyzed using specific analytical techniques. The data collection technique used in this study was a questionnaire consisting of teacher and student questionnaires, document studies, and tests of creative thinking skills and communication. Teacher and student questionnaires were used to find information about the use of ICT in learning and student characteristics; document studies were used to see the results of students' midterm assessments as well as ATP and teaching modules used by

teachers, tests of creative thinking and communication skills were used to see creative thinking skills and student communication through the PBL model.

The data analysis technique used in this research is descriptive statistical analysis. Descriptive statistics are statistic that function to describe the object under study through sample data or population as it is. On these descriptive statistics, without conducting analysis and making conclusions that apply to the public. Several presentations of data that can be used in descriptive statistics are, such as ordinary tables, frequency distributions, graphs, and explanations of data groups through the mode, median, mean value, group variation and standard deviation [30]. The first step is to quantitatively analyze the questionnaire data, namely to determine the highest score for each indicator. Then, calculate the total score given to all students sampled for each indicator. The next step is to calculate the percentage value of each indicator. The formula for calculating the indicator is as follows:

$$\text{Percentage of Value} = \frac{total\ score}{highest\ score} \times 100\%$$

The percentage of values obtained from data processing is analyzed using the categories in Table 1:

Table 1 . Tendency of Data Alignment of Learning Objectives with Learning Outcomes

Category	Percentage
Very good	80-100
Good	70-79
Sufficient	60-69
Not good	<60

Source: Ministry of Education and Culture [31]

III. RESULTS AND DISCUSSION

RESULTS

Results of Analysis of Problems Utilizing ICT in Physics Learning

The first result of the research is the problem of using ICT in learning in schools. The data collection technique and the instrument used was the teacher's questionnaire instrument. The questionnaire provided was filled out by three physics teachers at one of the state high schools in Padang City. Based on the questionnaire results, it was found that the use of ICT in learning physics in the classroom was in the sufficient category, with an average of 65.25%. These results do not align with the significant potential use of technology in schools, especially smartphones [32]. The questionnaire analysis consisted of four components consisting of the use of ICT in learning (L), the use of ICT in physics teaching materials (TM), the use of ICT in learning media (LM), and the use of ICT in assessment (A). Each component consists of three statement indicators. The results of the analysis of ICT utilization are explained in Figure 1.

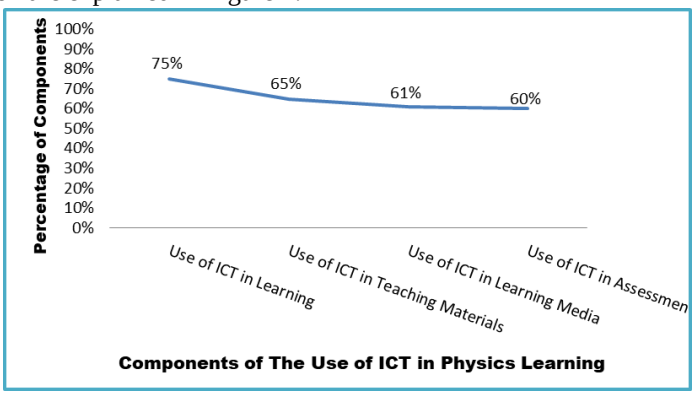

Figure 1. The Results of Analysis The Use of ICT in Physics Learning

The data in Figure 1 explains that the use of ICT in learning physics in schools is quite good. The use of ICT in physics learning has been carried out by teachers with a percentage of 75.00%. Teachers use ICT to send assignments, read references, and communicate with students. The use of ICT in physics teaching materials has also been carried out by teachers with a percentage of 65.00%; teachers use ICT to make teaching materials such as worksheets and modules. The use of ICT in learning media has also been carried out with a percentage of 61.00%; teachers make learning media in the form of PowerPoint slides to make it easier for teachers to teach physics. The teacher has also carried out the use of ICT in assessment with a percentage of 60%; the teacher conducts student assessments by using the Google form to see student learning outcomes on the learning

material that has been studied. The teacher only sometimes uses ICT in learning; the teacher uses ICT if learning is not effectively carried out in the classroom, for example, during the pandemic period, holiday commemorations, or specific events.

