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Development of Electronic Student Worksheet Based on Problem Based Learning on Electrochemical Materials

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Abstract: Learning resources that are often used in learning only use limited print media and do not attract students' motivation, scientific attitude, and learning independence. For this reason, the right learning media is needed to improve it through electronic student worksheet media. This study aims to produce electronic student worksheet based on Problem-based Learning (PBL) on electrochemical material that is suitable for use in learning chemistry, determine characteristics, analyze practicality based on the assessment of high school chemistry teachers, and analyze responses and readability based on the assessment of high school students. This research used the Research and Development (R&D) research method with the 4D development model. The electronic student worksheet contains 4 learning activities and is equipped with pictures, audio, video, and declared feasible by chemistry learning experts. The results of the practicality test assessment by chemistry teachers obtained an average score of 94.4 out of a maximum score of 105 and an ideal percentage of 89.90% which is included in the 'Very Good' category. The results of the response test assessment and readability by students obtained an average score of 52.2 from a maximum score of 60, an ideal percentage of 87.50% which is included in the 'Very Good' category.

Keywords: Electrochemistry; Electronic Student Worksheet; Problem based Learning

Introduction

The Indonesian government has made various efforts to improve the quality of education, one of which is the curriculum policy. The 2013 curriculum is an improvement to KTSP (Kurikulum Tingkat Satuan Pendidikan). The emphasis is on character education as well as mastery of competencies from the aspects of attitude, knowledge, and skills that characterize this curriculum. The 2013 curriculum initiated by the government refers to 21st century skills (Harjono et al., 2019). According to (Amin et al., 2022), there are several 21st century skills needed by students including cognitive abilities (the ability to learn independently and interact directly with teachers), affective (discipline in managing time, respecting friends, and creating harmonious relationships between parents, students, and teachers), and psychomotor (able to use computer devices, search and find learning resources and solve problems independently). State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Almost all learning models in the 2013 curriculum are student-centered as the main actors in education. However, learning today is still not focused on students' independence, responsibility and scientific attitudes (Maslihah et al., 2021; Sitorus & Soesanto, 2022; Suryawati & Osman, 2018). This is evidenced by some teachers who are still confused about determining a learning model that is appropriate to the material. The methods used to deliver learning have not been effective in increasing students' activeness, learning independence, and responsibility (Kurniaman & Noviana, 2017).

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Chemistry is one of the subjects in Senior High School (SMA)/MA (Madrasah Aliyah). Chemistry is one of the branches of Natural Sciences that studies the structure, composition, properties, and changes in matter and the energy that accompanies it. Chemistry subjects are often considered difficult by students. This is in accordance with the characteristics of chemistry, namely: (1) abstract, (2) simplification of the actual situation, (3) sequential and tiered (Adawiyah et al., 2021). Therefore, media and learning resources are needed that can overcome students' difficulties in learning chemistry.

Everything that the teacher must prepare before the learning process begins is a learning tool, such as student worksheet. Student worksheet is one of the learning tools that must be owned and designed by the teacher, because the student worksheet will help and make it easier for teachers to carry out learning and assist students in completing learning tasks independently (Lathifah et al., 2021).

The worksheet used is based on a learning model. Problem-Based Learning (PBL) is one of the learning models used with the aim that students acquire critical thinking skills, analyze daily life problems, access and use appropriate learning resources, organize information into meaningful conceptual frameworks, work in teams and small groups, and demonstrate effective communication skills by conveying information to others (Günter & Alpat, 2017). Students can build their knowledge independently during the learning process with PBL, thus showing that this learning has been in accordance with the characteristics of 21st century learning (Siagian et al., 2019).

An interactive worksheet is made that uses various supporting technologies, such as images, audio, and certain videos, so that students can better understand abstract chemical concepts. An interactive student worksheet is an alternative that can be used to support the learning process. It consists of material and practice questions that can be accessed through electronic devices such as computers or cell phones (Herawati et al., 2016).

A PBL-based worksheet on electrochemical material is still very rarely found, and if there is only limited material on oxidation-reduction reactions. Based on the background, it is necessary to develop a PBL-based electronic student worksheet for chemistry learning at school. The development of this electronic worksheet is expected to increase motivation, learning independence, and scientific attitudes among students because it contains interesting images, audio, and learning videos and activities based on the syntax of the PBL learning model.

Method

This research uses the Research and Development (R&D) research method with the 4D development model. According to Sugiyono (2015), the research and development (R&D) method is a research method used to produce certain products, and test the effectiveness of these products. In this study, the product developed is a PBL-based electronic worksheet on electrochemical material which aims to increase motivation, learning independence, and scientific attitudes of students. The research and development model used the 4D model. The 4D model is used to develop learning devices. The 4D research and development model consists of 4 stages, namely define, design, develop, and disseminate (Thiagarajan et al., 1974). In this development research, two data were used, namely qualitative and quantitative data.

