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Development Problem-Based-Learning Oriented E-worksheet To Train Analytical Skills On Chemical Equilibrium Material

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Abstract
The goal of this study is to explore the potential for teaching students analytical skills on chemical equilibrium material through the use of an online worksheet focused on problem-based learning. Based on validity, practicality, and effectiveness, an E-LKPD feasibility score can be obtained. The research and development (R&D) methodology used in this study makes use of Tiagharajan's 4D development process, which consists of the steps Define, Design, Develop, and Disseminate. Based on the findings of the research, the e-worksheet earned mode 3 on the validation sheet, indicating that it is legitimate. With an 86.44% percentage, the e-worksheet was judged to be very practical based on the results of the student response questionnaire. The e-worksheet is certified effective in terms of analyzing t test findings with a significance value of 0.00, implying that Ho is rejected and Ha is accepted. The n-gain score for analytical skills was 0.55 on element analysis, 0.59 on relationship analysis, and 0.59 on organizing analysis. Based on these findings, it is possible to infer that the problem-based learning-oriented e-worksheet produced to educate students' analytical abilities on chemical equilibrium content is suitable for usage.

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INTRODUCTION

Developing fundamental 21st-century thinking skills requires a holistic approach involving formal education, lifelong learning, and practical experience (Almazroui, 2023). This is crucial to prepare students to face the complexities and dynamics of the modern world (Afdareza et al., 2020; Dwyer et al., 2014). The complexities and dynamics of the modern 21st-century world demand proficient thinking skills so that students can adapt and succeed. Critical, creative, analytical thinking, and problem-solving skills are fundamental thinking skills that must be prepared to face the challenges of the 21st century (Carlgren, 2013; Chusni et al., 2020; Hulyadi et al., 2024). These skills are essential to understand and evaluate information objectively. This involves a series of activities in assessing the accuracy and relevance of information from various sources, identifying core problems, understanding cause-and-effect relationships, and making evidence-based decisions through thorough analysis. These activities

can train critical and analytical thinking skills (Abrami et al., 2015; Alsaleh, 2020; Carlgren, 2013).

In a rapidly changing world, the ability to think creatively and innovatively is essential to find new solutions (Akpur, 2020). The complexity of current global problems requires creative and holistic solutions. Complex analyses of each problem are needed to produce accurate and appropriate solutions (Carlgren, 2013). To face the complexities and dynamics of the modern 21st-century world, students need to develop proficient thinking skills. Education, training, and practical experience are crucial in building these capabilities so that students can adapt and thrive in an ever-changing environment (Miterianifa et al., 2021).

One of the fundamental thinking skills in the 21st century is analytical thinking (Erawan & Al, 2021). Training analytical thinking is vital to face the challenges of the 21st century, characterized by complexity, rapid change, and rapid technological advancements. The scientific approach to learning models is an appropriate method to foster critical, analytical, creative, and metacognitive thinking skills (Miterianifa et al., 2021; Rahmadani, 2019). Problem-based learning places students in situations where they must solve real, complex problems (Almulla, 2020; Amin et al., 2020; Hanipah et al., 2018). Problem identification involves students in identifying real problems relevant to their context. Students then engage in activities to gather information from various sources, followed by analysis to understand and analyze the given problems. The next step involves conducting a relevant literature review to build a hypothetical framework related to the given problems. This series of activities has proven to enhance critical thinking, analytical skills, and problem-solving abilities (Belecina & Jose M Ocampo, 2018; Bulu & Tanggur, 2021; Hanipah et al., 2018; Marinda, 2020).

Results from the PISA 2018 and 2022 assessments illustrate that the science, mathematics, and reading abilities of Indonesian students remain low, with Indonesia ranking 60th out of 72 assessed countries (Argina et al., 2017; Ismawati et al., 2023; Safari et al., 2020). This situation calls for significant attention from all stakeholders. Low competencies in science, mathematics, and reading are closely tied to low thinking skills. Contextual learning is essential to create meaningful learning experiences and increase student motivation. Case studies can be an effective model to present contextual problems in the learning process. Case studies offer students the opportunity to analyze real-life situations, identify problems, and develop solutions. Students read and comprehend the details of the provided cases, identify key problems and challenges, analyze available data and information, and develop solutions based on their analysis. This series of activities is believed to enhance students' thinking skills.