Results of Analysis of Student Characteristics

The second result of this study is the characteristics of students, as seen from the questionnaire instrument. Questionnaires were given to 70 class X students at one of the public high schools in Padang. The analysis results show that the characteristics of students in the SMA are in a good category with a percentage of 72.60%. The characteristics of the students who were assessed consisted of several components, namely, background (B), interest in learning (I), learning motivation (M), learning style (S), and attitude (A) during the teaching and learning process in the classroom. Student characteristics can be seen in Figure 2.

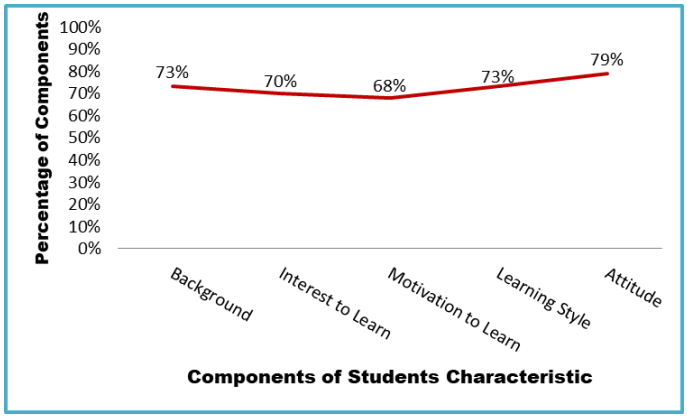

Figure 2. Results of Analysis of Students Characteristic

The results of the analysis of student characteristics can be seen in Figure 2 that class X students at the SMA have a good background with a percentage of 73.00%. It shows that some students come from economically capable families, have reasonably good achievements, and receive guidance from their parents in studying. Students' interest in learning physics is also quite good, with a percentage of 70%; some students are enthusiastic, earnest, willing, and self-aware. Students' motivation in studying physics is also quite good, with a percentage of 68.00%; some students are enthusiastic about working on and submitting physics assignments. Students' learning styles in physics are also quite good, with a percentage of 73.00%; some students like visual learning styles, some students like auditory learning, and some students like learning with kinesthetic learning styles. Students' attitude when learning physics in the classroom is also good, with a percentage of 79.00%; students listen to the teacher explaining the material, focus on learning, and are responsible for making assignments that the teacher has given. The teacher's concern for students must also support the characteristics of pretty good students, the teacher's teaching skills, the teaching materials and learning media provided by the teacher, and the learning models and methods carried out by the teacher [33].

The characteristics of good students are different from the value of physics knowledge in the midterm assessment of students and the value of students' creative thinking and communication skills. Analysis of students' midterm assessments and creative thinking and communication skills was conducted in two classes in one of the public high schools in the city of Padang. The students' midterm assessment was seen from the documents provided by the physics teacher in the two classes. Creative thinking skills are seen from the test scores of student's creative thinking skills essay questions with creative thinking components: fluency, flexibility, novelty, and elaboration [34]. Student communication is seen from the value of students' communication skill instruments using problem-based learning model steps. The student's communication assessed was written communication skills with systematic/format components, language use, and content completeness [35]. Analysis of the value of students' midterm assessment knowledge, creative thinking skills, and communication skills can be seen in Table 2.

