Development of Interactive E-Worksheet Based on STEM-Integrated Problem-Based Learning to Improve Students' Problem-Solving Abilities

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Abstract

This research aims to develop E-worksheet based on STEM integrated Problem-Based Learning (STEM-PBL) and to determine the level of feasibility of E-worksheet, the effectiveness of E-worksheet on students' problem-solving abilities, and students' responses. E-worksheet development uses the ADDIE model. The research was conducted at class XI of SMAN 12 Semarang, with sampling carried out using a purposive sampling technique. The instruments in this research are material and media validation sheets, readability sheets, practicality sheets based on student response questionnaires, and problem-solving ability test instruments. The results of this research are as follows (1) the feasibility level of E-worksheet based on STEM-PBL on hydrocarbon material in the material aspect is 98% in the very feasible category, and in the media aspect is 99% in the very feasible category, (2) E-worksheet based on STEM-PBL is effectively used based on the results of the N-Gain test of 0.707 with the high category and classical completeness of 85%, (3) the developed E-worksheet was received good response results from students, namely 88% which was included in the category very practical. Therefore, E-worksheet based on STEM-PBL to improve students' problem-solving abilities is appropriate to be implemented.

Keywords: E-worksheet based on STEM-PBL, Problem-solving abilities, ADDIE model

1. INTRODUCTION

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The development of the 21st century or the era of globalization marks a period of change in various fields, including science, technology, and education. Education is considered an important foundation for preparing the nation's next generation. Based on Law No. 20 of 2003 concerning the National Education System, education aims to form students who are spiritually competent, develop their potential, and have good behavior for themselves and society through the learning process.

The learning process requires teachers who master topics in-depth, including chemistry such as hydrocarbons. The three aspects of chemistry are macroscopic, microscopic and symbolic. These three aspects are interrelated with each other [1]. Based on the results of interviews at SMAN 12 Semarang, the hydrocarbon material studied is still not well understood, because it contains terms and names of compounds foreign to students that they do not encounter in everyday life, so students have difficulty understanding the concept of carbon material and its derivatives at the next grade level. Supported by research by Putra [2] that hydrocarbon material is a prerequisite material for other materials. If hydrocarbon material is not understood, then other material obtained at the next grade level will experience difficulties in learning the concept of carbon material and its derivatives. The Hydrocarbon material has material sections that contain many and varied terms that students must remember so that they can influence students' low learning outcomes. Hydrocarbon material is also dense material and requires more time to deliver the material in class. This is because the scope of hydrocarbon material includes the characteristics of carbon atoms, the classification of hydrocarbons, the nomenclature of hydrocarbon compounds, and much more. Studying hydrocarbon material requires the ability to solve problems so that students can identify, analyze, and describe abstract chemical concepts and principles into concrete ones. Problem-solving abilities can train students to solve chemical problems through the process of finding answers. In fact, Students' problem-solving abilities are still low [3][4]. It can be seen from the results of the Program for International Student Assessment (PISA) in 2015 which showed that Indonesia was ranked 64th out of 72 countries. Therefore, it is clear that this shows that students' problem-solving abilities in Indonesia are relatively low [5].

The low ability of students to solve chemistry problems indicates that chemistry learning in Indonesia still requires improvement in the learning process. The use of learning models that encourage students to solve problems must be tried as best as possible in its implementation to improve the problem-solving abilities of students. One learning model that encourages the problem-solving abilities of students is Problem-Based Learning. Problem-based learning is a learning model that uses real-life situations as a benchmark in learning and in terms of solving problems so that students need and gain new knowledge to solve problems [6]. According to Benjaphalaporn [7], the aim of implementing PBL is to build conceptual understanding through problems found in students' lives.

To improve the problem-solving abilities of students, implementing a STEM approach to learning can also be carried out. According to Anggraini and Huzaifah [8], the STEM approach is considered effective in improving the problem-solving

abilities of students to keep up with current developments by integrating four subjects and emphasizing real-world problems, namely Science, Technology, Engineering, and Mathematics. In line with Morrison's [9] research, STEM is also able to make students become problem solvers.

