KnE Social Sciences
ICMScE
International Conference On Mathematics And Science Education
Volume 2024

Research Article

Development of Electronic Worksheet Based on Problem-Based Learning in a Course on Acid-Bases to Develop Students' Problem-Solving Ability

Putri Deti Ratih[1]*, Eli Rohaeti[2]

[1]Master Student of Chemistry Education, Faculty Mathematics and Naturale Science, Universitas Negeri Yogyakarta, Yogyakarta, 55281, Indonesia
[2]Departement of Chemistry Education, Universitas Negeri Yogyakarta, Yogyakarta, 55281, Indonesia

ORCID
Putri Deti Ratih: https://orcid.org/0000-0002-0858-8182
Eli Rohaeti: https://orcid.org/0000-0002-0930-732X

Abstract.
This study aimed to analyze the characteristics and feasibility of electronic worksheets based on problem-based learning in the course on acid-base to develop student problem-solving abilities. This was a Research and Development (R & D) using a 4D modified model by Thiagarajan. The 4Ds were Define, Design, Develop, and Disseminate. Product validation was performed by experts. The product practicality test was performed by a reviewer and peer reviewer. Students performed the readability test. Instruments of data collection were product feasibility validation sheets, practicality test assessment sheets, and readability tests. Data analysis techniques were used to calculate the average score, which was categorized according to ideal assessment criteria. The results of the development research showed that an electronic worksheet based on problem-based learning was developed in the form of a website consisting of four learning activities with problem-based learning syntax adapted to the course on acid-base and an electronic worksheet based on problem-based learning in the course on acid-base was very feasible to be used. Based on validation from expert judgments, practicality test assessments from reviewers and peer reviewers, and readability tests by students, including the very good category, meaning that the electronic worksheet is very feasible for learning activities. Therefore, electronic worksheets based on problem-based learning were suitable for chemistry courses on acid-bases to develop problem-solving abilities.

Keywords: electronic worksheets, problem-based learning, acid-base, problem-solving

Corresponding Author: Putri Deti Ratih; email: putrideti.2020@student.uny.ac.id

Published: 3 April 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

1. INTRODUCTION

The COVID-19 pandemic emerged in early 2020 in Indonesia and had an impact on the education sector, so it is hoped that all educational institutions will not carry out activities as usual to reduce the spread of COVID-19 [1]. The impact that occurs in the education sector in Indonesia is the application of distance learning at all levels of education [2]. Education is an effort made in improving the quality and potential of each individual. It is important to do this continuously in improving the quality of each individual in the 21st century. The learning activities must ensure that students have the skills to face life in the 21st century, namely (1) critical thinking skills and problem-solving, communication and collaboration, creativity and innovation; (2) technology, information, and media skills; (3) life and career skills [3].

Problem-solving ability is one of the abilities that students must have in the 21st century [4]. Problem-solving is a systematic process of utilizing knowledge to solve a problem [5]. The ability to solve chemistry problems is an indicator of success in chemistry learning activities. However in reality, in Indonesia, students' problem-solving abilities are still low [6]. Therefore, it is necessary to apply a learning model that can guide students in constructing their thoughts, so that students can solve an existing problem.

The learning model that can be used to develop problem-solving skills is the problem-based learning model [7]. Problem-based learning is collaborative learning that involves students applying skills to solve a problem [8]. The problem-based learning model was chosen because it has several benefits including (1) helping students build broad and flexible basic knowledge, (2) helping students become effective collaborators, (3) improving effective problem-solving skills, 4) motivating participants students to learn, (5) developing students' independent learning skills [9].

Problem-based learning shows that effective learning can improve critical thinking skills and problem-solving abilities [10]. However, during the COVID-19 pandemic, students are required to do online learning, and teachers are required to innovate distance learning [1]. During the learning process during the pandemic, new habits occur, one of which is online teaching materials that can be accessed by all students. Online learning is considered not optimal because there is still a lack of online teaching materials that can be used in the learning process [11].