Table 2. Statistical Parameter Values of Knowledge, Creative Thinking Skills and Student Communication

Statistical Parameters	Mid-Semester Assessment Knowledge		Students' Creative Thinking Skills		Student Communication Skills	
	X.1	X.2	X.1	X.2	X.1	X.2
The number of students	35 people	35 people	35 people	35 people	35 people	35 people
Average	63,42	61.02	50.88	61,27	49,42	61.07

Median	68.00	60.00	50.00	56,25	50.00	60.00
Mode	76.00	56.00	58.75	50.00	31.67	68,33
The highest score	96.00	96.00	71.25	90.00	80.00	91.67
Lowest Value	4.00	24.00	33.75	45.00	30.00	38,33
Reach	92.00	72.00	37.50	45.00	50.00	53,34

Source: PTS Documents and Student Creative Thinking and Communication Skills Tests

The value of knowledge in the midterm assessment of students is in the sufficient category, with the average of each class respectively 63.42 and 61.02. Class X.1 in the midterm assessment got a higher average than class X.2. The highest score for the two classes is also the same, namely 96.00. However, the lowest score for the two classes is different and dramatically deviates from X.1 because the lowest score for class X.1 is 4.00 in the less category. The value of student's creative thinking and communication skills in both classes was in the less category, namely having a successive average of 50.88 creative thinking skills, 49.42 communication skills for X.1 and 61.27 creative thinking skills, and 61.07 communication skills for X.2. This is not in line with the characteristics of students at the school who have the character of students who have a reasonably good background, interest in learning, learning motivation, learning style, and attitude.

Results of Analysis of Learning Objectives

Learning objectives are analyzed by analyzing teacher documents in the form of ATP that exist in the teacher. This analysis of learning objectives refers to the Decree (SK) of the Head of Standards, Curriculum, Assessment, Education, Ministry of Education, Culture, Research, and Technology Number 033/H/KR/2022 [36]. The SK has made the expected Learning Outcomes (CP). The analysis of learning objectives consists of four components, namely, audience aspect (A), behaviour aspect (B), condition aspect (C), and degree aspect (D). The analysis results of learning objectives obtained a value of 65.00% in the sufficient category. The following is explained in Figure 3.

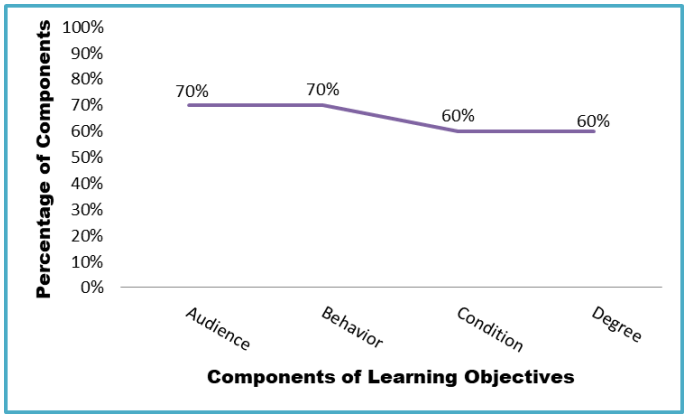

Figure 3. Results of Analysis of Learning Objectives

The results of the analysis of learning objectives made by teachers at ATP are good in the aspects of audience, behaviour, condition, *and* degree. The audience aspect from the ATP analysis of three physics teachers obtained an average score of 70% in the sufficient category. The teacher has shown that learning objectives are made for students based on the abilities of students. However, students have yet to be able to actualize them in the form of products or performances, either abstract or concrete. The behaviour aspect shows a reasonably good value, namely 70%; the teacher has made learning objectives based on active verbs or called good KKO; the teacher determines the main concepts and formulates questions that make students understand one unit of material being taught, but has not shown behaviour in student. The conditioning aspect shows a value of 60% in the sufficient category; the teacher has made learning objectives to improve students' thinking skills, such as higher-order thinking, but still needs to include critical and creative thinking skills. The teacher has also carried out the degree aspect for formulating learning objectives with a percentage of 60% in the sufficient category. The teacher has described several learning success criteria for each indicator, but not all learning objectives describe the success criteria for each indicator.

