

Development of E-Worksheet Project-Based Learning on Green Chemistry Materials to Improve Students Creative Thinking Skills

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Abstract: Creative thinking skills are one aspect of high-level thinking skills that students must have in 21st-century learning. Based on PISA 2022 data, the creative thinking skills of students in Indonesia are still relatively low. Therefore, this study aims to describe the feasibility of a project-based e-worksheet on green chemistry material to improve students' creative thinking skills. The type of research is Research and Development (R&D) with the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). Validity data is obtained from the validator's assessment using a validation questionnaire sheet. Practicality data is obtained from the results of the learner response questionnaire, which is supported by the results of observations of learner activities and observations of learning implementation. Practicality data is obtained from the results of the pretest and posttest of students' creative thinking skills. The validation results show that the content validity and construct validity of the e-worksheet are declared valid with mode 4. Practicality in terms of student questionnaire responses shows a very practical category with a material clarity percentage of 95.7%, ease of use of 100%, and usability of the e-worksheet of 100%. The effectiveness results are reviewed from the results of the N-gain score pretest and posttest of creative thinking skills in high categories. The N-gain on each indicator of fluency, flexibility, originality, and elaboration was 0.84, 0.82, 0.79, and 0.86. The results showed that a project-based e-worksheet on green chemistry material is feasible to use as a solution to improve students' creative thinking skills.

Keywords: Creative Thinking Skills; E-worksheet; Green Chemistry; Project-Based learning (PjBL).

Introduction

As science and technology continue to develop rapidly, the education system must also adapt to address the more dynamic problems of the Industrial Revolution 4.0 [1]. This is what encourages 21st-century learning with a focus on learner-centered learning [2]. One of the high-level skills that must be possessed by students in 21st-century learning is creative thinking skills. Creative thinking skills are included in the category of 21st-century skills that play an important role in encouraging learners to develop original ideas and formulate innovative solutions in response to the dynamics and complexity of the times [3].

On the other hand, the achievement of creative thinking skills of students in Indonesia is still relatively low. Referring to the Program for International Student Assessment (PISA) data in 2022, Indonesia is included in 14 countries with low achievements in creative thinking skills. As many as 59.0% of students were recorded to be below the basic level (level 2) in aspects of math, reading, and science [4]. In this context, the role of the government is needed to improve the quality of education in Indonesia by adopting the latest approaches in curriculum development and improvement in 21st-century learning [5].

Through Permendikbudristek Number 12 of 2024, creative thinking skills are one of the competencies in strengthening the Pancasila Learner Profile, as stated in the Merdeka Curriculum [6]. The implementation of appropriate learning can stimulate the creativity of students in facing the

era of the Industrial Revolution 4.0. Project-based learning in the Merdeka Curriculum focuses on approaches that support the development of the Pancasila Learner Profile, especially in the aspect of creative thinking, through the application of chemistry learning [6]. The Project-Based Learning (PBL) model is a learning model that emphasizes the achievement of learning objectives through an investigative process, where students are actively involved in the implementation of a project. In this approach, the teacher's role is more dominant as a facilitator who supports and guides learners throughout the learning stages [7]. In project-based learning, learners are given stimuli to engage in creative ways of thinking to meet indicators of fluency, flexibility, detail, and originality [8]. In project-based chemistry learning, one of the appropriate materials to be applied in designing chemical processes in maximizing the efficient use of earth resources is green chemistry material.

Green chemistry is a principle or concept that aims to design products and processes that minimize the use and formation of hazardous materials, with a focus on sustainability and reducing negative impacts on the environment [9]. This material is one of the new materials contained in the chemistry learning outcomes in Phase E of class X of Senior High School. Learning green chemistry materials requires a contextualized approach so that students are able to produce products that are aligned with the principles of green chemistry in real life, so that students' creative thinking skills can be seen in project-based learning.

The application of appropriate learning models and materials also needs to be supported by the use of learning

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media. In the Merdeka Curriculum, teachers must be creative in using effective and interactive learning media [10]. The learning media that can be used is the electronic Learner Activity Sheet (e-worksheet). An Electronic Learner Activity Sheet (e-worksheet) is a digital learner activity sheet that can be accessed using the internet. Learning media in the form of project-based e-worksheet provides opportunities for students to participate directly in planning a project during the learning process [11]. However, previous studies have not included the development of a project-based e-worksheet on green chemistry materials. Therefore, this research is focused on examining this, with the aim of producing a project-based e-worksheet on green chemistry material that can be tested for feasibility in improving students' creative thinking skills.

