

The Validity of a PBL-Based E-Worksheet Chemical Equilibrium for Enhance Creative Thinking

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ABSTRACT

This study aims to determine the validity of the Electronic Student Worksheet (E-LKPD) based on the PBL (Problem Based Learning) model to improve students' creative thinking skills in chemical equilibrium materials. The development model in this study is ADDIE (Analyze, Design, Development, Implementation, & Evaluation), and is limited to the development stage and there is an evaluation at each stage. The validation results are analyzed based on the mode in each aspect. Based on the validation results, a mode score of 3 is obtained for each aspect of content validity and construct validity with a valid category. So that the PBL-based E-LKPD that is developed can be considered valid to improve students' creative thinking skills.

Keyword: *Electronic Student Worksheets, Creative Thinking Skills, Problem Based Learning, Chemical Equilibrium*

Received: May, 25 2025;
Revised: June, 04 2025;
Accepted: June, 18 2025

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DOI: <https://doi.org/10.22437/jisic.v17i1.44474>

INTRODUCTION

Education serves as the main means of transferring knowledge and preparing the younger generation to face global change (Mukaromah, et al., 2025). In the 21st century, increasing competition in the education sector has become an increasing phenomenon (Nasution & Marito, 2024). The 21st century is an era where the world is developing faster and more complex. Basically, these changes are to improve the quality of life of modern society. Good quality Human Resources can be achieved by fulfilling the creativity and productivity possessed by a person (Nuraini & Hidayah, 2023). Creativity is one of several skills that need to be mastered by a person in the 21st century (Irwanto, 2023). This can be fulfilled

by providing education that is characterized by a learning paradigm or an emphasis on the active role of students.

Creativity is a person's ability to create something new, new ways, or new models that have different qualities from elements that may have existed before (Gaol, et al., 2022). Through creative thinking skills, students will be able to modify, reuse, or even create new product ideas (Qiara, 2024). According to Munandar (2012), indicators of creative thinking skills consist of aspects of fluency, namely the ability to generate many ideas/answers in a short time; flexibility, namely the ability to produce ideas with various ways of thinking, originality, namely



the ability to produce new and unique expressions in one's own way or idea, and elaboration, namely the ability to enrich and develop an idea to be better.

The need for creative thinking skills is also emphasized in the Independent Curriculum, namely that students at the senior high school (SMA) level are expected to master the creative dimension through chemistry subjects. Kusnadi et al. (2024) state that chemistry is a field of science suitable for digital learning media, as it examines the composition and properties of substances or materials at the atomic and molecular levels, meaning the physical properties of many chemical substances and materials are not directly observable by sight.

Most high school students consider chemistry to be a difficult subject (Lestari, et al., 2024). One of the difficult chemistry subjects is chemical equilibrium because it focuses on mastering symbols, memorizing formulas and solving problems mathematically (Gurusinga & Eddiyanto, 2025). This is evidenced by the results of a pre-research conducted on students of SMA Negeri 13 Surabaya, 64% of students had difficulty understanding chemical equilibrium material. The reaction process and changes that occur in chemical equilibrium material require good imagination, understanding, and problem-solving skills to be able to understand the processes that occur. Conditions in the field do not support the importance of training students' creative thinking skills in chemistry lessons. One of the causes is that the use of learning methods used is still conventional (Siahaan, et al., 2022).

One of the learning models that can improve students' creative thinking skills is the problem-based learning model (Silver & Edward, 1997). The Problem Based Learning (PBL) model is an educational approach that engages students with real-world challenges, enabling them to construct their own understanding, enhance advanced skills, self-regulate, and boost their self-esteem (Wena,

2020). This statement is in line with Adiilah & Haryanti (2023) who believe that the PBL model can be applied in learning to achieve learning goals and urgency, especially the development of creative thinking skills.

Furthermore, to enhance the learning process, it is essential to develop innovative instructional materials that effectively support both educators and students in teaching and learning activities. One of the teaching materials that is often needed in schools is LKPD or Student Worksheets. However, the use of printed teaching materials is less effective and practical, as a result, teaching materials in the form of E-LKPD are needed (Qonitah, et al., 2022). Research developed by Wahyuni, et al., (2021) shows that E-LKPD can foster the four indicators of creative thinking skills.

