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Design of E-Assessment for Creative Thinking in Project-Based Learning on Colligative Properties of Solutions

Slamet Reza Nasrullah[1]* and Rr. Lis Permana Sari[2]

[1]*Chemistry Education Study Program, Universitas Negeri Yogyakarta, Indonesia*

[2]*Department of Chemistry Education, Universitas Negeri Yogyakarta, Indonesia*

Email: rezzaslamet751@gmail.com

Abstract: *Assessment is an important part of the learning process in chemistry education, which requires conceptual understanding and creative thinking skills. However, traditional assessment often fails to accommodate the needs of 21st-century learning, which requires the integration of technology, creativity, and problem solving. This study aims to determine: (1) the characteristics of e-Assessment, (2) the feasibility of e-Assessment on teacher usability tests, and (3) the student responses to e-Assessment on student readability tests. This study employed a Design-Based Research model. In this study, a product trial was conducted with 10 high school chemistry teachers and 36 grade XII high school students. Data analysis techniques used descriptive qualitative and quantitative methods to determine product quality based on ideal assessment criteria. Based on teacher evaluations, the product was rated very high, with average scores for content (22.70 out of 25.00), presentation (23.00 out of 25.00), usability (27.60 out of 30.00), and project learning (22.70 out of 25.00). Based on student readability, the scores were very high, with average scores for presentation (22.11 out of 25.00), language (9.11 out of 10.00), and attractiveness (16.78 out of 20.00). Thus, the developed e-Assessment system is deemed suitable for use by teachers as a student assessment system.*

Keywords: *creative thinking; e-assessment; project-based learning*

INTRODUCTION

The Indonesian government has consistently aimed to improve education quality by implementing enhancements across various educational sectors, as mandated by Law No. 20/2003 on the National Education System. These improvements include the implementation of the "Merdeka Belajar" program, the "Kurikulum Merdeka," and the strengthening of the Pancasila student profile (Sulastri et al., 2022). According to Sulastri *et al*. (2022) as cited in Snyder *et al.* (2012), the improvement of the quality of education is expected to foster character education amongst students.

The character will be closely related to the soul of students who can emerge into *habits*. It is this habit that affects the character of students. Furthermore, character strengthening is explicitly addressed in Article 3 of Law No. 20/2003 on the National Learning System (Sisdiknas). Students must have high motivation to become the next generation of the nation with character and

moral quality as well as intellectual intelligence.

Strengthening students' character is crucial, especially as the practice of Pancasila values has diminished. In addition, it is influenced by the lack of implementation of character education and Pancasila in the learning process (Kahfi, 2022). Therefore, educators play a vital role as the primary agents of change. Educators need to innovate to prepare simple learning tools to integrate character education into subjects. According to Julianto & Nuryin (2022) the result of the application of this teaching method is also believed to be the ability to change the personality of students to be positive, have integrity, and have high moral attitudes accompanied by strong character.

The development of Science and Technology will have an impact on educational goals that emphasize strengthening character including attitudes and skills such as critical thinking, systematic thinking, creative thinking, and collaboration (Asy'ari et al., 2019). Most educational curricula emphasize the development of higher-order thinking skills that extend beyond mere memorization to include critical analysis and problem-solving abilities (Asy'Ari et al., 2021). Creative thinking involves high levels of curiosity and the ability to formulate effective solutions for problem-solving (Kardoyo *et al.,* 2021; Biazus & Mahtari, 2022). It enhances students' awareness of cognitive limitations and encourages them to employ diverse strategies based on both prior and newly acquired knowledge, fostering the development of higher-order problem-solving skills.