Results of Learning Setting Analysis

Setting analysis learning is done by analyzing documents in the form of teaching modules in the teacher. This teaching module was formulated after formulating ATP which was developed from Learning Outcomes or known as CP [37]. In the teaching module, there are settings learning which consists of preliminary activities

(P), core activities (Co), and closing activities (Cl). In the teaching module, the teacher uses the discovery learning model with the syntax of stimulation, problem statements, data collection,data processing, verification, and generalizations [38]. Based on the analysis, it was found that the value of 64.70% was sufficient. The following is explained in Figure 4.

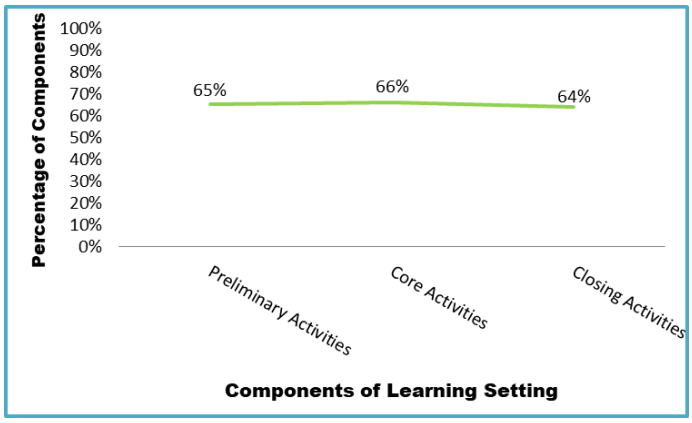

Figure 4. Results of Learning Setting Analysis

Physics learning by the teacher based on the results of the analysis of the learning settings in the teacher's teaching module is quite good. The teaching modules made by the teacher have steps of learning activities that refer to the discovery learning model. Preliminary activities in the learning steps are pretty good, with a percentage of 65.00%; the teacher starts learning activities by providing stimulus or stimulation to students by providing phenomena in everyday life. The core activities are also quite good, with a percentage of 66.00%; teachers in the core activities are set up to invite students to find problems, collect data, process data, and find solutions to the problems presented. However, it needs to be made clear whether students provide hypotheses, how students collect data and make data processing. Closing activities on the learning steps presented by the teacher are also good, with a percentage of 64.00%. The teacher closes the lesson by setting it so that students can conclude from the results of the investigation that has been carried out. However, the teacher still needs to present a review and evaluation of the problems in the material at the meeting.

DISCUSSION

The results of this preliminary research can be used e-module renewable energy-integrated PBL model based on a smartphone. Through the research conducted, it was found that the students' mid-semester knowledge values were sufficient, as well as the students' creative thinking skills and communication skills were classified as lacking. This is different from the characteristics of students in high school, which are pretty good. From the results of the first preliminary research, it was found that the use of ICT in physics learning had been carried out that is in the average percentage of 65,25% with a pretty good category, but this was not in line with the extensive use of ICT in these schools, especially in the use of smartphones [32].

The results of the second preliminary study regarding the characteristics of students are good because students at the high school are already aware of the importance of learning physics. The background component, students at the high school have a pretty good family background. The components of interest in learning, motivation to learn, learning styles, and attitudes in learning are also quite good with an average percentage of 72,60%. However, the characteristics of students who are good apart from good teachers, methods and learning models must also be supported by practical and easy-to-use teaching materials such as e-modules [33].

The results of the third preliminary study regarding the learning objectives formulated by the teacher were quite good with an average percentage of 65%. The learning objectives must include whom the learning is aimed at, what attitude should be carried out, what conditions are needed, and success in learning must include all indicators [36]. Based on the analysis of learning objectives carried out by researchers, the teacher has formulated the learning objectives quite well; it is just that there are still areas for improvement in each aspect of the learning objectives. For example, in the degree aspect, the teacher has described the criteria for success in learning but not all learning objectives include success criteria.