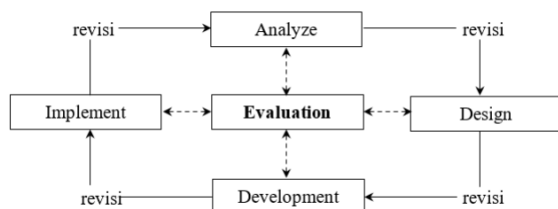
The development of PBL-based E-LKPD to improve creative thinking skills in chemical equilibrium material in its implementation requires a feasibility test. A feasibility test is an assessment that aims to determine whether the product being developed meets certain standards or requirements (Plomp & Nieveen, 2013). One of the criteria for the feasibility of teaching materials is validity. Validity means that all components must be based on the latest material and knowledge (content validity) and all components must also be related to each other consistently (Nieveen, 1999). Validity is carried out by experts using instruments developed to assess, as well as provide input and suggestions on E-LKPD. Experts conduct product assessments that include the suitability of the product to existing theories. Based on the problems above, good and innovative learning media are needed through the use of technology such as the use of E-LKPD. So that it is expected that there will be an increase in students' creative thinking skills in chemical equilibrium material. Therefore, the purpose of this study is to determine the level of validity of PBL-based E-LKPD to improve students' creative thinking skills in chemical equilibrium material.

METHODS

The research conducted uses the type of Research and Development (R&D) research, with the ADDIE development model which has stages including Analyze, Design, Development, Implementation, and Evaluation. The researcher chose to use the ADDIE research design because the sequence of product development activities in the form of electronic learning media, namely E-LKPD, requires descriptive and systematic development steps, so the ADDIE research design is considered appropriate for use in this study.

Research Procedures

Visually, the ADDIE development model flow is presented in the following figure.



(Irawan, 2014)

Figure 1. ADDIE research design stages

The ADDIE research design steps in this study are only limited to the development stage, while the evaluation stage is carried out at each stage of the ADDIE research design.

The development of PBL-based E-LKPD begins at the analyze stage, with details of performance analysis and needs analysis. Performance analysis aims to identify problems that occur in the learning process (Fadila & Ramadhani, 2024). In addition, it also aims to determine the curriculum used and determine the appropriate material to develop learning media in the form of PBL-based E-LKPD. Then the needs analysis aims to find out what educators and students need (Ningsih, et al., 2023). At this stage, an initial analysis is

carried out to determine the basic problems of the need to develop PBL-based E-LKPD.

Subsequently, an evaluation of the analysis phase is conducted to determine whether the analysis aligns with the identified needs or requires further improvement. This evaluation focuses on students' creative thinking skills in the context of chemical equilibrium and the application of E-LKPD teaching materials in the school setting.

The next stage is the design stage with details of the following activities: (1) selection of the form of presentation of learning media to be used, namely PBL-based E-LKPD; (2) preparation of the initial design of E-LKPD by reviewing and compiling supporting features that will be included in E-LKPD and the relationship between the components used. The components to be used are the PBL model and indicators of creative thinking skills. The learning material used is chemical equilibrium.

Next, an evaluation of the design stage is carried out by conducting a review by the Supervisor using a review sheet instrument with the aim of providing feedback on the initial design results of the E-LKPD. After improvements are made, it will enter the development stage with details of the activities being validated by experts, using an instrument in the form of a validation sheet. Validation aims to assess the level of validity of the resulting product (Tulaena, et al., 2024). Furthermore, an evaluation of the development stage is carried out by improving the E-LKPD that was developed according to the suggestions and input provided by the validator.

Method of collecting data

The data collection method used in this study is the questionnaire method. The instruments used in data collection are review

sheets and validation sheets. The review sheet aims to obtain input and suggestions from the supervising lecturer as an improvement to the E-LKPD that will be developed and then revised to produce an appropriate E-LKPD. Furthermore, a validation sheet is utilized during the validation process of the developed E-LKPD, encompassing both content validity and construct validity. Content validity pertains to the alignment of the E-LKPD with learning indicators, the Problem-Based Learning (PBL) model, and the enhancement of creative thinking skills. While construct validity includes graphic criteria and linguistic criteria. The validation sheet is designed to gather evaluations from media and content experts in order to determine whether the E-LKPD meets the established validity criteria. The sheet is completed by three validators, comprising two lecturers in chemistry education and one chemistry teacher.

