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Validity of Problem Based Learning Oriented E-LAPD to Improve Chemical Literacy Skills of High School Students

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Abstract: This study aims to produce valid Problem Based Learning (PBL) oriented E-LAPD to improve students' chemical literacy skills on acid-base material. This research method used development research with the 4D model which includes define, design, develop, and disseminate. However, it is limited to the development stage. The subjects of this study were phase F students of class XI SMAN 1 Krembung Sidoarjo as many as 36 students. The research instrument used in collecting data was a validation sheet. Data analysis techniques in this study used quantitative analysis techniques through the provision of validation questionnaires to validators. The results of this study indicated that the Problem Based Learning (PBL) oriented E-LAPD to improve students' chemical literacy skills on acid-base material was declared feasible to use because it got a mode score of 4 with valid criteria based on content and construct validity which includes aspects of language, presentation, and graphics.

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Introduction

The quality of human resources and the progress of a nation are greatly influenced by education (Rahayu et al., 2022). Humans will face many challenges in the 21st century due to the rapid advancement of science and technology in various countries. Therefore, education is very important in improving human resources (Imansari et al., 2018). The statement implies that education in Indonesia is faced with increasingly severe challenges. The Indonesian education system must be able to produce humans who can compete to become quality resources. One way to prepare young people who are ready to face the challenges of the 21st century is to become science and technology-literate individuals. According to Adytia & Dwiningsih (2018), a technologically literate individual can be defined as an individual who is able to use technology safely, appropriately, effectively, and efficiently, and knows the impact of its use. Meanwhile, science-literate individuals can also be referred to as individuals who have scientific literacy.

Learners from elementary to high school level are familiar with science subjects which are very important in the world of education. Science is a provision for students to face challenges in the global era. Therefore, a learning method is needed that can prepare students with good competencies, as well as science and technology literacy. In addition, students are expected to be able to think logically, critically, creatively, argue correctly, and be able to communicate and collaborate (Tulaiya & Wasis, 2020). Science is closely related to human life. One of the abilities that students are expected to master after learning science is scientific literacy (Fadhila, 2022).

Toharudin & Hendrawati (2011) define scientific literacy as a person's ability to understand and convey scientific ideas both orally and in writing and apply scientific knowledge to solve problems and make decisions based on scientific considerations. Everyone needs information and knowledge to make choices and solve everyday problems, so scientific literacy is very important to improve. Problem-solving in everyday life is an application of the process of connecting concepts in learning that trains scientific literacy (Asma & Muchlis, 2018). According to OECD (2019), scientific literacy is divided into three interrelated domains, namely the context domain (personal, national, and global), the knowledge domain (content knowledge, procedural knowledge, and epistemic knowledge), and the competency domain (explaining scientific phenomena, evaluating and designing scientific investigations, evidence, and interpreting scientific data).

According to Musayaroh et al. (2021), chemical literacy is part of scientific literacy because chemistry is part of science. In addition, Imansari et al. (2018) stated that chemical literacy encourages students to learn concepts about the properties of material particles, chemical reactions, chemical laws and theories, and general applications of chemistry in everyday life. Fuadi et al. (2020) stated that people who have sufficient chemical literacy skills can explain phenomena and solve problems in life by using their understanding of chemistry. In addition, they can also conduct scientific investigations, communicate a general understanding of chemistry, and draw conclusions using their knowledge (Rahmawati et al., 2020). In this 21st century era, scientific literacy in chemistry is considered very important to teach because chemistry is closely related to everyday life.

PISA (Programme for International Student Assessment) is an international survey conducted by the OECD (Organization for Economic Co-operation and Development) to measure the cognitive abilities of students in various countries. PISA assesses cognitive abilities with a focus on literacy. The aim is to measure the ability to process information and apply knowledge in new ways. Language literacy (reading literacy), math literacy, and scientific literacy are the three areas of literacy measured by PISA. The survey is conducted every three years, and from 2000 to 2018, Indonesia's PISA scores have been less than expected. According to PISA 2018, approximately 60% of Indonesian students scored below the minimum competency in scientific literacy (Anggraena et al., 2020). This is supported by data from the PISA International study related to Indonesia's scientific literacy skills by the OECD in 2018 getting a score of 396 or ranked 70th out of 78 participating countries (Cholifah & Novita, 2022). In addition, other studies show that the scientific literacy of students in Indonesia, especially in East Java is still relatively low. Based on the results of research by Tulaiya & Wasis (2020) in several schools in Sumenep Regency, the results show that students have low scientific literacy competencies. This is evidenced by the results of research in the first school, where the average percentage for explaining scientific phenomena is 34.04% which is included in the low criteria; for evaluating and designing scientific investigations, the average percentage is 14.22% which is included in the low criteria; and for the competency to interpret data and evidence scientifically, the average percentage is 60.10% which is included in the moderate category. Furthermore, research in the second school showed that for the competency to explain scientific phenomena, the average percentage obtained was 17.95% which was included in the low criteria; for the competency to evaluate and design scientific investigations, the average percentage obtained was 10.81% which was included in the low criteria; and for the competency to interpret data and evidence scientifically, the average percentage obtained was 27.88% which was included in the low criteria (Tulaiya & Wasis, 2020). Based on the results of research by Indrawati & Sunarti