Teaching materials are very much needed in the online learning process as it is today, one of which is in the form of student worksheets [2]. Educators are required to innovate online teaching materials such as worksheets which can be packaged innovatively in the online form which is commonly called e-worksheet or electronic worksheets [11] Electronic worksheets affect the level of cognitive, interest, and motivation of students towards the learning process [12]. The use of electronic worksheets for learning activities can be developed using a problem-based learning model [11].

Chemistry subjects, especially acid-base material, are felt by some students as material that tends to be difficult to understand [13]. Students are required to be able to understand acid-base material well so that at the time of evaluation they get good grades, even in a pandemic. This requires the role of educators to work harder to do interesting learning so that students can more easily understand the subject matter [11]. Based on these problems, it is necessary to make online teaching materials in the form of electronic worksheets based on problem-based learning that can be used the o deve as students' problem-solving abilities on acid-base materials. The objective of study were to analyze the characteristics and feasibility of electronic worksheet based on problem-based learning on acid-base materials to develop student problem-solving abilities.

2. RESEARCH METHOD

This research is a type of development research that adapts the stages of the Thiagarajan 4D development model which consists of four stages namely define, design, develop, and disseminate [14]. In general, the four stages of development research were briefly presented in Figure. 1.

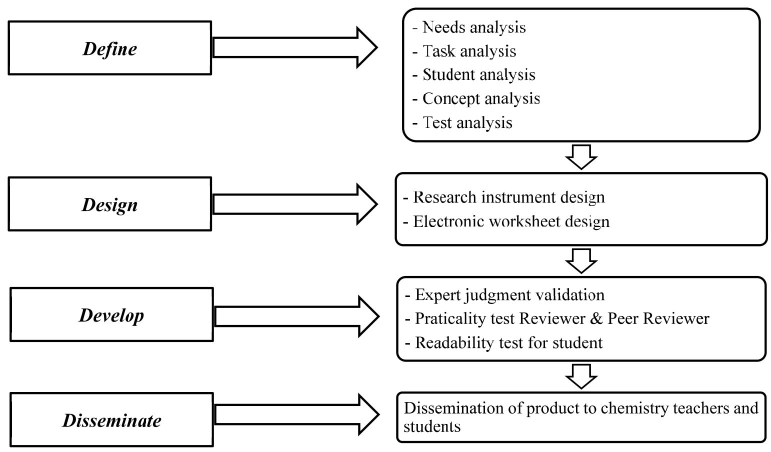

Figure 1: Stages of electronic worksheet development.

The electronic worksheets developed were compiled using HTML and web hosting. Electronic worksheet final product validation was performed by expert judgment, product practicality test was performed by reviewer and peer reviewer and readability test was performed by students. The development research was conducted at SMA Negeri 1 Bumiayu, Brebes. The subjects of the limited-scale trial were 20 high school students in class XI MIPA. Limited scale trials on students aim to obtain assessments and suggestions for electronic worksheet products. The data collection instruments in this research were: expert judgment validation sheet questionnaire, practicality test for reviewers and peer reviewers, and readability test for students.

Product development data in the form of qualitative data comes from expert judgment, reviewers, peer reviewers, and students. The resulting qualitative data is in the form of input and suggestions for improvement of the product that is used as consideration in developing the final product. Media assessment data was obtained from the learning media assessment sheets given to reviewers, peer reviewers, and students. The steps to get the data are by changing the qualitative data into quantitative data with the rules for giving the response questionnaire scores in Table 1.

TABLE 1: Product eligibility rating rules.

Rating Indicator	Score
Very good	5
Good Enough	4 3
Not enough	2
Very less	1

Then calculate the average score of each assessment indicator using equation 1.

$$\bar{X} = \frac{\sum x}{n}\bar{X} = \frac{\sum x}{n} (1)$$

Note:

$\bar{X}\bar{X}$: Average score

nn : Number of statement items

$\sum x \sum x$: Total score number

Furthermore, the average score is compared with the product assessment category according to the ideal assessment criteria in Table 2.

TABLE 2: Product ideal evaluation criteria.