Dwi W. et al. (2019) mentioned five core aspects of creative thinking including sensitivity, fluency, flexibility, originality, and elaboration. Creative thinking is described by several characteristics, such as sensitivity to understanding responses, fluency in solving problems, flexibility in making decisions, originality of ideas, and the accuracy of solutions in relation to the correctness of the answers. This aspect is aimed at the cognitive activity of students with curiosity, driven by new ideas that have never been thought of by others. The processes of creative thinking, practical thinking, and analytical thinking are distinct. Creative thinking can be considered a creative process within analytical and practical thinking. The existence of creative thinking skills is very important based on the demands of learning that focus on technology integration. However, research by Biazus & Mahtari (2022), as cited in Fitriani et al. (2019), highlights the low levels of creative thinking skills among students. This condition may result from the use of learning models that fail to stimulate creative thinking among students. Addressing this issue requires effective and innovative solutions.

The Project Based Learning (PjBL) model can help students improve problem solving and critical thinking skills. This learning model is student-oriented, focusing on enhancing communication skills and student engagement. Project-based learning is an innovative learning model that actively involves students in producing real project products (Nainggolan, 2019). On the other hand, according to Grossman *et al.* (2019), it was found that the PjBL model is not suitable for some materials and in line with the awareness of low student learning motivation (Rahardjanto *et al.,* 2019). These studies show a gap in the impact of PjBL on students' interest in learning when viewed from cognitive, affective, and psychomotor aspects, especially their ability in creative thinking skills. Based on Yamin *et al.* (2020) in creative thinking, the PjBL model can be utilized as a method to train and enhance students' creative thinking, though it has primarily been implemented in social science disciplines. Therefore, this research needs to be carried out in the discipline of chemistry in high school. Through PjBL, students will become more active in trying to solve existing problems and pour the results into a product, so that this can improve students' understanding of the material (Purba dan Fitri, 2021).

The emergence of Creative Thinking is driven by the rapid advancement of technology at every level of education. Nowadays, technology-based learning is essential for educators to adopt cutting-edge learning methods. Technological developments influence the learning process that is more effective and efficient so that it can be accessed anywhere and anytime. Many learning media provide benefits in the form of attractive learning offers from technological advances (Karmila et al., 2022). The utilization of learning technology has been developed to meet current needs (Permana Sari *et al.,* 2023). Teachers are given the skills to apply it in the learning process. Thus, digital learning tools, such as computers, the internet, videos, and others need to be adopted and mastered by educators to build teaching models and provide information easily to students.

Permana *et al.* (2023), as cited in Ana *et al.* (2020) mentioned that the use of technology in the learning process can generate large datasets that can be widely accessed, one of which is assessment technology. Assessment is a critical component of the learning process because it allows us to evaluate the achievements of both teachers and students. To support e-Learning technology, the concept of electronic assessment (e-Assessment) emerged. *e-Assessment* refers to the use of ICT to present and deliver assessment tasks, receive student responses, and record those responses (Divjak *et al.,* 2022). e-Assessment offers valuable features in every assignment given by the teacher, enabling students to access learning and assignments flexibly. Assessment strategies are structured in the form of tasks or projects contained in an assessment rubric using digital media to facilitate the process of achieving learning objectives. Based on the observation cited from Permana *et al.* (2023), interest in e-Assessment remains relatively low. Educators still use assessment primarily as a final assessment, without providing feedback to students. As we know that assessment is "part of assessment", not "the end" of it.

The availability of e-Assessment PjBL learning model enables students to create products by applying research, analysis, and presentation skills. Students' knowledge and skills in managing tools and materials are also a key focus of PjBL. The use of PjBL allows educators to assess the learning process from start to finish and provide feedback in the most effective way. This will also be supported by materials based on creative thinking. According to Zahroh's (2020) research, the PjBL learning model has a positive impact on students' creative thinking abilities in the context of colligative properties of solutions. So teachers can use creative thinking assessment indicators to evaluate students through the PjBL e-Assessment that will be developed.