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(2018), it states that the scientific literacy skills of students in one of the schools in Sidoarjo are still lacking. This is evidenced by the results of the study that as many as 66% of students are still classified as a category lacking in the competence to explain scientific phenomena, and as many as 60% of students are also still classified as lacking in the competence of evaluating and designing scientific investigations, and as many as 68% of students are still lacking in the competence of interpreting data and evidence scientifically (Indrawati & Sunarti, 2018).

Learning that trains students' scientific literacy needs to be improved because according to Adytia & Dwiningsih (2018), school quality, curriculum, and teaching quality can affect students' low scientific literacy skills. Learning by practicing scientific literacy has a positive impact on students' understanding. Every chemistry lesson can create meaning for students. The chemistry learning process that lacks a link to everyday life results in a lack of meaningfulness in the learning process for students. Learning will also become more meaningful when students are directly involved in it by applying learner-centered learning types, including peer discussion, problem-based learning, peer teaching, and inquiry-based learning (Cholifah & Novita, 2022).

For students' scientific literacy skills to be well achieved, choosing the right learning model is one of the factors in developing learning activities. One effective option is the Problem-Based Learning (PBL) model. This model is a potential learning model that raises authentic problems as a stimulus for students to develop thinking and problem-solving skills (Hafizah & Nurhaliza, 2021). The PBL model not only helps students understand material concepts but also encourages students to apply the material concepts obtained to solve everyday life problems (Asma & Muchlis, 2018). The application of the PBL model in learning activities can provide opportunities for students to work with other groups in conducting investigations, and to develop the learning process and social skills of students (Juleha et al., 2019). This PBL learning model involves the teacher as a facilitator, while students actively search in groups or individually to find solutions to the problems given (Sanova et al., 2021). Thus, the PBL model not only builds conceptual understanding but also develops collaborative and problem-solving skills. This is important to improve students' chemical literacy.

The selection of learning models and the application of appropriate media are expected to help understand learning strategies. Along with the times, Learner Activity Sheets (LAPD) can be innovated and integrated into a form of presentation in the form of electronic media in the form of E-LAPD which is considered more effective and efficient (Cholifah & Novita, 2022). According to Maullidyawati et al. (2022), E-LAPD is a structured learning media designed by adjusting certain learning materials and models. In E-LAPD there are features such as images, audio, video, and QR codes that are connected to the website to support the learning process and improve students' understanding. E-LAPD can be one of the supporting media in learning and helping learners bring up the skills needed in the 21st century, one of which is scientific literacy skills. These scientific literacy skills can be improved through the use of PBL-oriented E-LAPD, which can help learners think critically and have the skills to solve problems in the real world because one strategy to improve scientific literacy is to connect science concepts with real-life problems (Fadhila, 2022).

The chemical materials in this study are acids and bases. Saputri et al. (2022) stated that acid and base materials include materials that contain abstract concepts and are widely applied in everyday life. Therefore, as stated by Saputri et al. (2022), this acid and base material is suitable to be used as a learning context to measure chemical literacy skills. This is

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in line with the basic principles in PISA 2018, where the selected content of acid and base materials has relevance to everyday life, concepts that have long-term relevance, and are experimental where it does not only involve students' memories but the involvement of students in obtaining their knowledge. The concept of acid-base can be found in everyday life, especially in household chemicals and in industry, where all these concepts are known by students and are worthy of research (Saputri et al., 2022). According to Sari et al. (2018), in acid-base material, there is factual, conceptual, and procedural knowledge, so learning this material requires a high way of thinking to build and relate concepts or principles to one another through the PBL learning model.