The complexities of the education world demand learning approaches that keep pace with the times. Virtual learning can be a viable solution amid the surge of technology. Students must be brought closer to their learning resources. Mobile phones are a familiar technology at all levels of education in Indonesia, from elementary to higher education. It is crucial to provide engaging and easily understandable learning resources on devices like mobile phones and related internet tools. Technology can be an extremely effective tool for training analytical thinking (Gitomer & Bell, 2016; Muthmainnah et al., 2022; Saadé et al., 2012). This includes using simulations and games designed to develop analytical skills, leveraging online resources such as articles, journals, and videos to expand students' knowledge and understanding, and using collaborative platforms to allow students to work together on complex projects and problems (Nishiyama, 2023). Developing analytical thinking skills is key to facing the challenges of the 21st century. By using various methods and approaches such as problem-based learning, case studies, classroom discussions, technology use, project-based learning, and regular exercises, students can learn to analyze information, solve problems, and make well-informed decisions. Education that emphasizes analytical thinking skills will prepare students for success in an increasingly complex and dynamic world.

Analytical skills involve the mental ability to examine, categorize, sequence, identify patterns, and determine causation (Novita et al., 2016; Swami et al., 2014). These skills are crucial for students to identify the causes of everyday problems and find ways to solve them. Analytical skills are part of higher-order cognitive processes or higher-order thinking skills. According to Bloom's Taxonomy, analytical skills are divided into three components: analysis of elements, analysis of relationships, and analysis of organizing principles (Kusnawa, 2012).

Based on the results of an analytical skills test conducted on March 2, 2023, with 29 students from class XI Science 6 at SMAN 13 Surabaya, it was found that students' ability to analyze elements was 60%, to analyze relationships was 39%, and to analyze organizing principles was 42%. These results indicate that students' analytical skills need improvement in each component. Approximately 95% of the students were unable to complete case study assignments, with only 2-5 students able to answer test questions requiring analytical skills. Therefore, it can be concluded that students' analytical skills are still low and need to be developed through instruction. Analytical skills can be trained and applied in all school subjects, including chemistry.

Chemistry is a branch of science that studies phenomena and natural occurrences in the universe through systematic observation, experimentation, and measurement (Wong et al., 2020). Scientific activities in chemistry include observation, hypothesis formulation, experimental design, data collection and analysis, and drawing conclusions (Akyol & Taş, 2024; Mohzana et al., 2023). All these processes are carried out systematically, controlled, and measured to produce objective and verifiable results. Critical, analytical, and creative thinking skills are essential in these activities (Hulyadi et al., 2024; Ijirana et al., 2022). Scientific thinking in chemistry involves complex cognitive processes, such as problem identification, hypothesis formulation, experimental design, data analysis, and conclusion drawing. This process requires logical, inductive, and deductive thinking skills, as well as the integration of concepts, principles, and theories to understand chemistry phenomena comprehensively (Lubna et al., 2023). Scientific activities and systematic thinking in chemistry produce reliable, objective, and verifiable knowledge. This knowledge can be applied to solve problems and improve the quality of human life, preparing individuals to face 21st-century challenges. Scientific thinking skills in chemistry are also useful in decision-making, problem-solving, and innovation in various fields. A reliable thinking system is a fundamental competency in addressing the complexities of 21st-century problems.

In the 21st century, the challenges faced by society are increasingly complex and diverse, ranging from climate change and rapidly evolving technology to shifting social and economic dynamics. To address these challenges, a reliable thinking system becomes a fundamental competency. A reliable thinking system involves the ability to think critically, analytically, and creatively to understand and solve problems effectively (Fong et al., 2017; O'Reilly et al., 2022; Swami et al., 2014). Critical thinking involves the ability to analyze information objectively, identify biases, evaluate arguments, and draw conclusions based on available evidence. This ability is crucial for assessing the validity and reliability of information circulating in the digital age (Abrami et al., 2015). Analytical thinking is the ability to break down problems into smaller components, understand the relationships between these components, and formulate solutions based on in-depth analysis. This skill is very useful in tackling complex and multifaceted problems (Kirman-Bilgin & Kala, 2022; Pennycook et al., 2012).

Besides these reliable thinking models, creative thinking is also essential to master in facing future complexities. Creative thinking involves the ability to generate new ideas, view problems from various perspectives, and develop innovative solutions (Akpur, 2020). Creativity allows individuals to break free from conventional thinking patterns and find new

ways to solve problems (Huang et al., 2020; Park & Lee, 2022). The rapid advancement of technology requires the ability to continuously learn and adapt. A reliable thinking system enables individuals to understand new technologies, integrate them into everyday life, and utilize them to enhance productivity and efficiency. Global issues such as climate change, energy crises, and social injustices require complex and integrated solutions (Abbass et al., 2022; Carleton & Hsiang, 2016). A reliable thinking system helps individuals and groups formulate holistic and sustainable strategies. In the information era, individuals are faced with many choices and decisions. Critical and analytical thinking skills assist in making data-driven and fact-based decisions, reducing the risk of errors, and improving the quality of outcomes (O'Reilly et al., 2022). Learning models that emphasize systematic thinking skills and scientific processes, such as PjBL, are suitable for fostering reliable thinking abilities (Baran et al., 2021; Bulu & Tanggur, 2021). The PjBL approach encourages students to engage in real projects that require problem-solving, collaboration, and innovation (Diana et al., 2021; Hulyadi et al., 2024). Through PjBL, students can develop critical, analytical, and creative thinking skills in contexts relevant to real life.