The results of the fourth preliminary study regarding the learning arrangements in the teacher's teaching module are also quite good with an average percentage 64,70%. The teacher has opened, delivered, and closed the lesson quite well. However, in the teacher's teaching module, the learning steps using the discovery learning model still need to be sequential in syntax. The teacher still repeats discovery syntax in learning settings. This is a concern of researchers to improve the learning arrangements made by the teacher in the teaching module

according to the existing syntax. The syntax of the discovery learning model successive consists of stimulation, problem statements, data collection,data processing, verification, and generalizations [38].

An alternative solution provided by researchers to improve students' creative thinking and communication skills is to develop an integrated renewable energy e-module, a smartphone-based PBL model. Many previous researchers have indeed carried out the development of this e-module. However, the e-module developed by researchers differs from previous researchers because the e-module developed supports two aspects of skills, creativity and communication. Meanwhile, previous studies only supported one aspect, whether the creative or other aspects. Furthermore, integrating the PBL model into the e-module enables students to solve real-life problems [25]. In addition to the advantages, this e-module has limitations because only one material is presented.

IV. CONCLUSION

From the data analysis that has been done, there are four results of this preliminary research. First, the use of ICT in physics learning at one of the public high schools in Padang is still sufficient; this can be seen from the average value of the teacher's questionnaire analysis, which is 65.25%. This result is different from the important potential use of technology, especially the use of smartphones in the learning process at the school. Second, the analysis of the characteristics of students in one of the public high schools in the city of Padang is quite good, with an average of 73.00%. The characteristics of students who are already good enough are different from the midterm knowledge scores and the scores of student's creative thinking and communication skills which are in the less category. Third, the analysis of learning objectives formulated by the teacher, which includes aspects of audience, behaviour, condition, and degree, is quite good at 65.00% but still needs to be improved to make it even better and include all the essential components and indicators. Fourth, settings learning by the teacher, such as opening, conveying, and closing learning, is also quite good, with a score of 64.70%. However, the teacher needs to pay attention to the syntax of the learning model used.

ACKNOWLEDGMENT

The researcher would like to thank Drs. Barlius, MM., the head of the Education Office of West Sumatra Province, has been permitted to conduct research. On the other hand, the researcher would also like to thank Drs. H. Syamsul Bahri, M.Pd.I., the head of SMA Negeri 1 Padang, was permitted to conduct research at SMA Negeri 1 Padang. Thanks also go to Mr Irwan Khalik, S.Pd., M.Sc., Mrs Misnawati, S.Pd., M.Sc., and Mrs Liza Marnalista, S.Pd., M.Pd., and the student's class X.1 and X.2 who are willing to be resource persons in this study in obtaining preliminary data for developing smartphone-based PBL-integrated renewable energy e-modules. Thank you to the UNP physics lecturer, who gave their knowledge, and Vivi Mardian, S.Pd., who directed this article. Finally, the author also thanks her family and friends who have motivated her in preparing this article.

REFERENCES

[1] B. R. Simanjuntak and E. Budi, "The Development of Web-based Instructional Media for Teaching Wave Physics on Android Mobile," *J. Penelit. Pengemb. Pendidik. Fis.*, vol. 4, no. 1, pp. 1–10, 2018, doi: 10.21009/1.04101.

[2] A. S. Yeni, A. Hasra, and F. Mufit, "Pengaruh Penerapan Pendekatan Brain Based Learning Terhadap Hasil Belajar Fisika Siswa Kelas X SMAN 12 Padang," *Pillar Phyisics Educ.*, vol. 4, no. November, pp. 65–72, 2014.

[3] A. Jayadi, D. H. Putri, and H. Johan, "Identifikasi Pembekalan Keterampilan Abad 21 Pada Aspek Keterampilan Pemecahan Masalah Siswa SMA Kota Bengkulu Dalam Mata Pelajaran Fisika," *J. Kumparan Fis.*, vol. 3, no. 1, pp. 25–32, 2020, doi: 10.33369/jkf.3.1.25-32.