Therefore, this study aims to identify the characteristics of e-Assessment in the dimension of creative thinking based on PjBL and to determine the feasibility of the e-Assessment product based on the responses of teachers and students. The researcher designed e-Assessment as an electronic-based assessment tool with Learning Management System (LMS) characteristics. e-Assessment is used to assess students on colligative properties of solutions material that emphasises creative thinking aspects through a project-based learning model.

LITERATURE REVIEW

Permana Sari et al. (2023), in their study titled *Development of Electronic Learning Chemistry Assessment Applications Through Project-Based Learning for Increasing Student Scientific Performance*, developed an electronic assessment application to support digital chemistry learning through Project-Based Learning (PjBL). The study reported a high Content Validity Index (CVI) of 0.9 (very valid), an attractiveness level of 93.9% (very interesting), and a substantial improvement in students' scientific performance with a gain score of 0.70 (high). While these findings suggest the effectiveness of e-assessment in facilitating project-based chemistry learning, the study primarily

focused on students' scientific performance and did not address the dimension of creative thinking, which is a critical component of 21st-century skills.

In a separate study, Biazus and Mahtari (2022), entitled *The Impact of Project-Based Learning (PjBL) Model on Secondary Students' Creative Thinking Skills*, examined the impact of PjBL on students' creative thinking abilities. The results indicated a significant improvement in students' creative thinking, reinforcing the potential of PjBL to foster higher-order thinking skills. However, the assessment methods employed were conventional and lacked digital integration, limiting the scope for real-time feedback and dynamic evaluation, which are essential in assessing creative thinking in authentic learning environments.

Chanpet, Chomsuwan, and Murphy (2020), in their research *Online Project-Based Learning and Formative Assessment*, explored the integration of technology into PjBL and formative assessment practices. Their findings highlighted that technology-enhanced PjBL facilitated student engagement and interaction, and improved learners' perceptions of their own knowledge and skills. Despite these positive outcomes, the study focused more on students' perceptions and general technological implementation rather than the development of a dedicated electronic assessment tool to evaluate specific cognitive skills such as creative thinking.

From the analysis of the aforementioned studies, it is evident that while PjBL and e-assessment have been utilized to support student learning in various contexts, there is a research gap in the development of digital assessment tools specifically designed to measure creative thinking within the framework of project-based learning. No prior research has integrated an e-assessment platform within a Learning Management System (LMS) that targets the assessment of creative thinking in a structured and measurable way particularly in the context of chemistry education, such as colligative properties of solutions.

Therefore, the present study aims to design and develop an e-assessment tool that functions within an LMS environment to evaluate students' creative thinking skills in the topic colligative properties of solutions. The tool is intended to align with the principles of PjBL and offer a more targeted, interactive, and competency-based approach to assessing creativity in chemistry education.

METHODS

Instrument Development

This research employs the Design Based Research (DBR) method. According to Plomp (2013) in Hodijah Siti E., (2022), Design-Based Research is a comprehensive approach to designing, developing, and evaluating educational interventions, such as programs, strategies, learning materials, products, and systems, as solutions to complex problems in educational practice.

The development procedure follows Reeves (2006) and consists of four stages:

1. Problem Identification
   At this stage, the researcher conducts a needs analysis through interviews, observations, and documentation to identify problems and develop learning solutions.
2. Solution Design and Development
   This stage begins with creating a prototype based on the e-Assessment design. It starts with preparing the server installation with supporting software such as Apache (as a web server), MySQL (as a database), Laravel (as a PHP framework), and a web browser (for server testing). Next, the database is designed through the installation of Laravel on the local system. During this development phase, the design of the e-Assessment PjBL interface and features is carried out, including account management (school/teacher/student), assessment guidelines, My Course, and PjBL-based assignment features.

3. Recurring Cycle
   This stage involves assessing product feasibility with chemistry learning validation experts, assessment validation experts, and media validation experts. The aim is to obtain product suggestions before the feasibility test is carried out for teachers and students. Once the product is declared feasible, the final step is testing it with teachers and students to gather feedback.
4. Reflection
   This stage involves feasibility testing, including assessments of teacher usability and student readability. Additionally, product improvements and reflections are made to ensure a high-quality e-Assessment product.