In the Problem-Based Learning (PBL) model, students are required to think critically and find solutions. Additionally, it helps students understand tolerance and listen to different opinions from others. It instills the understanding that every problem has a solution. Another advantage of using the PBL model is that students find it easier to remember solutions to problems related to everyday life. The PBL learning model is very suitable for addressing the analytical skills of secondary school students, as it presents real-life problems related to the material and learning objectives. This direct involvement in problem-solving analysis is highly beneficial (Rahmadani, 2019). Implementing any learning model requires teaching media that align with the model's syntax. One effective teaching medium is the e-worksheet.

Learning media are tools that aid the teaching and learning process, making the message clearer and achieving educational or learning objectives effectively and efficiently (Nurrita, 2018). One such medium is the e-worksheet, which serves as a work guide for students, facilitating their understanding of lesson material in an electronic format accessible via desktop computers, notebooks, smartphones, or mobile phones (Umriani, 2020). E-worksheets offer the advantage of simplifying and narrowing the space and time needed for learning, thus making the process more effective (Suryaningsih & Nurlita, 2021). Furthermore, e-worksheets are easily accessible anytime and anywhere using laptops or smartphones (Apriliyani & Mulyatna, 2021). Currently, there are numerous applications and websites available for creating interactive e-worksheets, one of which is Liveworksheet. Liveworksheet is a web-based platform found at liveworksheet.com, which allows teachers to convert printable worksheets (such as PNG, JPG, PDF, or documents) into interactive online exercises that can include videos and other components to support student understanding during learning.

Based on the above explanation, this research aims to conduct a study titled "Development of Problem-Based Learning-Oriented E-Worksheet to Train Analytical Skills on Chemical Equilibrium Material." This study is expected to enhance students' analytical skills in learning chemistry, specifically on chemical equilibrium topics, using the problem-based learning model. Additionally, it is hoped that this can serve as a reference for teachers in developing teaching media.

METHOD

The study's focus is on research and development. Research and Development (R&D) is a research process used to create a given product and evaluate its efficacy, according to Sugiyono (2019). This study's research approach is based on a 4D development technique that Tiagharajan modified, which includes Define, Design, Development, and Diseminate (Kurniawan & Dewi, 2017). However, this e-worksheet's development is restricted to the development phase that will be chosen by students in grade XI SMAN 13 Surabaya. The design of the research area that will be implemented is as follows:

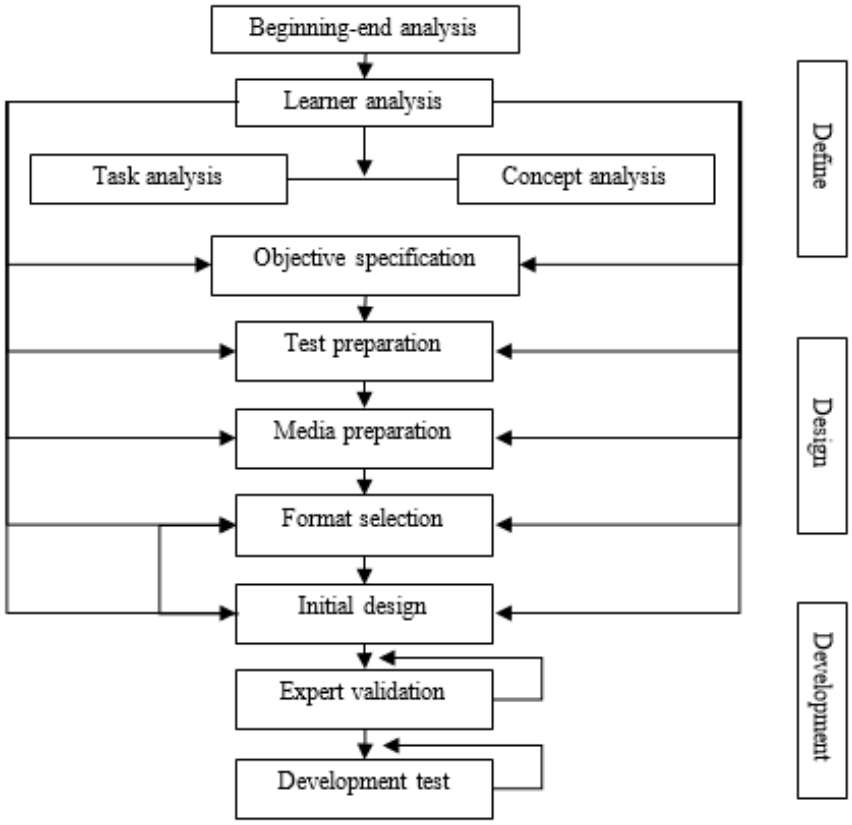

Figure 1. Design Chart 4-D Development Stages Up to Develop Stage

One-Group Pretest-Posttest Design, which permits research on one group to be done without the requirement for other groups to act as controls. The following images depict this design.