[4] F. Mufit, Asrizal, S. A. Hanum, and A. Fadhilah, "Preliminary Research In The Development of Physics Teaching Materials That Integrate New Literacy and Disaster Literacy," *J. Phys. Conf. Ser.*, vol. 1481, no. 1, pp. 0–12, 2020, doi: 10.1088/1742-6596/1481/1/012041.

[5] Y. Sawitri, A. Asrizal, and F. Mufit, "Analysis of Physics E-books Assisted By Application of Learning House Using Quantum Learning Models To Improve The 21st Century Skills of High School Student," *J. Phys. Conf. Ser.*, vol. 1876, no. 1, pp. 1–5, 2021, doi: 10.1088/1742-6596/1876/1/012041.

[6] Asrizal, Desnita, and Y. Darvina, "Need Analysis To Develop Electronic Enrichment Book of Physics Based on Contextual Teaching and Environmental Potential," *J. Phys. Conf. Ser.*, vol. 1481, no. 1, pp. 1–9, 2020, doi: 10.1088/1742-6596/1481/1/012123.

[7] Widya, Yusmanila, Zaturrahmi, and K. Ikhwan, "Praktikalitas E-Module Berbasis Model Creative Problem Solving (CPS) untuk Materi Fluida Dinamis Terintegrasi Keterampilan Abad 21," *Edukatif J. Ilmu Pendidik.*, vol. 4, no. 4, pp. 5700–5707, 2022, doi: 10.31004/edukatif.v4i4.3313.

[8] S. Zubaidah, "Mengenal 4C: Learning and Innovation Skills untuk Menghadapi Era Revolusi Industri