Sample in Validation

This study involved trial subjects consisting of:

1. Chemistry learning expert
   The e-Assessment trial was conducted by chemistry learning experts to test the feasibility of the colligative properties of solution material through the PjBL learning model. The criteria for chemistry learning experts are lecturers qualified in chemistry.
2. Assessment expert
   This trial stage was carried out by assessment experts who aimed to test the feasibility of assessments based on the colligative properties of solution material on creative thinking skills. The criteria possessed by e-Assessment expert subjects are lecturers who are competent in the field of chemistry learning assessment.
3. Media expert
   This trial stage was conducted by media experts to assist the suitability of the media for the e-Assessment design. The criteria possessed by e-Assessment expert subjects are lecturers qualified in the field of media and proficient in using assessment media.
4. High school chemistry teacher
   This trial was conducted by high school chemistry teachers to evaluate the feasibility of the e-Assessment. The criteria for participants in this trial are chemistry teachers who teach chemistry at the high school level and are familiar with the PjBL learning model.
5. High school students
   The purpose of the test conducted by students is to test the readability of the developed e-Assessment. The criteria that must be owned by the subject of this trial are XII grade high school students.

Data Collection Technique

Data collection was conducted using interviews and questionnaires. The interviews were conducted with chemistry teachers who teach at the senior high school level, specifically grade XII, aiming to explore their experiences, challenges, and needs related to classroom learning processes and assessment practices.

The instruments used in this study were adapted and refined based on the previous work of Agustina R. (2022), ensuring relevance to the current context while maintaining methodological rigor. The finalized instruments, along with their respective target respondents, are summarized in Table 1 as follows:

Table 1. Research Instruments

No	Steps	Instruments	Respondents
1	Needs Analysis	Interview guidelines	5 high school chemistry teachers
2	Readability Test	Readability survey	36 grade XII high school students
		Project creative thinking	36 grade XII high school students
3	Usability Testing	Usability survey	10 high school chemistry teachers

In this study, the usability test sheet for teachers was conducted by submitting a questionnaire developed through quantitative analysis methods converted according to Likert scale. The teacher usability questionnaire covers aspects of content, presentation, usability, and project. The aspects and indicators of teacher usability testing are detailed in Table 2 below:

Table 2. Aspects and Indicators of Teacher Usability Testing

No	Aspects	Indocators
1	Content	1. e-Assessment based on learning outcomes 2. e-Assessment tailored to student indicators 3. e-Assessment based on levels of creative thinking 4. e-Assessment materials are appropriate 5. e-Assessment uses various types of questions to test understanding
2	Presentation	6. The sequence of the e-Assessment is in accordance with the indicators and meets the criteria 7. The design format of the e-Assessment is easy to understand 8. The completeness of the e-Assessment instrument format in terms of the outline, instructions for use, and scoring 9. The e-Assessment instructions are conveyed clearly and are easy to understand 10. The test instrument measures the creative thinking abilities of students
3	Usability	11. e-Assessment facilitates student assessment 12. The e-Assessment PjBL design is the first product of its kind in this school 13. The developed e-Assessment is suitable for use at the senior high school level 14. e-Assessment can be accessed flexibly by teachers and students 15. Teachers can reflect on and evaluate students 16. e-Assessment allows students to demonstrate their understanding and skills
4	Project	17. Project-based learning integrates chemistry concepts into science and technology development 18. e-Assessment facilitates students in exploring themselves (active, skilled, creative) 19. e-Assessment PjBL provides transparent assessment rubrics 20. PjBL is relevant to learning that is appropriate to current issues 21. e-Assessment facilitates student reflection on project planning, process, and results