Based on existing problems, the application of chemistry learning requires an e-worksheet as a project-based learning tool (PjBL) on green chemistry material, with the aim of improving students' creative thinking skills. In addition, e-worksheet can be utilized as one of the project-based learning media that is feasible and in accordance with the essence of the Merdeka Curriculum.

Research Methods

The type of research applied in this study is Research and Development (R&D), which is a series of stages or processes that aim to produce a new product or improve existing products [12]. This research focuses on testing the development of learning media in the form of a project-based e-worksheet to improve creative thinking skills that refer to the ADDIE development model (analysis, design, development, implementation, and evaluation).

The target of this research was class X students in one of the public high schools in Surabaya, consisting of 35 people. Data collection techniques in this study consisted of three techniques, namely questionnaire data, observation data, and test data. The questionnaire data technique was used to determine the validity and practicality of the project-based e-worksheet. The instruments used in the questionnaire are content and construct validity instruments, and student response questionnaire instruments. The test technique was used to determine the effectiveness of the project-based e-worksheet. The test sheet consists of pretest and posttest questions, which aim to measure students' creative thinking skills.

Data analysis techniques for validity were analyzed descriptively quantitatively using a Likert scale with a rating scale of 1-5. Data analysis of validation results was carried out by determining the mode at each validated point. E-worksheet is declared valid if it gets a mode ≥ 4 .

Table 1. Likert Scale

Score	Statement Value
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

The data from the learner response questionnaire were analyzed descriptively quantitatively. The learner response questionnaire presented positive and negative

statements in the form of answer choices, "Yes" or "No". The data on the practicality of e-worksheet obtained from the learner response questionnaire is then calculated using a formula, which is interpreted in the form of a percentage. The developed e-worksheet is declared practical if the percentage of learner response scores reaches $\geq 61\%$.

Table 2. Interpretation of the Percentage Score of the Practicality Criteria

Percentage (%)	Category
0-20	Very Unpractical
21-40	Not Practical
41-60	Moderately Practical
61-80	Practical
81-100	Very Very Practical

Analysis of learning test data obtained from pretest and posttest scores is determined through the calculation of the N-gain score. The N-gain score calculation formula is as follows.

$$g = \frac{\text{posttest value} - \text{pretest value}}{\text{maximum score (100)} - \text{pretest score}}$$

The results of the calculation of the N-gain value or the improvement of creative thinking skills obtained are interpreted into the following table.

Table 3. N-gain Score Criteria

Percentage (%)	Category
0-20	Not Very Effective
21-40	Not Effective
41-60	Moderately Effective
61-80	Effective
81-100	Very Highly Effective

The effectiveness of e-worksheet can be seen through the N-gain score or the improvement of creative thinking skills. If the N-gain score ≥ 0.7 with high criteria or N-gain score ≥ 0.3 with moderate criteria is obtained, the project-based e-worksheet is said to be effective.

Results and Discussion

The first stage in the ADDIE development model is the analysis stage. The analysis stage aims to identify problems based on the results of field studies and literature studies, and collect all supporting information in developing learning media. The initial stage of the research involved a series of analyses, including school needs and learner characteristics.

At the needs analysis stage, pre-research and interviews with chemistry teachers in one of the public schools in Surabaya were conducted to obtain data relevant to school conditions. Based on the results of interviews with chemistry teachers, students' creative thinking skills have not been measured based on existing indicators. Therefore, it is necessary to measure and improve these skills. Based on the pre-research data of creative thinking skills test results, the details of the indicators of students' creative thinking skills are as follows; indicators of originality (36.3%), fluency (42.9%), flexibility (37.0%), and detail (39.1%).

Then, researchers also distributed questionnaires related to learning activities and project-based e-worksheet needs. The data obtained from the questionnaire can be used as a reference in designing a project-based e-worksheet on green materials. As many as 85.71% of students stated that they had never received project-based learning related to the principles of green chemistry. According to 57.14% of students, one of the main difficulties in learning green chemistry material is the material that needs to be memorized. Therefore, 91.43% of learners revealed that green chemistry is an interesting topic to be applied in project-based learning to solve problems that exist in everyday life.

The next stage is the design stage. The design stage aims to design learning media to be developed, focusing on media selection, format selection, and drafting an e-worksheet. At this stage, the initial design of the e-worksheet was made, which was adjusted to the syntax of the PjBL model, which each learning phase included indicators of creative thinking skills in each learning phase.