4.0," *2nd Sci. Educ. Natl. Conf.*, no. April, pp. 1–18, 2018.
[9] D. Yulianti and E. Handayani, "Enhancement of Communication Skills Through Physics Learning With Science, Technology, Engineering, and Mathematics (STEM) Approach," *J. Phys. Conf. Ser.*, vol. 1918, no. 5, 2021, doi: 10.1088/1742-6596/1918/5/052083.
[10] Y. Indarta, N. Jalinus, Waskito, A. D. Samala, A. R. Riyanda, and N. H. Adi, "Relevansi Kurikulum Merdeka Belajar dengan Model Pembelajaran Abad 21 dalam Perkembangan Era Society 5.0," *Edukatif J. Ilmu Pendidik.*, vol. 4, no. 2, pp. 3011–3024, 2022, doi: 10.31004/edukatif.v4i2.2589.
[11] A. N. Nurohmah, D. Kartini, and T. Rustini, "Relevansi Kebijakan Kurikulum Merdeka Dengan Pendidikan Abad 21 Pada Pembelajaran IPS di SD," *J. Ilm. Wahana Pendidikan, Februari*, vol. 9, no. 3, pp. 24–35, 2023, doi: 10.5281/zenodo.7594483.
[12] A. . Sugiono, *Outlook Energi Indonesia*. Jakarta: Badan Pengkajian dan Penerapan Teknologi (BPPT), 2016.
[13] R. E. Caraka and P. C. Ekacitta, "Simulasi Kalkulator Energi Baru Terbarukan (Ebt) Guna Memenuhi Ketahanan Energi Di Indonesia," *Stat. J. Theor. Stat. Its Appl.*, vol. 16, no. 2, pp. 77–88, 2017, doi: 10.29313/jstat.v16i2.1956.
[14] I. Malina, H. Yuliani, and N. I. Syar, "Analisis Kebutuhan E-Modul Fisika sebagai Bahan Ajar Berbasis PBL di MA Muslimat NU," *Silampari J. Pendidik. Ilmu Fis.*, vol. 3, no. 1, pp. 70–80, 2021, doi: 10.31540/sjpif.v3i1.1240.
[15] H. S. Abdilah, Desnita, and Umiatin, "Pengembangan Miniatur Pembangkit Listrik Tenaga Air Sebagai Media Pembelajaran Fisika Sekolah Menengah Atas (SMA)," *Pros. Semin. Nas. Fis. SNF2015*, vol. IV, pp. 77–80, 2015, doi: 2339-0654.
[16] R. P. Artiwi, Asrizal, Desnita, and Y. Darvina, "Pengaruh E-Book Pengayaan Fisika Disertai Tugas Berita dan Fakta Terhadap Keterampilan Berpikir Kritis dan Kreatif Peserta Didik Kelas X SMAN 2 Padang," *Pillar Phyisics Educ.*, vol. 13, no. 2, pp. 289–296, 2020.
[17] Nurlina, Nurhayati, and K. Arafah, "Penerapan Pembelajaran Berbasis Masalah Terhadap Hasil Belajar Fisika Peserta Didik Kelas X Sma Negeri 2 Majene," *J. Sains dan Pendidik. Fis.*, vol. 11, no. 3, pp. 245–250, 2015. Available: https://ojs.unm.ac.id/JSdPF/article/view/1727
[18] A. Azzahra, Sunaryo, and E. Budi, "Pengembangan E-Modul Interaktif Berbasis Pendekatan Sets (Science, Environment, Technology, and Society) Menggunakan Program Lectora Inspire Pada Materi Sumber Energi Terbarukan Kelas Xii Sma," *Pros. Semin. Nas. Fis.*, vol. X, no. 1, pp. 73–80, 2022, [Online]. Available: https://doi.org/10.21009/03.SNF2022
[19] P. Dona and Syafriani, "Validitas E-modul Fisika Berbasis Science, Environment, Technology, and Society untuk Meningkatkan Kemampuan Berpikir Kreatif Peserta Didik Kelas X SMA," *J. Penelit. dan Pembelajaran Fis.*, vol. 8, no. 2, pp. 113–121, 2022, doi: 10.24036/jppf.v8i2.115741.
[20] F. A. Almuharomah, T. Mayasari, and E. Kurniadi, "Pengembangan Modul Fisika STEM Terintegrasi Kearifan Lokal 'Beduk' untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa SMP," *Berk. Ilm. Pendidik. Fis.*, vol. 7, no. 1, pp. 1–10, 2019, doi: 10.20527/bipf.v7i1.5630.
[21] R. Inayah, P. Aswirna, and A. Asrar, "Pengembangan E-Modul Berbasis Etno-STEM Berbantuan Canva Terintegrasi Gordang Sambilan Terhadap Keterampilan Komunikasi Peserta Didik," *J. Cerdas Mhs.*, vol. 4, no. 2, pp. 78–90, 2022.
[22] A. Triwijaya, "Studi Pendahuluan Pengembangan E-Modul IPA Materi Energi Terbarukan pada Kurikulum Program Sekolah Penggerak Kelas X SMA," *Skripsi UNP*, 2022.
[23] Saprudin, A. H. Haerullah, and F. Hamid, "Analisis Penggunaan E-Modul Dalam Pembelajaran Fisika; Studi Literatur," *J. Lumin. Ris. Ilm. Pendidik. Fis.*, vol. 2, no. 2, pp. 38–42, 2021, doi: 10.31851/luminous.v2i2.6373.
[24] R. Arnila, S. Purwaningsih, and Nehru, "Pengembangan E-Modul Berbasis STEM (Science, Technology, Engineering and Mathematic) pada Materi FLuida Statis dan FLuida Dinamis Menggunakan Software KIVOSFT Flipbook Maker," *EDUMASPUL J. Pendidik.*, vol. 5, no. 1, pp. 551–556, 2021, doi: 10.33487/edumaspul.v5i1.1216.
[25] M. Roza, Festiyed, Asrizal, and Desnita, "The Analysis of Effect Size of the PBL Model on Science Competence of High School Students," vol. 10, no. 2, pp. 12–24, 2022, doi: 10.26714/jps.10.2.2022.12-24.
[26] I. D. G. S. Widura, G. W. Bayu, and N. N. A. Aspini, "Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Hasil Belajar IPA," *J. Ilm. Pendidik. Profesi Guru*, vol. 4, no. 2, pp. 200–209, 2021, doi: 10.23887/jippg.v4i2.
[27] Y. D. Amalia, Asrizal, and Z. Kamus, "Pengaruh Penerapn LKS Berorientasi Pembelajaran Berbasisi Maslah Terhadap Kompetensi Siswa Kelas X SMA Negeri 1 Gunung Talang," *Pillar Phyisics Educ.*, vol. 4, no. November, pp. 17–24, 2014.
[28] T. A. Rismayanti, N. Anriani, and Sukirwan, "Pengembangan E-Modul Berbantu Kodular pada