Data Analysis Techniques

The research results that have been obtained still require further analysis. In the study, the data analysis technique used was a quantitative method. In the analysis of the review data, the data obtained was analyzed descriptively regarding suggestions and input based on the results of the review conducted by the supervisor. The components to be reviewed include content and construct components. Meanwhile, in the validation

data analysis, it was carried out using a validation sheet in the form of a questionnaire with a Likert scale so that data was obtained quickly even though the topics assessed were broad (Cohen, et al., 2018). The Likert scale and acquisition scores used are based on the table 1.

Table 1. Likert scale in validity test

Category	Score
Invalid	1
Less valid	2
Valid	3
Very valid	4

(Riduwan, 2015)

The validators assess the E-LKPD using a 4-point Likert scale. The E-LKPD is considered valid if it receives a mode score of ≥ 3 from the three validators. The mode is employed as the basis for decision-making in this study because the validity data are ordinal in nature and cannot be subjected to mathematical operations, thus necessitating analysis using the mode (Lutfi, 2021). According to the criteria for analyzing validity data using the mode method, if the aspects or indicators evaluated by the validators yield a mode score of ≥ 3 , they are deemed valid. Conversely, if the mode score is < 3 , the aspects or indicators are considered less valid, requiring revisions and subsequent reassessment until the predetermined validity criteria—a mode score of ≥ 3 —are achieved.

RESULT AND DISCUSSION

Analysis stage

At the analysis stage, there is a performance analysis and needs analysis. The results of the performance analysis show that the curriculum used at SMA Negeri 13 Surabaya is an independent curriculum. According to Ramadani, et al., (2025) the independent curriculum is a curriculum that emphasizes the development of student skills, one of which is creative thinking skills. Creative thinking skills can be implemented for all

materials in chemistry lessons, one of which is chemical equilibrium material. In the independent curriculum, chemical equilibrium material is in phase F of grade XI SMA/MA/K equivalent.

Furthermore, in the needs analysis, pre-research and interviews with chemistry teachers were carried out at SMAN 13 Surabaya. Based on the results of the pre-research that had been carried out, students at SMAN 13 Surabaya had relatively low

creative thinking skills. Then, when interviews were conducted with chemistry teachers, there was no use of learning media, especially Electronic Student Worksheets during learning, especially on chemical equilibrium material, so E-LKPD learning media were needed to train students' creative thinking skills.

Evaluation of the analysis stage

Based on the results of the performance analysis and needs analysis, the researcher conducted an evaluation activity after conducting pre-research. Pre-research was conducted by providing questions and questionnaires to test students' creative thinking skills. The following are the results of the creative thinking skills test for each indicator.

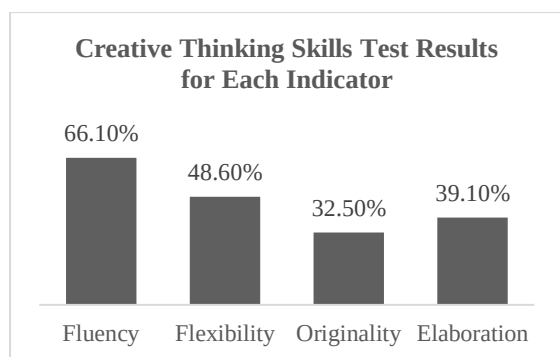


Figure 2. Creative thinking skills test results for each indicator

In the pre-study, the results of creative thinking skills were obtained fluency of 66.11%, flexibility of 48.6%, originality of 32.5%, and elaboration of 39.1%. This shows that students' creative thinking skills in chemical equilibrium material need to be improved. Then, this is also supported by an interview with one of the chemistry teachers at SMAN 13 Surabaya who explained that creative thinking skills can be given to students in chemical equilibrium material. In addition, he also said that in chemistry learning, it is still rare to provide practice questions that can improve students' creative thinking skills. According to him, the skills that are often taught are the skills of formulating problems, analyzing, and making conclusions. These skills are not

included in one aspect of creative thinking skills. This is what makes students' creative thinking skills still relatively low. Through the results of the pre-study and interviews that have been conducted, an increase is needed in all indicators of students' creative thinking skills in chemical equilibrium material.