O_1 X O_2

Figure 2. One-Group Pretest-Posttest Design

Caption:

O1 = pretest to determine the initial state of students before being given a PBL-enabled e-worksheet to develop analytical capabilities on chemical equilibrium material

O2 = posttest to determine the final state of students after being given a PBL-enabled e-worksheet to develop analytical capabilities on chemical equilibrium material.

The validity of the electronic worksheet is decided by the validation data examined through the assessment of two chemistry lecturers and one chemistry instructor who filled out the validation sheet given. The assessment score criteria were calculated using a Likert scale, as shown in the table below:

Table 1 Likert Scale Validation Sheet

Scale	Indicator
4	Very Valid
3	Valid
2	Less Valid
1	Invalid

(Riduwan, 2016)

Ordinal data from the validation results can be evaluated by finding the mode for each aspect or indicator under the following circumstances:

a. An aspect is deemed legitimate if its mode score ≥ 3.
b. An aspect is deemed invalid if its mode score < 3.

(Lutfi, 2021).

The results of the surveys that the students answered on the ease of use of the e-worksheet are used to assess its practicality. The proportion of learner answer questionnaire data is examined using the Guttman scale. The findings acquired include negative and positive comments; therefore, grading is based on table 2 below, which shows the Guttman scale.

Table 2 Guttman Scale for Learner Response Questionnaire

Answer	**Positive Answer Score**	**Negative Answer Score**
Yes	1	0
No	0	1

A quantitative descriptive approach will be used to examine the learner response data results, and the results will be presented as a percentage of the Guttman Scale data as determined by the formula:

$$\text{Total Score} = \frac{\text{sum of result scores}}{\text{criteria score}} x100\%$$

The percentages obtained were then interpreted into five response criteria, as presented in Table 3 below:

Table 3 Category of E-Worksheet Practicality

Range	**Category**
0-20%	Very impractical
21- 40%	Less practical
41-60%	Practical enough
61-80%	Practical
81-100%	Very Practical

(Riduwan, 2016)

If the percentage of research results ≥ 61% is obtained, the e-worksheet developed has practical criteria. The efficiency of the e-worksheet in training analytical abilities may be evaluated using the results of pretests and posttests administered before and after learning with the designed e-worksheet. The pretest determines students' beginning abilities, while the posttest determines the efficacy of using the generated e-worksheet. The following computation was used to determine the n-gain score for the descriptive quantitative analysis of the test outcomes of the students:

$$G = \frac{Skor\ posttest - skor\ pretest}{Skor\ maksimal - \ skor\ pretest}$$

The average score will then be translated into the gain level criterion listed in Table 4 below:

Table 4. Gain Level Criteria

G	Category
Gain ≥ 0,7	High
0,3 ≤ n-gain ≤ 0,7	Medium
n-gain < 0,3	Low

(Hake, 1999)

According to these standards, the e-worksheet is deemed successful if it raises the moderate group's n-gain score by at least 0.3. Additionally, the paired sample t-test hypothesis test was used in SPSS to assess the pretest and posttest results. This hypothesis test is performed after the data has been normalized and homogeneously distributed. A significance level greater than 0.05 indicates that the data is consistently shared. If the significance value is less than 0.05, it means that the data is not dispersed regularly. The hypothesis for this test is:

H_0: Students using PBL-oriented electronic spreadsheet learning materials have no improvement in their ability to analyze chemical balance materials.

H_1: Students that use PBL-oriented e-worksheet learning materials have improved their ability to analyze chemical equilibrium material.

The significance value is the base for this test's decision-making. Here's the explanation:

- When the significance value is < 0.05, H0 is disregarded and H1 is acknowledged
- If the significance level is ≥ 0.05, H0 is approved and H1 is disapproved

(Wahab dkk., 2021)

RESULTS AND DISCUSSION

The purpose of this study is to describe the viability of using e-worksheets focused on problem-based learning to develop analytical skills. The three factors that determine whether an electronic spreadsheet is viable are validity, practicality, and effectiveness.