Score Range	Classification
$\bar{X} > Xi + 1,8\ SBi$	Very good
$Xi + 0.6\ SBi < \bar{X} \le Xi + 1.8\ SBi$	Good
$Xi - 0.6\ SBi < \bar{X} \le Xi + 0.6\ SBi$	Enough
$Xi - 1.8\ SBi < \bar{X} \le Xi - 0.6\ SBi$	Not enough
$\bar{X} \le Xi - 1.8\ SBi$	Very less

Note:

DOI 10.18502/kss.v9i8.15504

$\bar{X}\bar{X}$: Average score

$XiXi$: ½ (ideal max score + ideal min score)

$SBiSBi$: Ideal standard deviation

3. RESULTS AND DISCUSSION

Product development research was conducted based on the 4D development model developed by Thiagarajan with the stages namely: define, design, develop, and disseminate [14]. Electronic worksheet based on problem-based learning products developed by researchers certainly has different characteristics from other learning media that have been developed. The use of problem-based learning teaching materials in learning activities aims to train students' problem solving abilities. The electronic worksheet is one of the media that can support online and offline learning and affect student learning outcomes in aspects of knowledge, skills, and attitudes [15]. Electronic worksheet based on problem-based learning is made in the form of a website with the help of web hosting and HTML applications that can be accessed through the address https://chemistry-education.000webhostapp.com. The electronic worksheets based on problem-based learning can be accessed anywhere and anytime by teachers and students using smartphones or computers. This electronic worksheet based on problem-based learning on acid-base materials can be used for grade XI students majoring in mathematics and natural sciences, SMA or MA.

Electronic worksheet based on problem-based learning that was developed is expected to be used to develop students' problem-solving abilities on acid-base materials. The difficulty of students in solving a problem in chemistry is usually caused by a lack of knowledge about the subject matter, misconceptions, and bad problem-solving strategies, so teachers need to explore learning that can develop students' chemistry problem-solving skills [16]. The developed electronic worksheet contains subject matter and student learning activities that follow the problem-based learning syntax so that students are trained in problem-solving abilities in chemistry. The problem-based learning model aims to improve critical thinking skills, analyze daily life problems, work together in teams and communicate skills [17]. Electronic worksheet based on problem-based learning that was developed has several components which can be seen in Figure 2.

Figure 2 shows the media homepage as the first view. The electronic worksheet contains several menus including covers, introductions, instructions for using media,

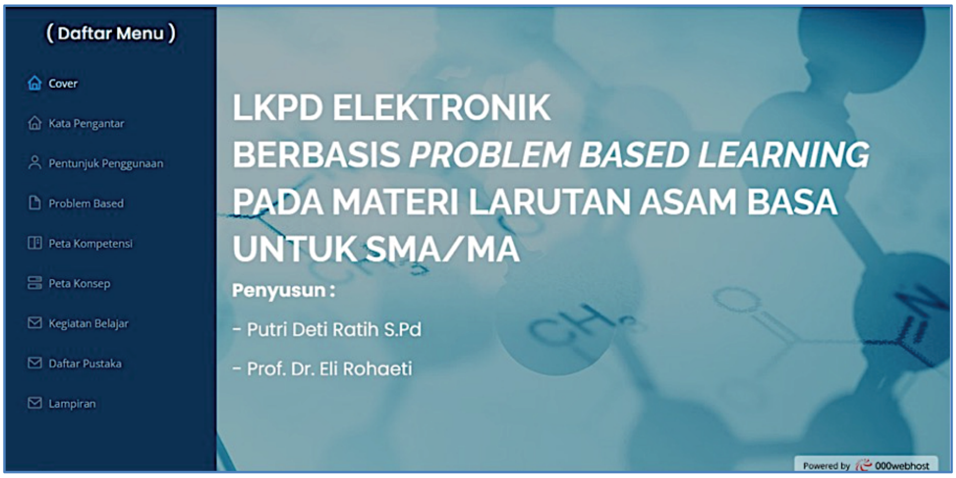

Figure 2: Electronic worksheet home page.

explanations on problem-based learning, competency maps and concept maps, learning activities, competency tests, glossaries, references, and attachments. The learning activity menu contains 4 activities that have been adapted to acid-base material, namely (1) acid-base theory, (2) acid-base indicators, (3) acid-base acidity degrees, and (4) acid-base reactions. Each learning activity follows the stages of the problem-based learning model syntax which consists of five phases, namely (1) problem orientation, (2) learning organization, (3) guiding investigations, (4) presenting results, (5) reflection, and evaluation. Furthermore, the menu for learning activities can be seen in the following Fig. 3.