Figure 1. Cover

The e-worksheet cover page is attractively designed so that it can present the content and green chemistry material contained in the e-worksheet (Figure 1). The e-worksheet cover page consists of several aspects, including (1) title; (2) logo (Ministry of Research and Technology, Merdeka Curriculum, and Unesa); (3) identity of the authors; (4) phase and class; and (5) images related to the project in the e-worksheet.

The e-worksheet user guide is an important part that contains guidelines for using the e-worksheet. The existence of e-worksheet instructions for use aims to provide convenience to users (teachers and students) in operating the features contained in the e-worksheet. The following is a display of instructions for use in the e-worksheet (Figure 2).

The learner activity sheet is prepared based on the PjBL learning model, which consists of 6 phases (Figure 3). Each phase in the PjBL model is associated with indicators of creative thinking skills, namely originality, fluency, flexibility, and elaboration [13].

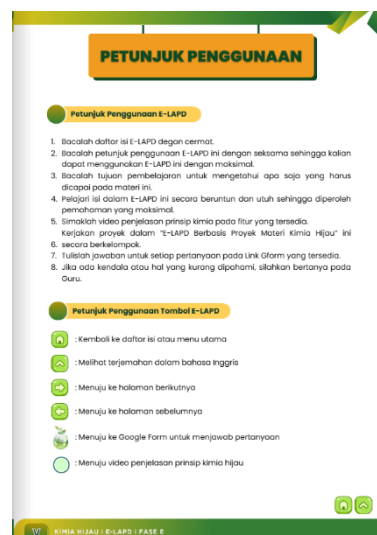


Figure 2. User Guide



Figure 3. Learner Activity

Table 4. Content Validity Results

Percentage (%)	Mode	Category
E-WORKSHEET contains the syntax of PjBL	5	Very Good
Suitability of e-worksheet with creative thinking skills indicators	4	Good

The development stage is the process of implementing the design or design that has been made in the previous stage into an e-worksheet (electronic Learner Activity Sheet) product that is ready for limited testing. At this stage, the validity test is used to assess the feasibility of learning devices, especially project-based e-worksheets on green chemistry material, to improve creative thinking skills. The validity test of the validation results was conducted by three validators, namely two lecturers from the Unesa Chemistry Education Study Program and one chemistry teacher. Content validity is the currency and correctness of knowledge concepts, and construct validity is the internal consistency of the learning media developed [12]. The

content validity of the e-worksheet includes two aspects, which are listed in Table 4.

Based on the content validity data by the validator, the first aspect regarding the e-worksheet contains the syntax of PjBL, which gets a mode of 5 with a very good category. The stages of project-based learning, namely (1) starting with fundamental questions, (2) designing project planning, (3) preparing schedules, (4) implementing and monitoring project progress, (5) reporting and presenting project results, and (6) evaluating project results experience [9]. In the second aspect regarding the suitability of e-worksheet with indicators of creative thinking skills. This shows that in the e-worksheet, there are indicators of creative thinking skills, including fluency, flexibility, originality, and elaboration.

Construct validity is the internal consistency of the learning media developed [12]. This study used aspects of construct validity assessment presented in Table 5.

Table 5. Construct Validity Results

Persentase (%)	Mode	Category
Language	4	Good
Presentation	4	Good
Graphics	4	Good

Based on construct validity data, the language aspect of the e-worksheet gets mode 4 with a good category. This proves that the language category in the e-worksheet is presented in a language that is brief, clear, and does not contain double meaning (ambiguous). The presentation aspect gets a grade of 4 with a good category. The presentation category of the e-worksheet is presented with complete components and features that make it easier for students to access the e-worksheet. The graphic aspect gets mode 4 with a good category. E-WORKSHEET has fulfilled the category of graphics, which shows that the e-worksheet uses an attractive, harmonious, and appropriate design and appearance.

A limited trial of project-based e-worksheet was conducted to find out how to improve students' creative thinking skills. This implementation was carried out in two meetings. Based on these activities, the practicality of the e-worksheet was obtained. This data was obtained from the questionnaire of students' responses to the developed e-worksheet.