Define

The first step in doing an initial analysis is to watch chemistry lessons. The observation exercise revealed that the learning paradigm adopted was still teacher-centered. In addition to observations, interviews with chemistry teachers, questionnaires, and pre-research tests were used to investigate the topic. The interview findings revealed that the students' analytical abilities remained poor since they were rarely provided practice questions to improve their analytical skills. This is strengthened by the results of pre-research findings of grade XI students at SMAN 13 Surabaya, which revealed 60% of students' skill in elemental analysis, 39% in relationship analysis, and 42% in analysis of organizing principles. The average cognitive understanding of pupils about chemical equilibrium materials is 42%.

SMAN 13 Surabaya's class XI pupils follow an autonomous curriculum. Students are required to actively participate in learning while implementing the autonomous curriculum (student center). The study's materials are based on the independent chemistry curriculum for class XI and its learning objectives.

According to the interview findings, the learning medium utilized at SMAN 13 Surabaya is the Learner Activity Sheet, which contains content that has yet to be modified to the learning model in accordance with the autonomous curriculum's features. As a result, a Learner Activity Sheet is required to teach students' analytical abilities using a learning model that is consistent with the features of an autonomous curriculum and can be applied to everyday situations for chemical equilibrium content.

The subjects of this study were 17–18-year-old class XI SMAN 13 Surabaya students. Based on Piaget's cognitive theory, the characteristics of students at this age are the development of reasoning, abstraction, and inference skills from knowledge already in existence (Marinda, 2020). This point allows students to have the ability to solve a problem. Using the available learning materials, students can now improve their analytical abilities, which are currently lacking in light of the findings of their pre-research.

The e-worksheet seeks to help students develop analytical abilities that are appropriate for the PBL learning approach. The duties involve identifying issue formulations, developing hypotheses, collecting and evaluating data, and drawing conclusions based on observations. Table 5 shows the association between PBL syntax and learner activities with features of analytical skills.

Table 5. Relationship between PBL Syntax and Analysis Ability

Syntax Problem Based Learning	Learner Tasks in the E-Worksheet	Characteristics of Analysis Ability
Phase 1 Orient learners to a problem.	Understand and analyze the problems contained in the e-worksheet.	-
Phase 2 Organize learners to research.	Learners formulate a problem and hypothesis about the problem.	Analyze elements and relationships
Phase 3 Assist in group investigations.	Learners make observations together with their group to solve the given problem.	Relationship analysis
Phase 4 Develop and present results	Learners analyze data from the observations given.	Relationship analysis
Phase 5 Analyze and evaluate the problem-solving process.	Learners make problem solving and conclusions from the problems given.	Analysis of organizational principles

Design

The design stage begins after the defining stage collects various information about the product to be designed. This step seeks to create a PBL-oriented e-worksheet to strengthen analytical abilities on chemical equilibrium materials using data from the defining stage. The e-worksheet was created using a website called liveworksheet, and students may quickly fill in the answers on the internet and save them by hitting the "submit" button. In the liveworksheet, the teacher can use words, images, and videos to help the students find information on their own and participate actively in their education, rather than relying on the teacher's explanation. The e-worksheet follows a preset framework to strengthen PBL-oriented analysis abilities on chemical equilibrium materials. The e-worksheet to be created will have an initial cover, introduction, idea map, learning resources, learning exercises, and a bibliography. The following are the outcomes of the e-worksheet design process.

Figure 3. E-worksheet Cover Design

The title, the logos of the Ministry of Education and Culture, Unesa, the learning model, the learners' identities (name, group, group member names, and absentee numbers), the class identity, and images related to the practicum of factors affecting chemical equilibrium are all on the front of the worksheet electronic cover.

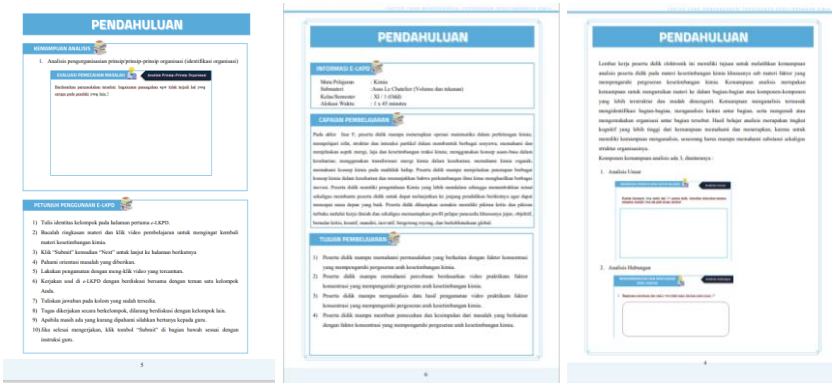

Figure 4. E-Worksheet Introduction Design

The introduction includes an overview of analytical skills as well as examples of each part of analytical skills, use instructions, information (topic, submaterial, class, semester, and time allocation), learning outcomes, and learning objectives to be met during the learning process.