The application of learning models and approaches requires a learning tool that can improve students' abilities. Research conducted by Muthoharoh [10] states that the student worksheet is a learning tool that is proven to increase student motivation and learning outcomes. The innovative use of the student worksheet makes students involved in activities that encourage them to think structured. Through the use of the student worksheet which encourages problem-solving abilities, students can also develop imagination and the ability to see a situation from various perspectives. The student worksheet is a type of teaching material that can be used by teachers and students to make learning activities more effective and efficient [11].

Education in the 21st century is starting to implement paperless technology so the use of learning devices is better presented in electronic form [12]. The student worksheet can be optimized with the help of technology. The worksheet design will become more interactive and can be combined with learning models that suit the students' conditions. It aims that learning activities can achieve predetermined competencies. One of the electronics of the student worksheet is to create the electronic student worksheet commonly called E-worksheet. E-worksheet is an innovation for students to understand the subject matter in school learning so that material concepts and evaluation can be carried out well [13]. Developing an interactive E-worksheet requires a device that is capable of presenting an E-worksheet with interactive features, one of which uses Liveworksheets.

Liveworksheets is a service from Google in the form of a free website which is one of the online interactive learning media by changing printed worksheets into online worksheets that can be accessed without time or place limits [14]. Teachers can access, create, and change conventional worksheet into E-worksheet which can be corrected automatically, or use worksheet templates already available in Liveworksheets [15]. According to Hariyati & Rachmadyanti [16], the application of Liveworksheets is very effective and suitable for use in the learning process and it can increase students’ activeness. It can be seen from the participation of students while completing Liveworksheets and there is an increase in students' self-confidence and curiosity about learning. Liveworksheets or interactive worksheets are also a service that allows users to convert traditional worksheets in the form of documents, PDFs, and JPGs into interactive online exercises in solving problems [17].

This research aims to develop E-worksheets based on STEM-PBL, determine the level of feasibility of E-worksheet, the effectiveness of E-worksheets on problem-solving abilities of students, and practicality based on students' responses. The development of interactive E-worksheet based on STEM-PBL with the help of Liveworksheets has the potential to improve the problem-solving abilities of students. The use of digital technology in interactive E-worksheet can increase student

involvement in learning, while the PBL model and STEM approach have been proven to influence students' problem-solving abilities and provide a relevant context for the application of science, technology, engineering, and mathematics concepts in solving real problems. This combination is certainly expected to produce a positive impact on increasing students' problem-solving abilities. Therefore, in this research, an interactive E-worksheet based on STEM-PBL has been developed to improve the problem-solving abilities of students.

2. METHODS

The research was carried out using the development method or Research and Development (R&D) with the ADDIE model. The following is the ADDIE scheme that can be seen in Figure 1.

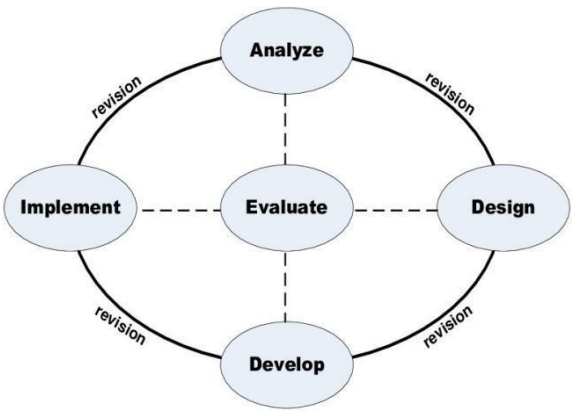

Figure 1. ADDIE scheme

(Image Source: Branch, 2009)

The research was conducted at SMA Negeri 12 Semarang in two stages, namely small-scale trials and large-scale trials. The research subjects were 15 students in small-scale trials and 33 students in large-scale trials. Small-scale trials were carried out to see the feasibility of validity testing, readability testing, and the level of difficulty of the test instrument items. The test instruments used were pretest and posttest questions which consist of 5 description questions. Based on Microsoft Excel calculations, it was found that item number 3 was included in the easy criteria, item numbers 1, 2, and 4 were included in the medium criteria, and item number 5 was included in the difficult criteria. The resulting items from this analysis were then used in large-scale trials.