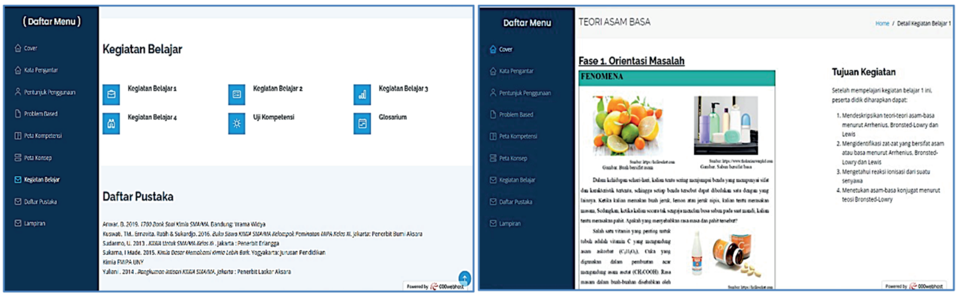

Figure 3: Learning activity menu page.

The feasibility assessment was carried out with validation by two expert judgments in the form of criticism and suggestions that were used to improve the electronic worksheets and the validation results electronic worksheets were suitable for use with some suggestions or feedback for revision. Furthermore, the product practicality test was carried out by two reviewers and two peer reviewers, resulting in the product feasibility category being presented in Table 3.

Table 3: Aspects of item test.

Aspect	Indicators	Average Score	Percentage	Category
Learning	5	23	90%	Very good
Theory	4	17.75	88.75%	Very good
Media Display	4	18.5	92.5%	Very good
Software engineering	5	22.5	90%	Very good
Overall Aspect	18	81.25	90.28%	Very good

Based on Table 3, the results of the product practicality test assessment can be seen by reviewers and peer reviewers for aspects of learning, material, media display, and software engineering, and all aspects. The results of the practicality test assessment for each aspect of the reviewers and peer reviewers were presented in Fig. 4.

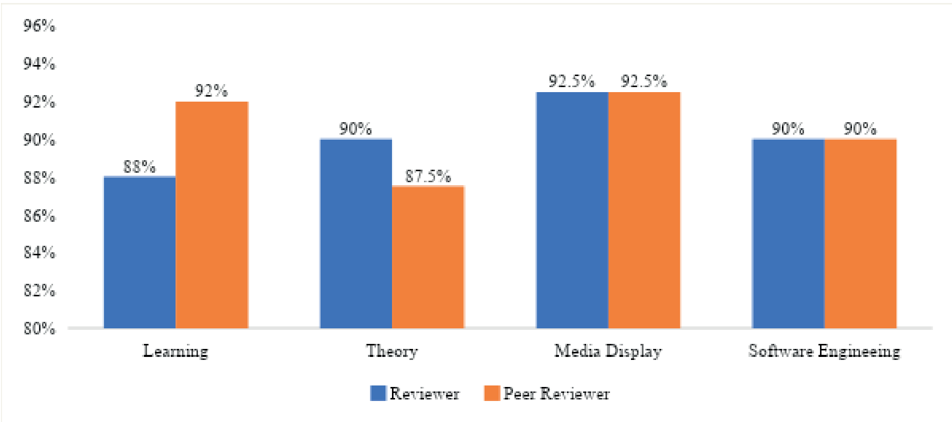

Figure 4: Percentage diagram of reviewer and peer reviewer ratings.