The readability test sheet for students was developed by submitting a questionnaire and completing an integrated creative thinking project. The student readability questionnaire covers the aspects of presentation feasibility, linguistic feasibility, and appeal feasibility. The aspects and indicators of the student readability test are detailed in Table 3 below:

Table 3. Aspects and Indicators of Student Readability Test

No	Aspects	Indicators
1	Presentation	1. e-Assessment presents questions in accordance with PjBL syntax material 2. e-Assessment questions are easy to understand 3. e-Assessment questions are oriented towards creative thinking 4. e-Assessment presents interesting questions and images 5. The time provided is appropriate
2	Lingustics	6. Clear and easy-to-understand sentences and paragraphs 7. Standard Indonesian that is easy to understand
3	Attractiveness	8. This e-Assessment makes me more enthusiastic about learning 9. The design of the e-Assessment does not make me bored of learning in class 10. The instructions for implementing the e-Assessment are clear and easy to understand 11. The projects in the e-Assessment challenge me to complete them

Data Analysis

The data obtained in this study were qualitative and quantitative data. The data were then processed using Microsoft Excel. Quantitative data were obtained from the results of feasibility tests by chemistry teachers and readability tests by students. The conversion values can be seen in Table 4 according to the Likert scale as follows:

Table 4. Conversion with *Likert* Scale

Category	Score
SB (very good)	5
B (good)	4
C (sufficient)	3
K (less)	2
SK (very less)	1

Based on the data obtained, we then calculated the average of each aspect using Microsoft Excel with the following equation:

$$\overline{X} = \frac{\sum x}{n}$$

Description:

$\underline{X}$ = Average score

Σx = Total score

n = Number of respondents (Teachers = 10 and Students = 36)

Furthermore, convert the data obtained into qualitative data using Microsoft Excel as shown in Table 5.

Table 5. Conversion of Ideal Score into Qualitative Data

	Interval (i)	Category
1	Score > Mi + 1.5 Sdi	Very good
2	Mi + 0.5 SDi < Score ≤ Mi + 1.5 Sdi	Good
3	Mi - 0.5 SDi < Score ≤ Mi + 0.5 Sdi	Simply
4	Mi - 1.5 SDi < Score ≤ Mi - 0.5 Sdi	Less
5	Score ≤ Mi - 1.5 Sdi	Very Less

Mi = Ideal average score, with the formula

$$\underline{Mi} = \frac{1}{2}\,(Ideal\,\max score + Ideal\,\min score)$$

SDi = Ideal standard deviation, with the formula:

$$SDi = \frac{1}{2} \times \frac{1}{3}\,(Ideal\,\max score + Ideal\,\min score)$$

The Mi and SDi values are calculated using a standard formula with maximum and minimum ideal scores from the Likert scale per aspect, which are then used to determine the assessment category intervals. Table 6 shows an example of Mi and SDi for the Content Feasibility Aspect by Teachers:

Table 6. Mi and SDi Calculations for 'Content Aspect – Feasibility Tests'

Average Score	22,7
Number of Indicators	5
Ideal Maximum Score	5 x 5 = 25
Ideal Minimum Score	5 x 1 = 5
Mi	$\frac{1}{2} \times (25 + 5) = 15$
SDi	$\frac{1}{6} \times (25 - 5) = 3{,}33$

No	Interval (i)	Category
1	22.7 > 20	Very good
2	16.7 < 22.7 ≤ 20	Good
3	13 < 22.7 ≤ 16.7	Simply
4	10 < 22.7 ≤ 13	Less
5	22.7 ≤ 10	Very Less

RESULT AND DISCUSSION

RESULTS

The feasibility assessment of the PjBL e-Assessment instrument was conducted using questionnaires administered to validators, teachers, and students. Teachers and students assessed the instrument using a Likert scale, while material expert validators, chemistry learning experts, and media experts employed a checklist format (Feasible, Not Feasible, or Feasible with Revision) accompanied by comments. The feedback provided by validators served as the basis for product improvements.