Design stage

In this study, the platform chosen is Liveworksheet, because it can be accessed by anyone and anytime easily through the link <https://www.liveworksheets.com/>. Teachers need to register an account first, then edit and save the E-LKPD media. After that, the teacher will get a link that can be shared with students to work on the E-LKPD.

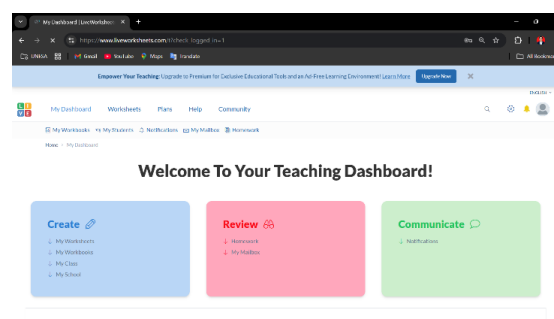


Figure 3. Liveworksheet page

The developed E-LKPD consists of Initial E-LKPD containing guidelines for using E-LKPD and E-LKPD Factors Affecting Chemical Equilibrium Shifts containing each factor. Initial E-LKPD consists of 6 pages, while factor E-LKPD consists of 14 pages. Both, on the cover page, contain the title, student identity, class, author, Unesa logo, the words S-1 Chemistry Education Study Program, and the teacher/student handle. The difference is in the middle section which shows Initial E-LKPD or factor E-LKPD.



Figure 4. E-LKPD Cover Page

The initial E-LKPD contains a foreword, general instructions, descriptions of creative thinking aspects, instructions for using the E-LKPD, instructions for the delivery stage, learning outcomes, learning objective flow, and hyperlinks to the E-LKPD learning for each factor that influences chemical equilibrium shifts.



Figure 5. Initial E-LKPD Content Design

The second and third pages contain a summary of the material regarding the concept of chemical equilibrium for each factor and motivation that contains news about the application of the concept of chemical equilibrium in life.



Figure 6. Summary of E-LKPD Material and Motivation

The fourth page contains news or problems that must be identified, in accordance with the syntax of the PBL model, namely the orientation of students to the problem. Then, students are given practice questions to express the problems presented, which are included in the aspect of

creative thinking fluency. In working on these questions, there is a hyperlink that leads to Google Form. The purpose of filling in via Google Form is to find out how long it takes students to answer the question.



Figure 7. Fluency Skill & Phase 1 PBL

The fifth and sixth-pages present discourse related to laboratory activities related to the problems presented. This is intended to guide students in the experimental activities that will be carried out in the laboratory. Then, students are given several questions to review from various literatures regarding the components that will be used in the experiment, which are included in the flexibility aspect of creative thinking.

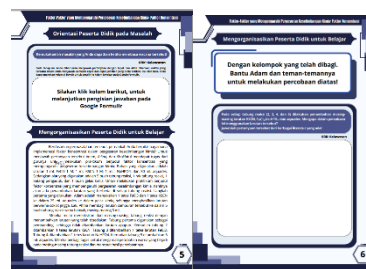


Figure 8. Flexibility Skill & Phase 2 PBL

Pages seven to nine present several questions before conducting the experiment that are included in the aspect of creative thinking flexibility. One example is predicting the color changes that occur in each test tube. Furthermore, students are directed to conduct the experiment by designing the tools, materials, and procedures in groups. This experiment design activity is included in the aspect of creative thinking, namely fluency, flexibility, and originality.