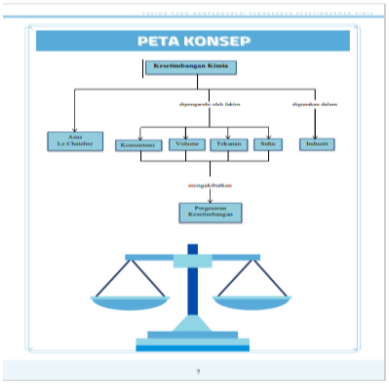

Figure 5. E-Worksheet Concept Map Design

The idea map comprises a summary of the material provided through a structural description, with the goal of allowing students to quickly comprehend the essential content of chemical equilibrium material that will be conveyed throughout learning.

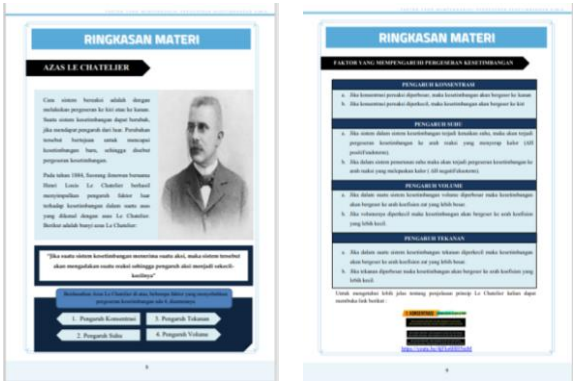

Figure 6. E-Worksheet Material Summary Design

The content summary includes a discussion of chemical equilibrium material, particularly the elements that influence chemical equilibrium, with the goal of providing students with a foundation before studying and solving the issues, as well as a short video that explains the topic.

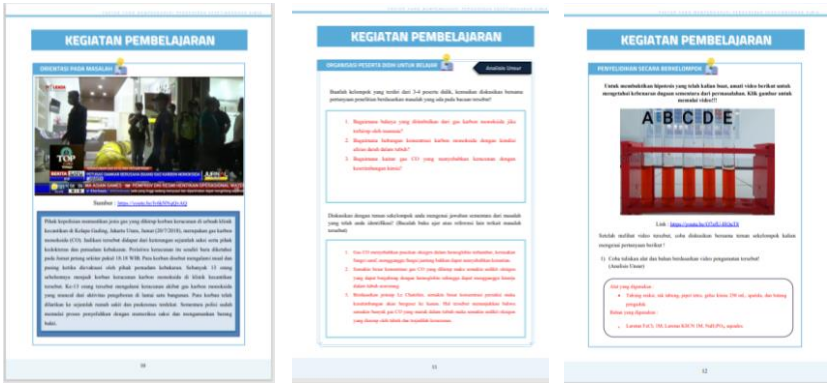

Figure 7. E-Worksheet Learning Activities Design

Learning activities include tasks that are organized according to the PBL terminology shown in Table 5. In the learning exercises, a practicum video is offered as a reference that students will use to answer subsequent questions.

Figure 8. E-Worksheet Bibliography Design

The bibliography contains references used in the e-worksheet in the form of books and website links.

Development

The development stage's objective is to produce the final draft of a useful teaching tool. At this stage of development, product validation and field testing are conducted to provide data on the feasibility and efficacy of e-worksheet values.

Validity

Validity is determined by the findings of media validation performed by three expert validators. The validation sheet has four components of validity that must be reviewed: the viability of the language, design, presentation, and content, all of which are assessed using the manner. The following is the mode acquisition for every aspect of validity.

Table 6. E-Worksheet Validity Results

Validity aspect	Modus		
	Concentration Factor	Pressure and Volume Factors	Temperature Factor
Content eligibility	3	3	3
Presentation	4	3	3
Language	3	4	4
Design	3	4	4

Based on the validation results table, mode 3 with valid criteria is obtained for the four elements of validity on the e-worksheet as a whole and the three components. The validity of the e-worksheet on the feasibility of content, presentation, language, and design is shown by its mode score of ≥3 (Lutfi, 2021).

Practicality

The learner activity observation sheet and the learner answer questionnaire provide practical information. An overview of the responses from the students is provided below.