Table 7 presents the results of the usability test conducted by 10 high school chemistry teachers in Yogyakarta. This test aimed to evaluate the feasibility of the e-Assessment in assessing students' creative thinking within the Project-Based Learning (PjBL) model for colligative properties material. The aspects evaluated include content feasibility, presentation, usability, and project. The data reflect teachers perceptions of the system's practicality and its effectiveness as a learning assessment tool.

Table 7. Results of Teacher Usability Tests on PjBL e-Assessment

Aspect	Indic -ator	$\bar{x}$	$\Sigma\bar{x}$	Category
Contents	1	4.6	22.7	Very Good
	2	4.6		
	3	4.2		
	4	4.6		
	5	4.7		
Presentation	6	4.7	23.0	Very Good
	7	4.6		
	8	4.5		
	9	4.8		
	10	4.4		
Usability	11	4.6	27.6	Very Good
	12	4.6		
	13	4.7		
	14	4.9		
	15	4.4		
	16	4.4		
Project	17	4.8	22.7	Very Good
	18	4.5		
	19	4.6		
	20	4.5		
	23	4.3		

Table 8 displays the results of the readability test involving 36 Grade XII high school students. This test assessed three key aspects of the e-Assessment interface: presentation, linguistic, and attractiveness. The students responses indicate how well the systems design supports ease of use and engagement during learning activities involving creative thinking tasks.

Table 8. Results of Student Readability Tests for PjBL e-Assessment

Aspect	Indic -ator	$\bar{x}$	$\Sigma\bar{x}$	Category
Presentation	1	4.556	22.1	Very Good
	2	4.5		
	3	4.305		
	4	4.4		
	5	4.25		
Linguistics	6	4.5	9.11	Very Good
	7	4.611		
Attractivene	8	4.194	16.8	Very Good
	9	4.138		
	10	4.361		
	11	4.083		

DISCUSSION

1. Problem Identification

The identification of problems in this developmental research was conducted through a needs assessment, which included interviews with 10 high school chemistry teachers in Yogyakarta. In addition, a software and hardware requirements analysis was also performed to support the development of the PjBL e-Assessment system.

Based on the interviews with high school chemistry teachers, the following issues were identified; 1) chemistry topics, particularly the colligative properties of solutions, are rarely taught in project-based experiments, 2) there is no project-based learning guide for chemistry topics that aim to enhance students' creative thinking skills, 3) Teachers primarily rely on a paper-based assessment system, 4) the school Learning Management System is used only for exam assessments, 5) there are no standardized guidelines or assessment rubrics available for teacher evaluations, 6) no system exists for tabulating teacher assessment data effectively.

Based on the analysis of software and hardware requirements, it shows that this PjBL e-Assessment system requires a server equipped with PHP, Apache, and MySQL functionalities. To access the developed system, users only need hardware connected to the internet in which there is a browser capable of loading modern websites.

In response to these findings, the design of a PjBL e-Assessment system focused on creative thinking skills was developed. This system is intended for teachers to assess project-based activities on the colligative properties of solutions for Grade XII high school students.

2. Solution Planning and Development

The implementation of this developmental research involves two critical stages: the planning stage and the development stage of the PjBL e-Assessment system. In the planning stage, a prototype was designed by analyzing the identified problems and proposing a Learning Management System (LMS)-based solution, designated as "e-Assessment," to evaluate student learning outcomes.

The initial development stage of the e-Assessment was done by making a database design consisting of a class diagram with the help of the software used, such as Apache, MySQL, Laravel, Visual Studio code, DB

Diagram, and Web browser. e-Assessment can be accessed at the link https://lms.khamim.my.id. To create the framework for the PjBL e-Assessment system, Laravel was installed on a local system. According to Permatasari & Ekohariadi (2023), Laravel is highly suitable for use because all the features that have been needed are available and easy to obtain, this Laravel framework is also open source. **Figure 1.** is the Laravel Framework source code that functions to run a PjBL e-Assessment system as a Learning Management System (LMS) media.