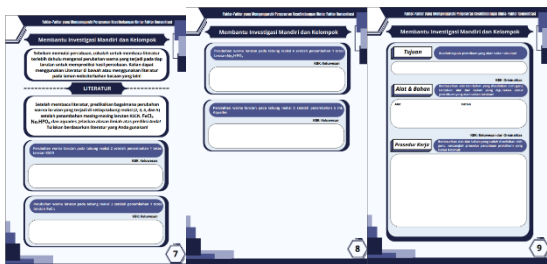


Figure 9. Fluency, flexibility, and Originality Skill & Phase 3 PBL

Pages ten to twelve present a table of observation results that will be filled in based on the experiments that have been carried out, this activity is included in the aspect of creative thinking flexibility. The next activity is given several questions to help students analyze the results of the experiments that have been obtained, this activity is included in the aspect of elaboration in creative thinking. Then, there are questions to conclude the results of the experiment, this activity is included in the aspect of originality of creative thinking.

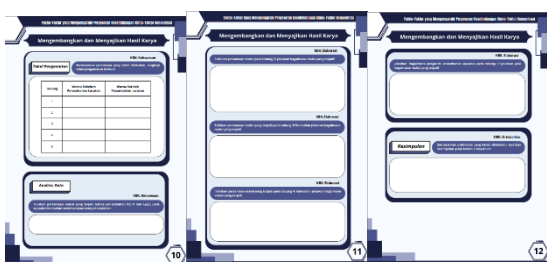


Figure 10. Flexibility, originality, and elaboration skill & Phase 4 PBL

Page thirteen presents two questions. The first question is to connect the results of the experiment with the problems that have been presented. This activity is included in the aspect of creative thinking flexibility. The next question is an evaluation of the problem-solving process in the form of solutions and

recommendations from the problems presented, this activity is included in the aspect of originality and elaboration of creative thinking.



Figure 11. Originality and elaboration skill & Phase 5 PBL

The last page of the E-LKPD contains a bibliography, containing various sources and references used in making the PBL-based E-LKPD on the sub-material of factors influencing chemical equilibrium shifts.

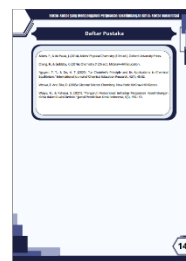


Figure 12. E-LKPD bibliography

Evaluation of the design stage

At this stage, a review of the PBL-based E-LKPD was conducted first in order to obtain input and suggestions for the PBL-based E-LKPD developed as draft 1, then a revision was made to the PBL-based E-LKPD draft 1 based on the suggestions and input that had been obtained. The revised results of the E-LKPD creative thinking skills draft 1 are called draft 2. Improvements and suggestions from draft 1 to draft 2 will be described in the table 2.

Table 2. E-LKPD Review Results

E-LKPD Input/Review	E-LKPD Revision Results
Improved brief explanation of the four aspects of creative thinking that are easy for students to understand.	
Addition of a title to the motivation section in each E-LKPD.	
Addition of linguistic features along with additional information regarding the timer for answering KBK questions: Fluency	

Development stage

This stage is the process of developing the design in the previous stage into an E-LKPD product. At this stage, the E-LKPD that is developed will be tested for its validity. The assessment of the content and appearance of the E-LKPD aims to obtain a product in the form of a valid E-LKPD by using a validation sheet as an instrument to obtain data (Sugiyono, 2013).

Validation of the PBL-based E-LKPD was obtained from a validation sheet filled out by 3 expert validators. The validation sheet in this study includes content validation and construct validation. The data from the E-LKPD validation test results that have been filled out by 3 validators are described in the following table.

Table 3. E-LKPD Content Validation Results for Each Aspect

Aspect	Mode
Suitability of E-LKPD content with learning achievements and learning objectives	3
Suitability of E-LKPD content with PBL model phase	3
Suitability of E-LKPD content with creative thinking skills indicators	3

The first aspect, which concerns the alignment of the E-LKPD content with learning outcomes and objectives, received a mode score of 3. This indicates that the material presented in the E-LKPD is consistent with the intended learning outcomes and instructional goals. In addition, the suitability of the E-LKPD with the sub-material of factors that influence chemical equilibrium shifts also obtained mode 3 with

a good category so that it can be declared valid. According to BSNP (2012), an E-LKPD that meets the eligibility of content is if each activity contained in the E-LKPD has a clear learning objective. The delivery of a clear learning objective flow can make learning effective and focused on the material to be delivered. Based on this, it can be concluded that the material and practice questions contained in the E-LKPD are in

accordance with the learning achievements of phase F of the chemistry subject and are in accordance with the learning objectives for the sub-material of factors that influence chemical equilibrium shifts.