Table 7. Recapitulation of Learner Response Questionnaire

Aspects	Percentage	Category
Content	90%	Very Practical
Presentation	89,5%	Very Practical
Language	82,5%	Very Practical
Design	83,75%	Very Practical

The outcomes of a summary of the students' answers to the generated e-worksheet are displayed in Table 7. The content component includes the adequacy of the clarity of the electronic worksheet material to increase students' knowledge for a percentage of 90%, as well as the objective of exercising analysis skills for a percentage of 90%. The presentation factor pertains to students' ease of use of the e-worksheet, which received an 89.5% rating. The language component, which relates to how words or concepts are used on the electronic worksheet, received an 82.5% rating. While the design component is connected to students' enthusiasm in utilizing the e-worksheet, with a proportion of 83.75%. Based on the examination of the students' response questionnaire, all assertions received a percentage in the extremely practical category of ≥61 percent. The e-worksheet generated has an overall practicality score of 86.44%. It can say that the electronic worksheet is classified as extremely practical. This is corroborated by earlier research; the PBL-oriented e-worksheet generated was rated as extremely practical to use with a practicality rating of 98.44% on the answer questionnaire (Hidayah, Azizah, & Nasrudin, 2024).

Effectiveness

The results of the pretest and posttest show how beneficial the e-worksheet is for enhancing students' analytical skills. The following are the N-gain scores for each component's analytical skills on the pretest and posttest.

Table 8. N-gain of Analysis Ability

Ability	N-gain	Category
Elemental Analysis	0.55	Medium
Relationship Analysis	0.59	Medium
Organizing Analysis	0.59	Medium

Based on the n-gain findings from the analysis ability exam, we can conclude that each component of analysis ability has increased. Relationship analysis receives an n-gain of 0.59 and a moderate category for organizing analysis, whereas element analysis receives an n-gain of 0.55. As a result, the produced e-worksheet may help students improve their analytical abilities in all aspects of analysis, including element analysis, relationship analysis, and organizational analysis. The T test in SPSS was used to assess the critical thinking skills pretest and posttest values in addition to the N-gain. The normality test of analytical abilities using the Shapiro-Wilk approach yielded the following findings.

Table 9. Analysis Skills Normality Test Results

	Statistic	df	Sig.
Pretest	.941	34	.068
Posttest	.940	34	.062

The results of the Shapiro-Wilk normality test show that the data from the students' analytical skills pretest and posttest have a significance value > 0.05, indicating that the data is normally distributed (Wahab dkk., 2021). The data from the students' analytical skills pretest and posttest have a significance value > 0.05, indicating that the data is normally distributed, according to the results of the Shapiro-Wilk normality test (Bierera & Muchlis, 2021). Furthermore, there will be a paired sample t-test run. The following outcomes were obtained using the paired sample t-test analytical ability:

Table 10. Paired Sample T-Test Result of Analysis Ability

t	df	Sig. (2-tailed)
-11.727	33	.000

According to Table 10 of the t-test results, Ho is rejected and Ha is accepted with a 2-tailed significant value of <0.05. Ho asserts that the pretest and posttest do not significantly differ from one another. Ha, however, asserts that there is a significant difference between the pretest and posttest. According to the t test findings, it is possible to infer that the designed e-worksheet is successful in teaching students analytical abilities.

Problem-Based Learning (PBL) is an approach that places students at the center of the learning process by presenting them with contextual and relevant problems to solve. This approach is crucial as it helps create meaningful and deep learning experiences. In the PBL model, students are encouraged to think critically and provide solutions. This model also teaches students about tolerance and listening to different opinions, emphasizing that every problem has a solution. Another advantage of the PBL model is that students find it easier to remember solutions to problems related to everyday life. PBL is very suitable for addressing the analytical skills of secondary school students because it presents real-life problems related to the material and learning objectives, involving students directly in problem-solving analysis (Rahmadani, 2019). Implementing any learning model requires appropriate teaching media, and one effective medium is the e-worksheet.

Learning media are tools that aid the teaching and learning process, making messages clearer and achieving educational or learning objectives effectively and efficiently (Nurrita, 2018). One such medium is the e-worksheet, which serves as a work guide for students, facilitating their understanding of lesson material in an electronic format accessible via desktop computers, notebooks, smartphones, or mobile phones (Umriani, 2020). E-worksheets offer the advantage

of simplifying and narrowing the space and time needed for learning, thus making the process more effective (Suryaningsih & Nurlita, 2021). Furthermore, e-worksheets are easily accessible anytime and anywhere using laptops or smartphones (Apriliyani & Mulyatna, 2021). Currently, there are numerous applications and websites available for creating interactive e-worksheets, one of which is Liveworksheet. Liveworksheet is a web-based platform found at liveworksheet.com, which allows teachers to convert printable worksheets (such as PNG, JPG, PDF, or documents) into interactive online exercises that can include videos and other components to support student understanding during learning.

Contextual problems in PBL are those relevant to students' real lives and environments (Hanipah et al., 2018; Rahmadani, 2019). Students are more motivated to learn when they see how the knowledge they acquire can be applied in real-life situations (Fitriani et al., 2022). Contextual problems engage students more deeply in the learning process because they feel challenged to find practical and applicable solutions (Belecina & Jose M Ocampo, 2018; Carlgren, 2013). Through solving contextual problems, students can understand concepts more deeply as they practice the knowledge they acquire.