Large-scale trials were carried out to see the feasibility of E-worksheet, the effectiveness of E-worksheet on the problem-solving abilities of the students, and the practicality of E-worksheet based on students' responses. Data collection techniques in this research were interviews, questionnaires, and tests. The instruments of this research included material expert validation questionnaire sheets, media validation questionnaire sheets, readability questionnaire sheets, E-worksheet practicality questionnaire sheets based on student responses, and validation questionnaire sheets of the students' problem-solving ability test instruments.

The research data obtained were the results of material expert validation questionnaires, media validation questionnaires, readability questionnaires, E-worksheet practicality questionnaires, students' problem-solving ability test instrument questionnaires, and student pretest and posttest scores. The data from the questionnaire was then subjected to percentage descriptive analysis by converting the quantitative data into percentage form. Meanwhile, the students' pretest and posttest score data were analyzed using the N-Gain and classical completeness tests.

3. RESULTS AND DISCUSSION

This development research produced a product in the form of an interactive E-worksheet based on STEM-PBL on hydrocarbon material. The product was developed using the ADDIE development model, which includes the Analysis, Design, Development, Implementation, and Evaluation stages.

Analysis Stage

Analysis stage, the first step taken before analyzing the characteristics of interactive E-worksheet based on STEM-PBL, is the problem analysis or observation stage. Initial observation activities by conducting interviews are the first step taken in the research process to obtain information and facts in the field. Based on the results of interviews with the class XI chemistry teacher at SMA Negeri 12 Semarang, researchers received information that students still had difficulty solving problems including hydrocarbon materials in everyday life. It happens because the hydrocarbon material has a material sub-chapter that contains a large and varied number of term

facts and must be memorized by students so it has an impact on students' low learning outcomes.

The learning resources used are only printed worksheet and student handbooks, where students are only required to read the material in the textbook and answer the questions in the worksheet. The worksheet used by teachers does not yet integrate STEM so the content does not prioritize elements of science, technology, engineering, and mathematics. The practice questions given by the teacher are also presented in printed book form, which causes students must answer them manually. Apart from that, regarding the learning method applied by the teacher, namely lectures, the teacher is only limited to explaining the material so that students easily get bored while following the lesson. It will trigger a lack of students' ability to solve problems. That condition can't train students' thinking power in dealing with problems so students' problem-solving abilities are low.

As a result of further observations, researchers also obtained information that students had experience using Android devices and laptops. Students could buy data packages and the internet network at school was well-connected. After reviewing these various things, the researchers developed a STEM-integrated PBL-based E-worksheet which is expected to be an additional learning resource for students so that students can be actively involved in learning and students' problem-solving abilities will increase.

Design Stage

The next stage is the design stage. This second stage begins with designing the tools needed including designing the E-worksheet to be developed, question design, and instrument design consisting of questionnaire sheets and E-worksheet validation sheets from material experts and media experts based on BSNP guide with modifications according to the needs of the media being developed. Forming the initial format of the E-worksheet is carried out to determine the content to be studied and contained in the E-worksheet. This content includes a cover, title page, foreword, table of contents, instructions for using E-worksheet, concept map, PBL-STEM learning, the scope of STEM, and description of learning activities.

In this research, the characteristic of the media chosen is electronic-based worksheet which presents learning activity steps according to PBL and contains STEM content in usual environments. Choosing Liveworksheets, that support the E-worksheet being developed, aims to ease access to the E-worksheet. Liveworksheets is a free website service in the form of interactive online learning media by converting printed worksheets into online worksheets that can be accessed on the page www.liveworksheets.com. The e-worksheet in this research was designed using the Canva application. The design was made in an attractive format, starting from graphics, and a combination of colors, shapes, and sizes.

The initial display of the E-worksheet is presented in Figure 2 and the display of learning activities in the E-worksheet is presented in Figure 3. Each learning activity is also given practice questions which are expected to help students. In addition, the final appearance of the E-worksheet is delivered in Figure 4.