The second aspect, namely the suitability of the E-LKPD content with the PBL model phase, obtained mode 3 with a valid category. This is because the contents of the E-LKPD that were developed have been systematically arranged based on the syntax of the Problem Based Learning learning model. The syntax contained in E-LKPD includes: (1) orienting students to problems, (2) organizing students to learn, (3) assisting independent and group investigations, (4) developing and presenting work results, (5) analyzing and evaluating the problem solving process (Arends, 2012).

The third aspect, which pertains to the alignment of the E-LKPD content with indicators of creative thinking skills, received a mode score of 3, indicating that it falls within the valid category. This is because the E-LKPD that was developed already contains components of creative thinking skills including: aspects of fluency, aspects of flexibility, aspects of originality, and aspects of elaboration.

Based on the validation results provided by the validators, the developed E-LKPD obtained a mode score of 3, placing it in the valid category. This suggests that the content of the E-LKPD aligns with the criteria for fostering creative thinking skills. The PBL-based E-LKPD offers students opportunities to examine problems from multiple perspectives and to generate innovative solutions, thereby encouraging the development of their creative thinking abilities.

The aspect of fluent thinking is the ability to produce a number of ideas, questions, concepts, or answers (Filsaime, 2008). This provides an opportunity for students to provide ideas and concepts related to the methods used to present problems from various perspectives. The aspect of fluent thinking in the E-LKPD Concentration

Factor, E-LKPD Temperature Factor and E-LKPD Pressure & Volume is found in the activity of formulating problems, determining experimental tools and materials.

The aspect of flexible thinking, namely the ability to produce a number of ideas, concepts that vary from various perspectives (Filsaime, 2008). The aspect of flexible thinking in the E-LKPD Concentration Factor, E-LKPD Temperature Factor and E-LKPD Pressure & Volume is found in the investigation activities of literature reviews, writing experimental procedures, writing experimental data, and investigations related to the relationship between experimental results and problems. The experimental activities carried out by students in each factor are the same, namely identifying the influence of concentration factors, temperature, pressure & volume in shifting chemical equilibrium. Furthermore, students determine the tools, materials, and experimental procedures according to group discussions. In the experiment design activity, students are trained to compile and conduct experiments from literature studies and discussions between friends so as to produce ideas from various points of view.

The aspect of originality, which is the ability to produce unique, new ideas that have not been thought of by others (Filsaime, 2008). The aspect of original thinking of E-LKPD Concentration Factor, E-LKPD Temperature Factor and E-LKPD Pressure & Volume is found in the activities of writing down tools, materials, and experimental procedures, concluding experimental results, and evaluating problems. Original thinking behavior includes students being able to think of new things in designing experiments, making relevant conclusions according to the investigation activities that have been carried out, as well as the latest solutions to the problems presented.

The aspect of elaboration, which is the ability to add, develop, and refine ideas, or details of certain objects (Filsaime, 2008). The aspect of elaboration thinking of E-LKPD Concentration Factor, E-LKPD

Temperature Factor and E-LKPD Pressure & Volume is found in the activities of analyzing experimental results, and evaluating problems, by providing solutions and recommendations for problems. In the activities of analyzing experimental results and evaluating problem solving, students are trained to develop ideas based on experimental results and combining them with understood literature studies, as well as discussion results between friends. Elaborative thinking behavior is seeking deeper knowledge in solving problems comprehensively and expanding or enriching

ideas from various sources (Munandar, 2012).

Furthermore, in terms of construct validity, the validators assess the structure of the developed PBL-based E-LKPD. This assessment encompasses three criteria: presentation, language, and visual design. The construct validation results yielded a mode score of 3, indicating that the E-LKPD is valid and meets good quality standards. A detailed explanation of the construct validation results for each aspect is provided in the table 4.