The use of online learning media in PBL has several advantages. Students can access information anytime and anywhere, enhancing flexibility in learning (Encarnacion et al., 2021; Tsang et al., 2021). Online media provide access to a wide range of rich and varied resources, including articles, videos, journals, and online databases. Encarnacion et al. (2021) and Noesgaard & Ørngreen (2015) reported that both teachers and students agree that e-learning is an effective tool for enhancing instructional delivery and developing knowledge acquisition skills. E-learning received high ratings based on five criteria of effectiveness. There were no significant differences in the perceptions of teachers and students regarding e-learning, indicating consistency in their experiences and assessments. E-learning is considered to enhance flexibility in teaching methods, allowing better adaptation to individual student needs. It helps students develop independent and proactive learning styles, increasing their engagement in the learning process.

Yuwono & Sujono (2018) stated that e-learning can be considered one of the best strategies to adopt in teaching and learning. Integrating e-learning solutions allows education to extend beyond a single campus and be accessible nationwide through distance learning. This study confirms that e-learning is effective in improving instructional delivery and developing students' thinking skills (Salter et al., 2014). E-learning has the potential to shape the future of education by advancing traditional classroom settings into the virtual world. The entire academic community needs to ensure that the factors of e-learning effectiveness are adequately delivered and its use regularly evaluated to ensure optimal outcomes. Online learning platforms enable students to collaborate virtually with classmates and mentors, enriching discussions and the exchange of ideas (Chen & Lin, 2024).

Yustina et al. (2022) reported that the PBL learning model through e-learning is more effective in enhancing students' creative thinking skills compared to learning without the PBL model, especially in the aspects of original thinking and elaboration. These findings support the effectiveness of e-worksheets in developing analytical thinking skills. Analytical thinking forms the foundation for generating creative ideas to meet 21st-century demands (Afdareza et al., 2020; Chusni et al., 2020; Dwyer et al., 2014). Although this study shows the effectiveness of PBL through e-learning, generalizing these results to other contexts or subjects should be done cautiously. Further studies with larger and more diverse samples are needed to ensure these findings can be widely applied. These findings have important implications for educators and policymakers in designing effective curricula during pandemics. However, the implementation of PBL through e-learning requires adequate technological support and teacher training to ensure its success. Further studies are recommended to explore various learning

models and other technological approaches that can be used to enhance students' creative thinking skills in the context of e-learning.

In PBL, students go through a series of activities involving several important steps. First, students are encouraged to identify and understand the presented problem, which involves initial analysis and understanding of the problem's context. Next, students gather relevant data and information from various sources, including academic literature, case studies, and interviews with experts. Based on the collected data, students formulate hypotheses or possible solutions to be tested further (Liu & Pásztor, 2022; Yustina et al., 2022). These processes can enhance students' analytical thinking skills. Students learn to analyze information critically, evaluate the accuracy and relevance of data (Fadilla et al., 2021; Simbolon & Koeswanti, 2020). They learn to organize information systematically, connecting various pieces of information to form a bigger picture. Students identify effective and efficient solutions based on in-depth data analysis. Contextual and online problem-based learning prepares students for real-world challenges that are often complex and multifaceted (Yustina et al., 2022). Contextual problems in problem-based learning are crucial for creating meaningful learning processes. Using online learning media, students can more easily access information and engage in interactive and collaborative learning processes. Activities such as identifying problems, gathering data, and proposing hypotheses can help develop students' analytical thinking skills, preparing them better to face real-world challenges (Liline et al., 2024).

Conclusion

Based on the results and discussion, it can be concluded that this development research has produced a learning medium in the form of a Problem-Based Learning-oriented e-worksheet to train the analytical skills of 11th-grade high school students on chemical equilibrium material. The e-worksheet developed is suitable for use as a learning medium as it meets the criteria for feasibility in terms of validity, practicality, and effectiveness. The validity of the e-worksheet achieved a mode of 3, categorized as valid. Based on the questionnaire responses filled out by the students, the overall practicality level of the developed e-worksheet was 86.44%, categorized as very practical. According to the paired sample t-test results, the significance value was $0.00 < 0.05$, indicating a significant difference between pre-learning and post-learning analytical skills using the e-worksheet. This is supported by the n-gain results per analytical component, showing improvements in element analysis, relationship analysis, and organizational principle analysis. Thus, it can be concluded that the developed e-worksheet is effective in training students' analytical skills in chemical equilibrium material.

Recommendations

This research is limited to the Problem-Based Learning model. Future researchers are encouraged to develop e-worksheets using other learning models that align with the latest curriculum.

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