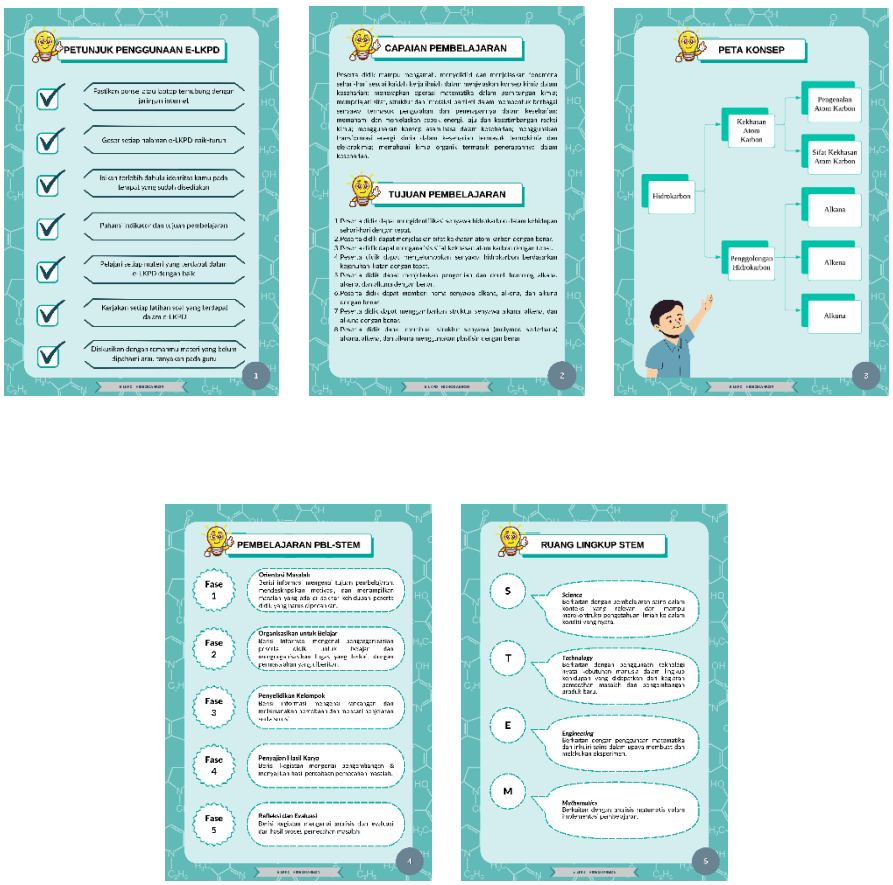

Figure 2. The initial display of E-worksheet

Figure 3. The STEM-PBL-based E-worksheet Display

Figure 4. The final display of E-worksheet

Development Stage

The development stage includes expert validation activities for products and instruments that have been designed, trials, and revisions. The E-worksheet development process begins by validating the E-worksheet with expert validators to determine the suitability of a product with input and suggestions, which then can be revised. The validation sheet is used to measure the suitability of a learning media using interpretation criteria with a Likert scale [18].

The developed e-worksheet was assessed for its feasibility from two aspects, namely the material and media aspects. Material validation consists of four aspects, namely content suitability aspects, presentation aspects, language aspects, and PBL-STEM aspects. The content suitability aspect assesses the suitability of the material to the learning objectives. The presentation aspect assesses the supporting material, consistency, and variety of presentation. The language aspect assesses the good and correct use of Indonesian language rules. In addition, the PBL-STEM aspect assesses the suitability of activities and materials with the syntax of the PBL model and STEM elements (science, engineering, technology, and mathematics). Suggestions and input given by experts can be seen in Table 1.

E-worksheet has been arranged coherently according to each learning objective to be achieved. E-worksheet is presented not only in the form of monotonous text but E-worksheet is also enriched with various interesting images and videos. Therefore, students can watch worksheet by accessing it via the provided link. This is by research by Nurwahidah & Zaharah [19] which shows that the use of videos in learning can involve students to build competence in the field of affective, cognitive, psychomotor, and communication skills. This E-worksheet can be accessed using the internet in real-time.