Table 4. E-LKPD Construct Validation Results for each Aspect

Aspect	Mode
The presentation includes images, videos, hyperlinks used in E-LKPD which are clearly visible	3
Language includes words or terms that are used appropriately and consistently	3
Graphics include a combination of writing and images in E-LKPD that are attractive and harmonious.	3

The first aspect is the presentation criteria, the presentation criteria aim to determine the presentation of material, references, sources, completeness of identity in the E-LKPD that was developed. In the presentation criteria, the mode score is 3 with a valid category. This is because the news, images, and videos available are clearly visible and can be easily accessed by students. The presentation of attractive illustrations and complete identities can help students understand the reading and motivate students to explore more information and other sources. This is because the main purpose of the media is to visualize things or concepts that cannot be learned directly due to limitations in the learning process in the classroom (Nurdyansyah, 2020). In addition, there is also a hyperlink that when pressed will lead to Google Forms to answer questions on the fluency aspect. Hyperlinks in E-LKPD are also used when students press "literature" it will lead to teaching materials that have been provided by researchers as additional references for working on E-LKPD.

The second aspect pertains to the language criteria, which aim to evaluate the appropriateness of the language used in the developed E-LKPD. This criterion received a mode score of 3, indicating a valid category. This outcome reflects that the E-LKPD employs simple sentences that are easily understood by students. Additionally, the vocabulary and terminology used are accurate and consistent. Moreover, the language adheres to proper grammar rules and the Enhanced Spelling System (EYD). Ensuring grammatical correctness, conformity to EYD, and consistent terminology is crucial in the preparation of instructional materials for students (Haspen, et al., 2021). This is because short, concise, clear, and coherent language will help students to understand and carry out activities in the E-LKPD easily, so that students are not confused when studying chemical equilibrium material.

The third aspect concerns the graphic criteria, which evaluate the typography, layout, and graphic illustrations utilized in

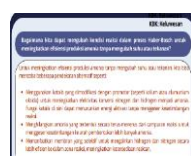
the developed E-LKPD. This criterion received a mode score of 3, indicating a valid category. The developed E-LKPD employs font styles that enhance readability for users, demonstrating that the E-LKPD possesses high graphic quality and effectively supports ease of reading (Pangestuti, et al., 2025). The preparation of a worksheet must pay attention to the use of font types and text sizes, for example the use of block letters and using bold letters that are larger than Latin letters for writing titles and not using words with underlines, then using frames as markers for questions and answers for students. This aims to ensure that the E-LKPD product can be used comfortably by students.

Based on the validation results carried out by the three validators on the PBL-based

E-LKPD, it can be seen that the developed E-LKPD is declared valid with a mode score of 3 for both content and construct validity aspects. All E-LKPDs have also been revised based on suggestions and input provided by the validator. Based on the assessment results, E-LKPD is declared to meet the two validation aspects above and can be declared valid. Based on the validation results of the construct aspect in the table, the mode obtained is 3 with good criteria. This is in accordance with table 2 of the Likert scale score which states that E-LKPD is declared valid if it gets a mode ≥ 3 .

After the validator assessment, the E-LKPD was revised according to suggestions to produce draft 3. Improvements from draft 2 to draft 3 are outlined in the following table.

Table 5. Revised results from validator

Revision	E-LKPD Revision Results
Change of the title of E-LKPD from “Main E-LKPD” to “Initial E-LKPD”	
Added description of the color changes that occur	
Explained regarding the relationship with shifts in chemical equilibrium	

Evaluation of the development stage

PBL-based E-LKPD is declared valid with a score mode of 3 in the content and construct validity aspects. At the

development evaluation stage, revisions were made by considering input from validators related to the development of PBL-based E-LKPD which has been described in table 5.

CONCLUSION

Based on the results of the research that has been conducted, the PBL-based E-LKPD to improve students' creative thinking

skills on chemical equilibrium material is declared valid in terms of the validation sheet score with a mode of 3 in the good category.

ACKNOWLEDGMENTS

The researcher would like to thank all those who supported the preparation of this article, especially the students of class XI-9 who made it easier for the researcher to conduct the research. The researcher would like to thank the supervisor who has guided the researcher in preparing this article.

Thanks also to two chemistry education lecturers and one chemistry teacher of SMAN 13 Surabaya who have become validators for this research. The researcher would also like to thank JISIC: Journal of The Indonesian Society of Integrated Chemistry as a forum for publishing this research work.

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