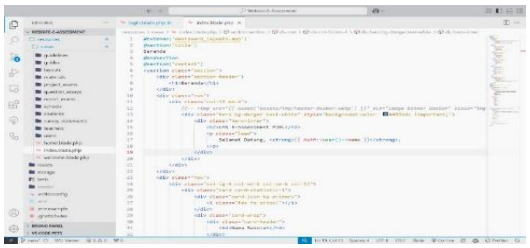

Figure 1. *Laravel Framework Source Code*

The stages of developing PjBL e-Assessment features consist of home page, school list page, teacher management page, student management page, account management page, assessment guidelines page, MyCourse page, basic questions page, project page, and report page. The development results are presented in the **Figure 2-7.**

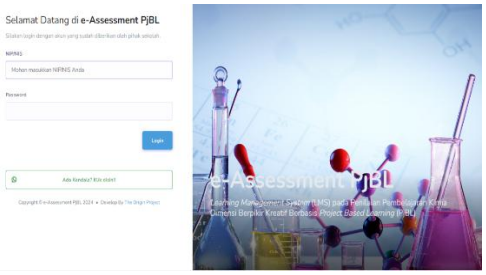

Figure 2. *Login* view

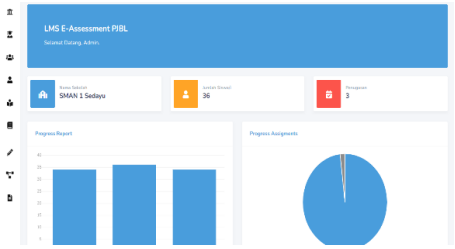

Figure 3. *Dashboard* view

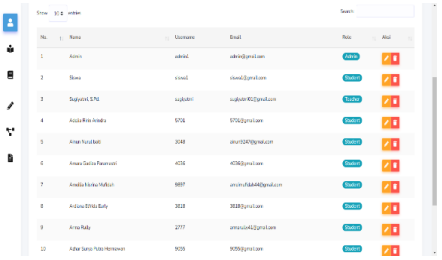

Figure 4. Account management page view

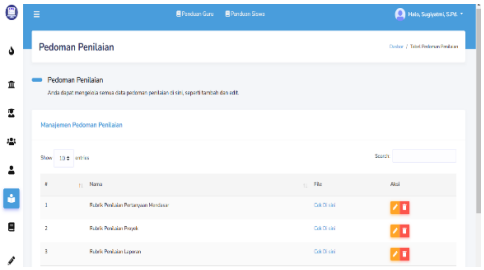

Figure 5. Assessment guidelines page view

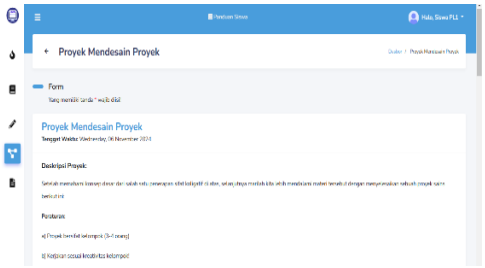

Figure 6. "Project" work page view

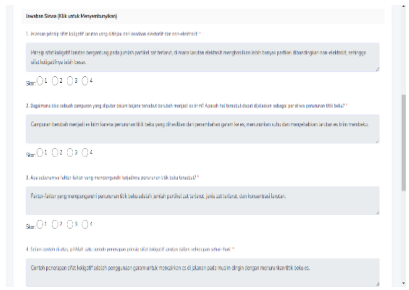

Figure 7. Teacher assessment page view

3. Recurring Cycle

At this stage of development, researchers conducted feasibility assessments product validation tests to chemistry learning experts, assessment experts, and media experts. This development stage is conducted by revising the product until the final product can be used.