Table 1. Suggestions and input from validators of material experts and media experts

Assessment Aspects	Comments and Suggestions
Material Expert	1) Page 7 is explained so that students have no difficulty understanding 2) There is an incorrect writing of the compound formula
Media Expert	1) On the cover, the material writing has been changed to be bigger 2) Move the writing position in the contents of the table to make it neater 3) Addition of the references

Table 2. The recapitulation of material validation results

Aspects	Total of Statements	Total of Scores per Aspect			Percentage (%)	Criteria
		V01	**V02**	**V03**		
Content	3	12	12	12	100	Very Decent
Presentation	7	28	27	28	98,80	Very Decent
Language	4	16	15	16	97,91	Very Decent
PBL-STEM	6	24	22	24	97,22	Very Decent
Average					**98,49**	**Very Decent**

Table 3. The recapitulation of validation results from media experts

Aspects	Total of Statements	Total of Scores per Aspect			Percentage (%)	Criteria
		V01	**V02**	**V03**		
Appearance	6	24	22	24	97,22	Very Decent
Consistency	2	8	8	8	100	Very Decent
Physical Criteria	3	12	12	12	100	Very Decent
Average					**99,07**	**Very Decent**

The validation results of the E-worksheet material expert based on STEM-integrated PBL obtained a percentage of 98.49% with very decent criteria. The content aspect got a percentage of 100%, the presentation aspect got a percentage of 98.80%, the language aspect got a percentage of 97.91%, and the PBL-STEM aspect got a percentage of 97.22%. Meanwhile, the media validation results in this research obtained a percentage of 99.07% with very decent criteria. The appearance aspect obtained a percentage of 97.22%, the consistency aspect obtained a percentage of 100%, and the physical criteria aspect obtained a percentage of 100%. This data shows that the results of the material and media validation assessment are included in the very decent criteria so that E-worksheet can be used in the learning process. Therefore, learning tools in the STE- STEM-integrated PBL model are valid and suitable for use in research. The results of material and media validation can be seen in Tables 2 and 3.

The revised E-worksheet and test instruments were conducted in the next stage, namely the small-scale test which was carried out in class XII with 15 students. The small-scale test was carried out by testing the readability of the developed E-worksheet and testing the test instrument on students who had received hydrocarbon material.

Analysis of the E-worksheet practicality was also carried out at this stage based on student responses. Based on the analysis results, it was found that E-worksheet obtained a percentage of 87.63% with very practical criteria. The results of the student response questionnaire assessment carried out by 33 students showed that 20 students are included in the very practical category and 13 students are included in the practical category. The recapitulation results of the material aspect obtained a total score of 456 with a percentage of 86.36%, the presentation aspect obtained a score of 701 with a percentage of 88.51%, and the language aspect obtained a score of 581 with a percentage of 88.03%. The scores obtained from the practicality questionnaire sheet were analyzed and presented in Table 4.

Table 4. The recapitulation of the E-worksheet practicality questionnaire results

Aspects	Total of Statements	Total of Scores per Aspect	Percentage (%)	Criteria
Material	4	456	86,36	Very Practical
Presentation	6	701	88,51	Very Practical
Language	5	581	88,03	Very Practical
Average			**87,63**	**Very Practical**

Apart from the practicality questionnaire, students also provide suggestions and input on the E-worksheet being developed during the learning process. Suggestions and input from students will be used as revision material to obtain appropriate E-worksheet and to improve the teaching process in the future.

Implementation Stage

In the implementation stage, the product design takes the form of a large-scale trial that aims to produce data that is used to analyze the effectiveness and responses of students to the E-worksheet being developed. A large-scale trial was carried out on 33 students in class XI-F.6 at SMAN 12 Semarang. The effectiveness of E-worksheet can be determined through test instruments, in the form of pretest and posttest questions. The test instrument was carried out by students before learning began (pretest) and after learning ended (posttest). The pretest and posttest questions consist of 5 descriptive questions that have been integrated with problem-solving skills. The results of the posttest carried out by students can be used to determine classical mastery. The classical mastery results of class XI-F.6 students in hydrocarbon material obtained a percentage of 84.84%. It can be seen from the total of 33 students in one class showing that 28 students have completed it and 5 students have not completed it. This is in line with research by Trianto [20]. His research shows that E-worksheet will be effective if classical mastery is achieved with at least 75% of students in the class, who have been declared complete in learning. The results of classical completion can be seen in Table 5.