Based on Figure 4, it can be seen the percentage of feasibility assessment from reviewers and peer reviewers for each aspect. Based on these four aspects, it can be seen that the percentage of product feasibility from reviewers and peer reviewers is 90.28%, meaning that the development of electronic worksheet based on problem-based learning on acid-base materials is categorized as very feasible for use. This is in line with research conducted by Sukorini & Purnomo showing that the level of validity of electronic worksheets based on problem-based learning based on the feasibility of content, presentation, and language gets a percentage of 93% which is included in the very feasible category [18].

The readability test of electronic worksheet based on problem-based learning products was carried out on a small scale, involving 20 students of class XI MIPA at SMA Negeri 1 Bumiayu, Brebes. The product readability test was carried out by researchers asking students to use an electronic worksheet based on problem-based learning on acid-base materials without guidance from teachers or researchers. The results of the student's readability test assessment of the product produced in the product quality category are presented in Table 4.

Table 4: The Results of the Readability Test for Students.

Aspect	Indicators	Average Score	Percentage	Category
Theory	4	18.15	90.80%	Very good
Media Display and Operation	7	31.8	90.86%	Very good
Overall Aspect	11	50	90.82%	Very good

Based on Table 4, it can be seen that the results of the product readability test assessment by students for all aspects, namely the material and operational appearance of the media, obtained an average score of 50 out of 11 indicators with a resulting percentage of 90.82%, so it can be concluded that based on the readability test of students, the electronic worksheet based on problem-based learning on acid-base material is categorized as very good or very feasible for use.

The development of electronic worksheet based on problem-based learning on acid-base materials after being validated by expert judgment, and practicality test assessments by reviewers and peer reviewers, as well as student readability tests, it can be concluded that electronic worksheet based on problem-based learning on acid-base materials were developed resulted in a high percentage of feasibility so that it can be said that the electronic worksheets based on problem-based learning on acid-base materials are categorized as very good or very feasible for use. This is the same as the results of the analysis conducted by Febriyanti et al. on the analysis of the feasibility assessment of the electronic worksheet based on problem-based learning on chemical equilibrium material by expert judgment, educators, colleagues, and students, the results of the assessment are very good. The results of other analyzes also show that the development of electronic worksheet on electrolyte and nonelectrolyte solution chemistry received assessments from expert judgment, reviewers, peer reviewers, and students indicating that the developed media is very feasible to use. Electronic worksheets help the learning process during the pandemic [2] and electronic worksheets based on problem-based learning are feasible for use as online teaching materials during the Covid-19 pandemic [11]. Based on this, the development of electronic worksheets based on problem-based learning can be a new solution in developing learning tools that are integrated with technological developments that can help the learning process online or face-to-face. Therefore, electronic worksheets based on problem-based learning are suitable for use in chemistry learning on acid-base materials to develop problem-solving abilities.

4. CONCLUSION

The results of the development research showed that an electronic worksheet based on problem-based learning was developed in a form of a website consisting of four learning activities on acid-base materials with problem-based learning syntax which consists of five phases, namely (1) problem orientation, (2) learning organization, (3) guiding investigations, (4) presenting results, (5) reflection and evaluation. The electronic worksheet based on problem-based learning on acid-base was very feasible to be used. Based on validation from expert judgment, practicality test assessments from reviewers and peer reviewers, and readability tests by students including the very good or very feasible category. Furthermore, it is necessary to develop electronic worksheets based on problem based learning on other chemical materials to support online or face-to-face learning activities.

ACKNOWLEDGMENTS

Thanks to Yogyakarta State University for providing a lot of research experience and supporting the author to learn more. Thanks to chemistry teachers and students of SMA Negeri 1 Bumiayu, Brebes who have helped and contributed to this research.

References

[1] Abidah A, Hidaayatullaah HN, Simamora RM, Fehabutar D, Mutakinati L, Suprapto N. The impact of covid-19 to Indonesian education and its relation to the philosophy of 'merdeka belajar,'. Studies in Philosophy of Science and Education. 2020;1(1):38–49.