Research conducted by Fadhila (2022) states that PBL-based E-LAPD to improve scientific literacy is declared feasible for use in learning activities by obtaining an average validation percentage in all aspects of 82.61% based on aspects of material feasibility, presentation feasibility, readability feasibility, language feasibility, scientific literacy aspects and PBL step aspects, research by Suryani & Rusmini (2022) shows that LAPD based on acid-base material scientific literacy is able to train students' scientific literacy skills so that it is feasible to use and can be used as a reference in learning. LAPD received scores from validators in terms of content, language, presentation, and graphics with an average score of 81% valid criteria LAPD obtained activity results and student responses of 92.45% and 92.26% respectively very practical criteria. The results of LAPD train scientific literacy skills for students which are characterized by an increase in scores on the pretest-posttest obtained by students through the n-gain test. The respective scores on the cognitive knowledge aspect were 85% and scientific literacy skills were 86% with high effectiveness criteria. Therefore, LAPD can be used as an alternative learning resource that can train students' scientific literacy skills and facilitate students' understanding of acid-base material so that learning objectives are achieved and learning becomes meaningful. These studies are one of the efforts to improve students' scientific literacy skills in learning chemistry. The development of Problem Based Learning (PBL) oriented E-LAPD to improve chemical literacy skills is very important to meet the demands of 21st-century learning. In addition, it is expected to meet the needs of students and teachers, meaning that this E-LAPD is feasible to be implemented in schools as one of the electronic learning media whose contribution can meet the improvement of students' chemical literacy. Based on the description that has been presented above, this study aims to develop and describe the validity of Problem-Based Learning (PBL) oriented E-LAPD to improve students' chemical literacy skills on acid-base material.

Research Method

This research method used research and development with the 4-D model by Thiagarajan et al. (1974) which consists of the define stage, design stage, develop stage, and disseminate stage. However, the focus of this research is only on the develop stage. This research activity was tested on phase F students of class XI at SMAN 1 Krembung Sidoarjo. This study took a sample of 36 students. The data collection process was carried out using a validation sheet as an instrument. Data collection techniques were obtained through the E-LAPD validation assessment process carried out by two lecturers from the Chemistry Education study program at Surabaya State University and one chemistry teacher from SMAN 1 Krembung Sidoarjo. The validation assessment was conducted to measure the validity of the E-LAPD developed based on content validity and construct validity. The validity of the developed E-LAPD was measured from the score of the validation results, whose assessment criteria are listed in Table 1 using a Likert scale.

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Table 1.E-LAPD validation scoring criteria

Score	Statement
1	Not valid
2	Less valid
3	Fairly valid
4	Valid
5	Very valid

(Adaptation Riduwan, 2015)

The data obtained is ordinal data which cannot be added, multiplied, or divided so that the data analysis uses mode. Based on the assessment obtained from the validator, the data analysis of the validation results uses the mode on each validated aspect. The decision-making requirements are as follows:

1) If the mode ≥ 3, then the assessment is declared valid.
2) If the mode < 3, then the assessment is declared invalid.

(Adaptation Lutfi, 2021)

Results and Discussion

1) Defining Stage

The define stage is the initial stage that aims to define the learning requirements of acid-base material. This stage consists of five steps which include front end analysis, learner analysis, task analysis, concept analysis, and learning objective analysis (Thiagarajan et al., 1974). Front-end analysis is a phase of analyzing the main problems that will be needed in the development of E-LAPD. Front-end analysis is carried out by considering the use of the curriculum, namely the independent curriculum and future demands to prepare for the needs of the 21st century, one of which is to improve chemical literacy skills.

Learner analysis was conducted with the aim of analyzing the academic abilities of learners, as well as the age and cognitive development of learners. Based on Piaget's cognitive development theory, grade XI students have the ability to think abstractly and can think logically. In addition, students also have the ability to solve problems scientifically and make conclusions from the information they get (Dahar, 2011). Task analysis is conducted to identify tasks that should be completed by students in teaching and learning activities. The tasks contained in E-LAPD aim to improve students' chemical literacy skills, where students must be adapted to Problem-Based Learning (PBL) oriented practicum.

Concept analysis is done with the aim of classifying important concepts that will be learned by students in the developed E-LAPD. Acid and base materials with natural indicator sub-materials and artificial indicators are the main concepts that will be used. The summarized results based on task analysis and concept analysis will be used in the formulation of learning objectives on acid-base material adapted to the independent curriculum.