Table 5. Classical mastery results

Description	Test	
	Pretest	***Posttest***
The number of students who completed	2	28
The number of students who did not complete	31	5
Classical Mastery	**6,06%**	**84,84%**

Table 6. The N-Gain calculation of the students

Category	Criteria	XI-F.6	
		Total	**%**
g ≥ 0,7	High	19	57,57
0,3 ≤ g < 0,7	Medium	14	42,42
g < 0,3	Low	0	0
N-Gain		**0,707**	

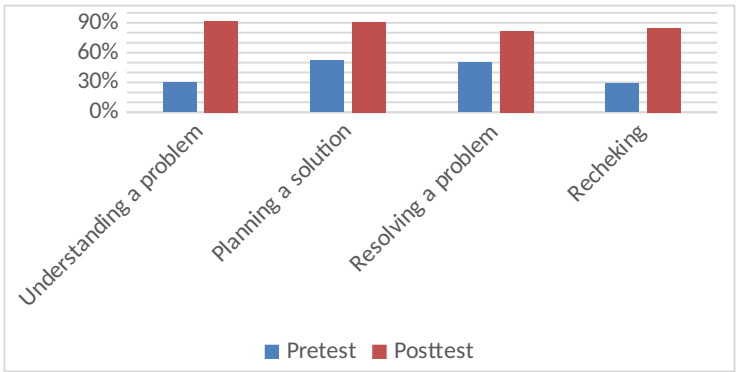

Figure 5. The percentage of problem-solving abilities for each stage from pretest and post-test results

The obtained pretest and post-test data were then calculated using N-Gain to measure the increase in problem-solving abilities before and after learning. Based on the results of the pretest and post-test recapitulation presented in Table 6, the N-Gain test got a score of 0.707 in the high category. Based on the N-Gain increase group of students, there are 19 students or 57.57% of students who achieved the N-Gain achievement level in the high category, and 14 students or 42.42% of students are in the medium category from the total of 33 students.

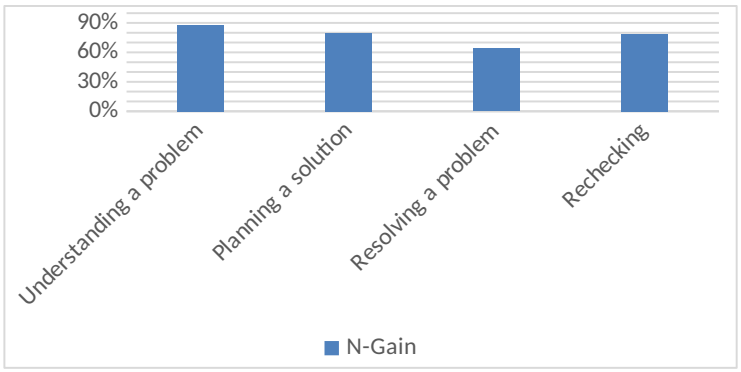

Figure 6. The N-gain graph at each stage

Furthermore, the increase of N-Gain can be seen from each stage of problem-solving ability, namely understanding the problem, planning a solution, resolving the problem, and rechecking. Based on Figure 6, there is a significant increase at each stage of problem-solving ability. N-Gain at the stage of understanding the problem got a percentage of 88%, N-Gain at the stage of the planning solutions got a percentage of 80%, N-Gain at the stage of solving the problem got a percentage of 64%, and N-Gain at the rechecking stage it got a percentage of 79%. The following is an explanation of increasing students' problem-solving abilities at each stage.