Chemistry learning experts recommended the inclusion of learning materials within the system, improvements to assessment guidelines in accordance with the Project-Based Learning (PjBL) syntax, and the addition of user manuals for administrators, teachers, and students. As a result, a "My Course" feature was added, containing resources such as PowerPoint materials, teaching aids, and student worksheets (LKPD), along with a comprehensive user guide.

Assessment experts advised aligning the question items with creative thinking indicators and refining their context based on key aspects of creative thinking. In response, the question items were revised to focus specifically on one concept—freezing point depression—and the wording was adjusted to match the PjBL syntax.

Media experts suggested enhancing the system's interface by adding a history and progress report menu, clarifying the font size and color of the main menu, and including relevant illustrations to improve the visual appeal. These recommendations were incorporated into the final product to enhance usability and attractiveness of the e-Assessment system.

4. Reflection

The reflection stage involved usability testing by teachers and readability testing by students. Data on the quality of the PjBL e-Assessment product were collected and analyzed to determine its overall quality and the percentage of ideal scores for each assessed aspect. Quantitative data were converted into qualitative evaluations using the Likert scale. The usability testing stage by teachers was conducted on 10 high school chemistry teachers in Yogyakarta. Teachers assessed the usability of the product which includes aspects of content feasibility, presentation, use, and project learning.

The feasibility data for the PjBL e-Assessment product indicate that all assessed aspects fall into the **Very Good** category. Aspects of the feasibility of use achieved an average score of 27.60 out of a maximum score of 30.00. Aspects of content feasibility and project learning feasibility scored 22.70 out of a maximum score of 25.00. In addition, the feasibility aspect of presentation received an average score of 23.00 out of a maximum score of 25.00. The feasibility test can be used as an illustration to determine how effective the use of PjBL e-Assessment is used as an assessment experience by the teacher. The existence of e-Assessment is expected to be used as a reflection to determine the level of development and achievement of students to achieve the quality of education through improving the quality of the assessment system.

The readability test was conducted with 36 high school students from Class XII in Yogyakarta. The product readability test was conducted by distributing a student readability questionnaire. There are three aspects in the PjBL e-Assessment readability test, namely presentation feasibility, linguistic feasibility, and attractiveness feasibility.

Data on the feasibility of the PjBL e-Assessment products were analyzed across three key aspects: presentation feasibility, linguistic feasibility, and attractiveness feasibility. Each aspect was rated within the **Very Good** category. The presentation feasibility aspect with an average score of 22.11 from a maximum score of 25.00. The linguistic feasibility aspect with a mean score of 9.11 from a maximum score of 10.00. In addition, the feasibility aspect of attractiveness with an average score of 16.78 out of a maximum score of 20.00. The student readability feasibility test served as a method to gather feedback from students on their experience using the PjBL e-Assessment system. Students will experience using PjBL e-Assessment when working on chemistry learning projects given by the teacher. Data from the students' readability experience when using the system will be calculated and analyzed for the average score of each aspect component tested.

CONCLUSION

Based on the research conducted, the following conclusions can be obtained the e-Assessment PjBL for creative thinking

dimension is characterized as a Learning Management System (LMS)-based assessment instrument. The system integrates chemistry learning materials that foster creative thinking skills, incorporates everyday-life contexts, follows a project-based learning (PjBL) syntax, and provides guidelines and rubrics for student project assessments. The quality of the e-Assessment for creative thinking dimension in the context of PjBL-based colligative properties material, as evaluated through teacher usability testing, is rated very high. The quality of the e-Assessment for creative thinking skills in the context of PjBL-based colligative properties material, as evaluated through the readability test by students, is also rated very high. These findings imply that e-Assessment PjBL is effective as an authentic assessment innovation that supports 21st-century chemistry learning, particularly in developing students' creative thinking skills.

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