2) Design Stage

The design stage is the process of designing the developed E-LAPD. The design stage has four stages, namely compiling test standards, selecting media, selecting formats, and making initial designs (Thiagarajan et al., 1974). The preparation of test standards is carried out to design cognitive test questions and chemical literacy tests based on the learning objectives that have been formulated. Chemical literacy test questions are adapted to the characteristics of PISA questions. Media selection is adjusted to the characteristics of the learning material and the objectives to be achieved. Based on these objectives, the researchers

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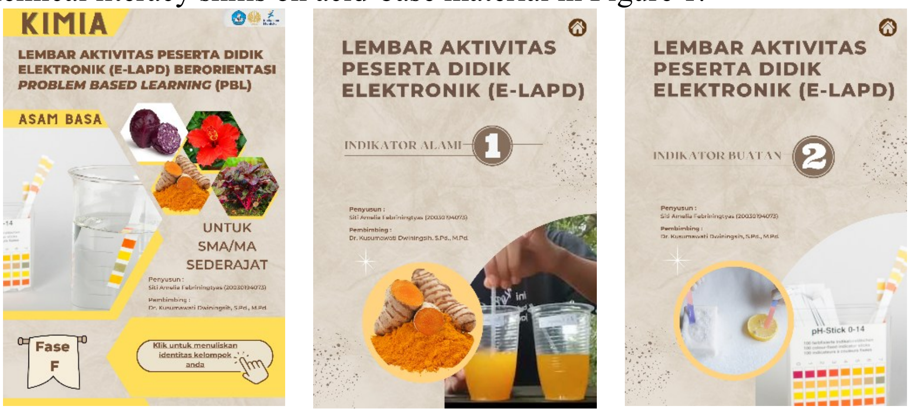
chose E-LAPD as the learning media used by students to improve chemical literacy skills. E-LAPD was chosen because it can help students understand chemical concepts in depth, as well as create meaningful learning and make the learning process more interesting and fun.

Format selection is done by finding sources by reviewing books on learning media formats by modifying or adopting existing learning media formats. The selected learning media format was then developed in the form of PBL-oriented E-LAPD to improve students' chemical literacy skills on acid-base material in which there are several components, namely cover, preface, table of contents, instructions for using E-LAPD, Learning Outcomes, and Learning Objectives, concept map, E-LAPD content section, and bibliography which will later be used as draft I. The initial design in developing E-LAPD was the first draft. The initial design in developing E-LAPD is designing E-LAPD. Designing E-LAPD is an overall design that is carried out before the implementation of limited trials and E-LAPD development. Making the E-LAPD design was edited through the Canva application. The following is presented as an image of one component of PBL-oriented E-LAPD to improve students' chemical literacy skills on acid-base material in Figure 1.



(a) (b) (c)

Figure 1. Main Cover (a); E-LAPD cover 1 (b); E-LAPD cover 2 (c)

3) Development Stage

The development stage is carried out to obtain E-LAPD which is feasible in accordance with input and comments from draft experts I. This stage has two sub-stages namely product validation and limited testing of E-LAPD. The product validation test was carried out by two lecturers from the Chemistry Education study program at Surabaya State University and one chemistry teacher at SMA Negeri 1 Krembung Sidoarjo using a validation sheet instrument. The product validation assessment assessed by the validator is content validity and construct validity. This is following Nieveen (1999) statement that the validity of E-LAPD is reviewed based on content validity and construct validity. All statements on the validation sheet were rated on a scale of one to five. The following is Table 2 which shows the results of content validity and construct validity.

Table 2. Results of Content Validity and Construct Validity

Number	Rated Aspect	Mode	Criteria
1.	Content validity	4	Valid
2.	Construct validity	4	Valid

The purpose of content validity is to determine the suitability of learning media with learning materials (Dzikro & Dwiningsih, 2021). The content validity component of E-LAPD includes conformity to the curriculum, conformity to the syntax of the Problem Based Learning (PBL) learning model, conformity to the chemical literacy domain, and the correctness of the

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substance of the learning material. Table 2 shows that content validity obtained a mode score of 4 with valid criteria.

The developed E-LAPD contains three literacy domains according to PISA 2018 including context, competence, and knowledge domains (OECD, 2019). In the context domain, learners are expected to understand important issues that exist in everyday life both personally, locally, nationally, and globally. In the competency domain, learners are able to explain scientific phenomena, evaluate and design scientific investigations by conducting practicum, and interpret scientific data and evidence. In this case, learners not only see and hear but also get involved so that learning will be more meaningful. By doing activities that teach learners to understand reading, formulate problems, make hypotheses, determine variables, conduct experiments, observe, analyze data, answer questions, and conclude, and relate, the chemical literacy skills of students can be improved. Knowledge in the procedural and epistemic domains is supported by the constructivism learning theory which allows students to construct their knowledge through active experiences in learning (Ulandari & Mitarlis, 2021). The chemical literacy domains presented in E-LAPD are also combined with the five phases of the PBL learning model according to (Arends, 2012). The following is a display of one of the chemical literacy domains combined with the phases of the PBL learning model can be seen in Figure 2.