Smartphone Untuk Meningkatkan Kemampuan Berpikir Kritis Matematis Siswa SMP," *J. Cendikia J. Pendidik. Mat.*, vol. 06, no. 01, pp. 859–873, 2022, doi: 10.56704/jirpm.v3i3.13292.
[29] Asrizal, Festiyed, and R. Sumarmin, "Analisis Kebutuhan Pengembangan Bahan Ajar Ipa Terpadu Bermuatan Literasi Era Digital Untuk Pembelajaran Siswa Smp Kelas VIII," *J. Eksakta Pendidik.*, vol. 1, no. 1, pp. 1–8, 2017, doi: 10.24036/jep/vol1-iss1/27.
[30] Sugiyono, *Statistika Untuk Penelitian*. Bandung: Alfabeta, 2014.
[31] Kementerian Pendidikan, Kebudayaa, Riset, dan Teknologi Republik Indonesia, "Panduan Praktis Penyusunan E-Modul Pembelajaran," Jakarta: Direktorat Pembinaan SMA, Ditjen Pendidikan Dasar dan Menengah, 2017.
[32] Z. Siregar and T. B. Marpaung, "Pemanfaatan Teknologi Informasi dan Komunikasi (TIK) Dalam Pembelajaran di Sekolah," *BEST J. (Biology Educ. Sains Technol.*, vol. 3, no. 1, pp. 61–69, 2020, doi: 10.30743/best.v3i1.2437.
[33] D. Meriyati, M.Pd, *Memahami Karakteristik Anak Didik*. Lampung: Fakta Press IAIN Raden Intan Lampung, 2015.
[34] I. M. Harisuddin, *Secuil Esensi Berpikir Kreatif dan Motivasi Belajar Siswa*. Bandung: PT. Panca Terra Firma, 2019.
[35] R. Medriati and E. Risdianto, "Penerapan Pendekatan Student Centered Learning (SCL) Untuk Meningkatkan Keterampilan Berpikir Kreatif Dan Komunikatif Mahasiswa Pendidikan Fisika Semester III Universitas Bengkulu," *J. Kumparan Fis.*, vol. 3, no. 1, pp. 67–74, 2020, doi: 10.33369/jkf.3.1.67-74.
[36] Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. *Surat Keputusan Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan, Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 033/H/KR/2022*. Jakarta: Badan Standar, Kurikulum, dan Asesmen Pendidikan, 2022.
[37] Rahimah, "Peningkatan Kemampuan Guru SMP Negeri 10 Kota Tebingtinggi dalam Menyusun Modul Ajar Kurikulum Merdeka Melalui Kegiatan Pendampingan Tahun Ajaran 2021/2022," *J. Ansiru PAI Pengemb. Profesi PAI*, vol. 6, no. 1, pp. 92–106, 2022, [Online]. Available: http://jurnal.uinsu.ac.id/index.php/ansiru/article/view/12537/5670
[38] T. Kusuma, Indrawati, and A. Harijanto, "Model Discovery Learning Disertai Teknik Probing Prompting Dalam Pembelajaran Fisika Di MA," *J. Pendidik. Fis.*, vol. 3, no. 4, pp. 336–341, 2015.