Table 6. The percentage of practicality of the learner response instrument

Aspect	Percentage (%)	Category
Clarity of material	95.7	Very Good
Ease of use	100	Very Good
Usability of e-worksheet	100	Very Good

Based on the data from the students' responses, the project-based e-worksheet on green chemistry material is considered very practical as a learning media in improving creative thinking skills. This is indicated by the acquisition in the material clarity aspect of 95.7, with a very good category. The material clarity aspect indicates that the material in the e-worksheet contributes to increasing the level of understanding of students, especially the green chemistry material. Green Chemistry material discusses the principles and practices of environmentally friendly

chemistry. The goal is to reduce or prevent the negative impact of chemicals on the environment and living things. This material is relevant to the Learning Outcomes of Chemistry phase E of the Merdeka Curriculum, which emphasizes the ability of students to respond to global issues and provide solutions related to daily chemistry, including the use of waste and natural materials.

The percentage of the second aspect regarding ease of use is 100%, with a very good category. This shows that the e-worksheet is easy to use by students. One of the functions of e-worksheet as a learning media is efficient, concise, and contributes to the ease of students in carrying out the learning process [14]. Presentation of material through videos can allow students to observe directly, thus stimulating the learning process in strengthening students' understanding [15]. In addition, e-worksheets as electronic media equipped with video features and other interactive features have a strong potential to attract learners' interest. In optimizing the learning experience of learners, the e-worksheet is presented with a display size that can be modified through the zoom in/out feature located in the lower right corner of the page. The e-worksheet is designed using interactive features to facilitate learners. The process of filling in answers is done intuitively by utilizing a button that directs to the Google Form.

The percentage of the third aspect regarding the usefulness of e-worksheet is 100%, with a very good category. This shows that e-worksheets are practical to use in improving students' creative thinking skills. Learning media in the form of a project-based e-worksheet that involves the process of planning and developing projects improves students' creative thinking skills [7].

The effectiveness of the e-worksheet was reviewed from the pretest and posttest results conducted by students at the beginning and end of learning after using the project-based e-worksheet to improve students' creative thinking skills. The results of the participants' creative thinking skills test were analyzed using the N-gain method. The results are presented in Table 7.

Table 7. N-Gain Score of Creative Thinking Skills Indicator

Creative Thinking Indicators	Pretest	Posttest	N-gain	Category
Fluency	37.78	90.16	0.84	High
Flexibility	37.14	88.89	0.82	High
Originality	34.60	86.35	0.79	High
Elaboration	33.33	90.48	0.86	High

Based on Table 4.13, the N-gain score on the fluency indicator is 0.84, with a high category. Fluency indicator can be said to be achieved if students are able to express many ideas in solving a problem effectively [16]. The ability of students to provide varied answers to various problems is an indicator of flexibility [16]. The N-gain score on the flexibility indicator is 0.82, with a high category. The N-gain score on the originality indicator is 0.79 with a high category. Students have met the originality indicator, which is shown through the ability to express ideas that are original and different from other students [17]. The N-gain score on the elaboration is 0.86 with a high category. Learners have fulfilled the elaboration indicator, which is shown through detailed and systematic student answers [18-20]. The results

of the N-gain score of all indicators of creative thinking skills obtained an N-gain score ≥ 0.7 , with a high category. This shows that e-worksheets can be interpreted as effective for use as a learning media.

In the ADDIE development model, evaluation has a formative nature and is carried out at each stage of the process to collect data used in improving e-worksheet products. Evaluation is carried out continuously from the analysis, design, development, to the implementation stage [16].

Conclusion

The project-based Electronic Learner Activity Sheet (e-worksheet) on green chemistry material to improve students' creative thinking skills is suitable for use as a learning medium to improve students' creative thinking skills. Based on the findings obtained from this study, it can be concluded that the validity of the project-based e-worksheet on green chemistry material to improve students' creative thinking skills in terms of content and construct validity is obtained mode 4 with a good category, so that it can be declared valid. The practicality of project-based e-worksheet on green chemistry material to improve students' creative thinking skills is stated to be very practical in terms of the results of the students' response questionnaire. The effectiveness of project-based e-worksheet on green chemistry materials to improve students' creative thinking skills is declared very effective in terms of improving students' creative thinking skills. In addition, this media can be used as a reference for further research in developing interactive learning media in the form of more innovative and effective e-worksheets.

Author's Contribution

Shafna Nor Janah: Responsible for designing and developing learning media, preparing media designs, conducting limited trials, and analyzing trial data. In addition, prepare the initial draft of the scientific article. Rusly Hidayah: Provide overall guidance, conceptual direction, and supervision throughout the research and development process.

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