The first stage is understanding the problem. The problem parameters were identified by students to obtain an overview of the problem [21]. The student's abilities at this stage experienced the highest increase, namely 88%. During the pretest, the score at this stage was a percentage of 30% with poor criteria, while the posttest got a percentage of 92% with very good criteria. It shows that students during the posttest were able to digest the problems they faced well. At this stage, students are also asked to understand problems packaged in the form of news, discourse, or images with a review of sentences related to hydrocarbon problems in everyday life, such as fires caused by leakage of Liquefied Petroleum Gas (LPG). Therefore, students are expected to be able to understand the problems being discussed more easily. It is by research by Sujarwanto [22] states that problem-solving ability is students' efforts to find various information themselves to provide the best solution by maximally involving their abilities. However, there was an obstacle during the pretest, namely the many students immediately wrote down formulas and finished on the problems presented. A small number of students are not able to understand the problem and details regarding what is given in the problem presented. It will make students unable to solve problems correctly. It is in line with research by Azizah [23] that some students still make mistakes in understanding the problem. At the stage of the understanding problem, students were asked to analyze and identify carbon compounds in everyday life, and other information contained in the E-worksheet. After students conducted learning using E-worksheet, they were used to being able to understand problems. Apart from that, E-worksheet is also easy to use in learning and

can make students more interested and focused in understanding the material so that they can do the posttest questions well. In addition, there is an increase in students' posttest results in the stage of understanding problems. Most students almost achieved the maximum score for the stage of understanding problems. It occurred because students can write down what they have understood. However, it was still incomplete so many students didn't achieve the maximum score.

The second stage is planning a solution. At this stage, the students were expected to be able to determine steps to solve the problem [21]. The completion planning stage experienced an increase of 80%. The improvement that occurred at this stage can be seen in the ability of students who model problems that came from the analysis of the problems presented. During the pretest, the score at this stage got a percentage of 52% with sufficient criteria, while the posttest got a percentage of 91% with very good criteria. These results show that the students in the posttest were able to relate the problem to real conditions. At this stage, the students were directed to relate the hydrocarbon problems presented previously to experiences in everyday life. In line with research by Anwar [24] which states that Polya problem solving taught the students not to rely on memory in solving problems but they were directed to be able to relate problems to real situations they have experienced. However, there was an obstacle during the pretest, namely the students had difficulty distinguishing between the stages of understanding the problem so they tended to give the same answer to formulate the problem and understand the problem. The pretest results still show that the students have difficulty modeling existing problems because some of them have not been able to understand the problem presented well. Therefore, some of them did not understand what steps must be taken and had difficulty modeling the existing problem. It is supported by Suraji [25] stating that errors in selecting and planning solutions to solve problems are still within very low criteria. Based on the results of the E-worksheet, most students have started to write down their completion plans correctly. Apart from that, the material in E-worksheet can also help students connect hydrocarbon material with everyday life. Therefore, the improvement that occurred at the planning completion stage can be seen in the post-test results. They got a fairly high score because they were used to routinely working on questions in the E-worksheet. However, some students didn't write down the completion steps correctly because the students were wrong in identifying the problem so they still had difficulty planning to solve the problem given.

The third stage is solving problems. The students carried out plans based on what had been previously planned [21]. At the stage of implementing the plan, there was the lowest increase, namely only 64%. During the pretest, the score for the stage of implementing the mastery plan got a percentage of 50% with sufficient criteria, while the post-test got a percentage of 82% with very good criteria. It indicates that the students during the posttest at this stage were more precise in choosing solutions that were in accordance with the plans they had made. At the stage of implementing the plan, the students were asked to provide appropriate solutions to the impact of fires caused by LPG gas leakage so the students' problem-solving abilities could develop. However, there was an obstacle during the pretest, namely some students

were able to solve the problems presented but not all of what the students wrote was correct. Only half or some of them were able to answer correctly. It happened because the students had missed the stage of understanding the problem and had not been able to plan the solution correctly. It is in line with research by Nadhifa [26] which states that in the stage of solving the problem, it depends on the experience of students to be more creative in arranging a plan to solve a problem. At this stage, it can be seen that some students made mistakes in solving problems due to the unsuitable formula used for the question. Most of the students made mistakes and had not finished planning the solution to the fourth and fifth questions. It was caused by students who were inaccurate in formulating problems.