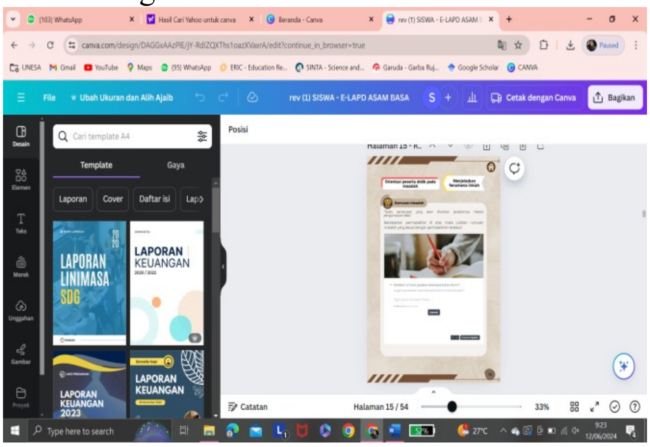

Figure 2. Display of Chemical Literacy Domain combined with PBL Learning Model Phases

In addition to content validity, the E-LAPD validity assessment was also reviewed based on construct validity. Construct validity of E-LAPD is reviewed from the suitability of E-LAPD with the criteria of language, presentation, and graphics. The following is Table 3 which shows the results of the construct validity assessment.

Table 3. E-LAPD Construct Validity Results

Number	Rated Aspect	Mode	Criteria
1.	Linguistics	4	Valid
2.	Presentation	4	Valid
3.	Graphic	4	Valid

Table 3 shows that all aspects of construct validity obtained a mode score of 4 with valid criteria. In the linguistic aspect, four points are assessed, namely readability, clarity of information presented, conformity with good and correct Indonesian language rules, and effective and efficient use of language (clear and concise). The linguistic aspect of the E-LAPD construct validity developed obtained a mode score of 4 with valid criteria. According

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to Sihafudin & Trimulyono (2020), the use of appropriate language will help students understand concepts easily and prevent misinterpretation.

In the presentation aspect, there are six points that are assessed including the cover representing the contents of E-LAPD, the problems presented are in accordance with the subject matter, there is a place to write answers as needed, the presentation of illustrations or images relevant to the subject matter seen in the features, the completeness of the components presented in E-LAPD and the suitability of E-LAPD with the display. The presentation aspect of the E-LAPD construct validity developed obtained a mode score of 4 with valid criteria.

In the graphical aspect, three points are assessed including the use of the right font type and size, layout and layout are appropriate, and the design of the E-LAPD display is attractive. The graphical aspect of the construct validity of the developed E-LAPD obtained a mode score of 4 with valid criteria. According to the validator's assessment, the use of font types and sizes is appropriate so that it attracts the attention of students to study E-LAPD. This is in line with the opinion of Hendriani & Gusteti (2021) which states that the selection of the right font type can attract students' attention to study and work on E-LAPD. In addition, the design of the E-LAPD display is also made as attractive as possible so that students are interested in participating in the learning process using E-LAPD. Based on the opinion of Adytia & Dwiningsih (2018), the E-LAPD display design that is made as attractive as possible can encourage students to learn E-LAPD.

Based on the assessment of content validity and overall construct validity, PBL-oriented E-LAPD to improve students' chemical literacy skills on acid-base material is declared valid because it obtains a mode score of 4 which indicates that it is included in the valid criteria. This is in line with the results of research by Ulandari & Mitarlis (2021), and Maullidyawati et al. (2022) which state that E-LAPD is declared valid based on content and construct validity which includes aspects of language, presentation, and graphics. Therefore, learning media in the form of PBL-oriented E-LAPD is suitable for use by educators and students in the learning process, especially on acid-base materials to improve students' chemical literacy skills. This learning media in the process of using it can provide benefits to educators and students, including easy access via pc/laptop or smartphone, easy of use, and increase motivation with an attractive appearance.

Conclusion

The conclusion obtained from the results of this study is that Problem Based Learning (PBL) oriented E-LAPD to improve students' chemical literacy skills on acid-base material is declared feasible to use because it gets a mode score of 4 with valid criteria based on content and construct validity which includes aspects of language, presentation, and graphics.

Recommendation

Based on the results of the development and research that has been carried out, recommendations that can be written in this study are that the E-LAPD developed is limited to acid-base material with natural indicator and artificial indicator sub-materials, and the context domain used is limited to personal context so that further research can be developed E-LAPD with broader material and use local/national and global context domains to better motivate students in working on E-LAPD and understanding the application of material in everyday life.

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