[2] Syafitri RA. The importance of the student worksheets of electronic (E-LKPD) contextual teaching and learning (CTL) in learning to write description text during pandemic COVID-19. The 3rd International Conference on Language, Literature, and Education; 2020. Atlantis Press; 2020. https://doi.org/10.2991/assehr.k.201109.048.

[3] Anazifa RD, Djukri D. Project-based learning and problem-based learning: are they effective to improve student's thinking skills? Jurnal Pendidikan IPA Indonesia. 2017;6(2):346–55.

[4] Irwanto S, Saputro AD, Rohaeti E, Prodjosantoso AK. Promoting critical thinking and problem solving skills of pre-service elementary teachers through Process-Oriented Guided-Inquiry Learning (POGIL). Int J Instr. 2018;11(4):777–94.

[5] Hidayat T, Susilaningsih E, Kurniawan C. The effectiveness of enrichment test instruments design to measure students' creative thinking skills and problem-solving. Think Skills Creativity. 2018;29:161–9.

[6] Arif A, Istyadji M, Syahmani S. Implementasi problem based learning berbantuan diskusi daring terhadap kemampuan pemecahan masalah dan hasil belajar kimia pada materi larutan penyangga [Journal of Chemistry And Education]. JCAE. 2018;1(3):237–44.

[7] Valdez JE, Bungihan ME. Problem-based learning approach enhances the problem solving skills in chemistry of high school students. JOTSE. 2019;9(3):282–94.

[8] Shultz GV, Li Y. Student development of information literacy skills during problem-based organic chemistry laboratory experiments. J Chem Educ. 2016;93(3):413–22.

[9] Alrahlah A. How effective the problem-based learning (PBL) in dental education. A critical review. Saudi Dent J. 2016 Oct;28(4):155–61.

[10] Aidoo B, Boateng SK, Kissi PS, Ofori I. Effect of problem-based learning on students' achievement in chemistry. J Educ Pract. 2016;7(33):103–8.

[11] Hidayah AN, Winingsih PH, Amalia AF, Fisika D. Development of physics e-LKPD (electronic worksheets) using 3d pageflip based on problem based learning on balancing and rotation dynamics. Jurnal Ilmiah Pendidikan Fisika-COMPTON. 2020;7(2):36–43.

[12] Lailiah I, Wardani S, Sudarmin S, Sutanto E. Implementasi guided inquiry berbantuan e-LKPD terhadap hasil belajar kognitif siswa pada materi redoks dan tata nama senyawa kimia. Jurnal Inovasi Pendidikan Kimia. 2021;15(1):2792–801.

[13] Zuhroti B, Marfu'ah S, Ibnu MS. Identifikasi pemahaman konsep tingkat representasi makroskopik, mikrokopik dan simbolik siswa pada materi asam-basa [Jurnal Pembelajaran Kimia]. J-PEK. 2018;3(2):44–9.

[14] Thiagarajan S. "Instructional development for training teachers of exceptional children: a sourcebook.," p. 1974.

[15] Sya'idah FA, Wijayati N, Nuswowati M, Haryani S. Pengaruh model blended learning berbantuan e-LKPD materi hidrolisis garam terhadap hasil belajar peserta didik. Chem Educ. 2020;9(1):76–83.

[16] Yuriev E, Naidu S, Schembri LS, Short JL. Scaffolding the development of problem-solving skills in chemistry: guiding novice students out of dead ends and false starts. Chem Educ Res Pract. 2017;18(3):486–504.

[17] Günter T, Alpat SK. The effects of Problem-Based Learning (PBL) on the academic achievement of students studying 'electrochemistry,'. Chem Educ Res Pract. 2017;18(1):78–98.

[18] Sukorini P, Purnomo T. Kelayakan dan kepraktisan lembar kegiatan peserta didik (LKPD) berbasis problem based learning (PBL) untuk melatihkan keterampilan penyelesaian masalah pada submateri daur ulang limbah peserta didik kelas X SMA. *Berkala Ilmiah Pendidikan Biologi*. 2019;8(1).