The fourth stage is rechecking. It was done to recheck whether the answers to solving problems have been written according to plan so that conclusions can be drawn [21]. At the re-checking stage, students' problem-solving abilities increased by 79%. The improvement that occurred can be seen in the results of students who can check or review the completion steps by reviewing the questions that they have worked on carefully. The score for the stage of re-checking the problem-solving results during the pretest was 29% with poor criteria, while the posttest obtained a percentage of 85% with very good criteria. It indicates that students during the posttest were more careful in checking the answers they had written. At this stage, students were asked to correct answers from previous stages so that they could conclude. In line with research by Anwar [24] which states that using Polya problem-solving can make it easier for students to answer questions because they are trained in arranging Polya stages until they are coherently arranged. However, there was an obstacle during the pretest, namely the students felt confused about to answer because they were not used to concluding the answers given to the previous questions. The results of the students' pretest showed that only a small number of students were able to write conclusions in solving the questions because the students were not used to writing conclusions. Besides that, they also felt that the results of their work were correct so they didn't recheck. Supported by research by Nadhifa [26], this stage consists of activities using specific checks for each information and solution step as well as using checks to find out problems in general. However, at the re-checking stage, some students didn't carry out a re-examination. Students are expected to be more active in writing conclusions and checking answers carefully because of the importance of this stage in ensuring the accuracy and correctness of students' work results.

The increase in the N-Gain value from the pretest and posttest questions was due to the use of STEM-integrated PBL-based E-worksheet. The pretest and posttest results obtained show that the developed E-worksheet can help students improve their problem-solving abilities. It is in line with the research results of Silaban [27] which state that the application of the PBL model assisted by worksheet shows higher chemistry learning outcomes for students compared to learning that did not use the PBL and worksheet models. It also reinforced by research by Fahmidani [28] showing that the application of a problem-based learning model with problem-based worksheets can have a better effect on chemistry learning outcomes.

Evaluation Stage

The evaluation stage of the ADDIE development model was carried out at each stage of the learning process, starting from the analysis, design, development, and implementation stages. The aim is to produce a worthy E-worksheet development product. At the analysis stage, evaluation was carried out on information related to problems in learning, availability of teaching materials, and student needs, which need to be evaluated to find the right solution. The solution provided by researchers is Eworksheet based on PBL integrated by STEM.

At the design stage, the evaluation was carried out by consulting with the supervisor regarding the initial design and content of the E-worksheet. After that, the overall preparation or creation of the Eworksheet was carried out. Evaluation at the development stage was carried out with product validation tests by expert validators. The results of the expert assessment that have been explained previously show that the E-worksheet developed is in the very feasible category with several revisions based on the suggestions and input provided.

At the implementation stage, evaluation was carried out by direct assessment from students, which showed that students' responses to E-worksheet were in the very good category. Overall, research activities did not experience significant obstacles. Obstacles appeared during the implementation stage where students had difficulty operating E-worksheet because the internet network was less stable. Thus, it can be said that the STEM based E-worksheet developed is valid and suitable for use as a supporting teaching material in chemistry learning.

4. CONCLUSION

The feasibility level of E-worksheet based on STEM-integrated Problem-Based Learning (STEM-PBL) on hydrocarbon material has an average percentage in the material aspect of 98% and the media aspect of 99%. Based on the results of validity tests carried out by expert validators, it can be stated that E-worksheet based on STEM-PBL is very suitable for use with a very valid category. Eworksheet is also able to have a positive influence on students' problem-solving abilities as shown in the N-Gain test of 0.707 and classical completeness of 85%. Therefore, the E-worksheet developed is effective in improving students' problem-solving abilities. E-worksheet got a percentage of 88% based on student responses. It shows that E-worksheet based on STEM-PBL on hydrocarbon material is very practical to use.

The following are suggestions that can be recommended regarding the research that has been carried out, namely that the use of E-worksheet in this research is

feasible, effective and has a good response to increasing participants' problem solving abilities educate. Based on the limitations in this research, to better understand the effectiveness of using E-worksheet based on STEM-integrated Problem-Based Learning, research should be conducted involving a control class.

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