Data regarding practicality of PBL-based electronic student worksheet was obtained from the assessment of 5 teachers, while response and readability data were obtained from 25 students. The data was analyzed descriptively qualitative by collecting information such as criticism, input and suggestions and then processed as a consideration for improving the worksheet. Furthermore, the assessment results were analyzed descriptively quantitative by converting the assessment results obtained using a Likert scale. The data was processed with the following steps:

1. Determine the average score of the product assessment using the formula 1:

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

2. Converting the average score into a category value. To determine the quality and effectiveness of the worksheet, the data previously in the form of scores were converted into qualitative data with a scale of five for teacher practicality, and a scale of four for student responses and readability. The reference for converting scores into a scale of five and a scale of four can be seen in the Table 1 and 2.

Tabel 1. Ideal Scoring Criteria on a Scale of 5

Score Range	Category
$X > \bar{X}i + 1{,}8\ SBi$	Very Good
$\bar{X}i + 0{,}6SBi < X \leq \bar{X}i + 1{,}8\ SBi$	Good
$\bar{X}i - 0{,}6SBi < X \leq \bar{X}i + 0{,}6\ SBi$	Fair
$\bar{X}i - 1{,}8SBi < X \leq \bar{X}i - 0{,}6\ SBi$	Not Good
$X \leq \bar{X}i - 1{,}8\ SBi$	Very not good

Source: (Widoyoko, 2016)

Tabel 2. Ideal Scoring Criteria on a Scale of 4

Score Range	Category
$X \geq (\bar{xi} + 1.\ SBi)$	Very Good
$\bar{xi} \leq X < (\bar{xi} + 1.SBi\ )$	Good
$(\bar{xi} - 1.\ SBi) \leq\ X < \bar{xi}$	Fair
$X < (\bar{xi} - 1.\ SBi)$	Not Good

Source: (Suratman et al., 2021)

3. Calculate the ideal percentage of each assessment component using the formula:
4. Determining the practicality of teachers, and the readability of students on PBL-based electronic worksheet on electrochemical material by comparing the average score obtained with the ideal assessment criteria.

Result and Discussion

Product Development Result

The results of this development research are in the form of PBL-based electronic student worksheet on electrochemical material for students of class XII SMA / MA. There are 4 stages involved in this development research model, namely define, design, develop, disseminate. The details of the product development results that have been carried out are as follows.

This initial analysis was conducted by researchers by interviewing XII grade teachers in three high schools in Sleman. This interview was used to find out the basic problems faced in high school chemistry learning in the field. The results of interviews conducted to teachers can be summarized as follows:

1) Some teachers admitted that it is difficult to arouse students' learning motivation and understanding of chemistry material due to the absence of direct meetings between teachers and students and the limited variety of learning methods that can be used during online learning.
2) Students' interest in learning chemistry can be increased by using interesting media, such as videos, interesting pictures and by providing stimulus by linking the chemistry material to be learned with everyday life.
3) PBL-based electronic worksheet is suitable for teaching electrochemical material, with the hope that students will be more motivated, independent, and more active in learning.

Student analysis

Student analysis conducted by researchers is by conducting interviews with 12th grade high school students in Sleman Regency. This interview was conducted to find out learning motivation, difficulties experienced, and previous learning experiences. The results of interviews with 12th grade MIPA students are that they have difficulty in understanding abstract chemical concepts in electrochemistry material and lack of learning resources with videos and interesting images.

Concept Analysis

The material developed in the PBL-based electronic worksheet is electrochemistry. The details of the material presented in the worksheet are Volta cells and their notations, calculating standard potential, electrolysis cells, and Faraday's law. The details of the material are made into 4 learning activities that need to be carried out by students in learning.

Electronic Student Worksheet Design

This worksheet was developed using Microsoft Word, Canva, and Flip PDF Professional software. The developed electronic student worksheet contains 62 pages with 4 learning activities including, Learning Activity 1 Voltaic Cell and its Notation, Learning Activity 2 Calculating Standard Potential. Learning Activity 3 Electrolysis Cells, and Learning Activity 4 Faraday's Law. In each activity there are videos and audio that can help students' understanding, and at the end of each learning activity, practice questions and quizzes are presented. This electronic worksheet uses the syntax of the PBL learning model which presents several problems and then students provide solutions to these problems. Some of the worksheet designs are presented in Figure 1.

Figure 1. Design PBL-based Electronic Student Worksheet

Teacher Practicality of PBL-based Electronic Student Worksheet

The teacher's practicality of PBL-based electronic worksheet on electrochemical material as a whole gets an idealized percentage of 89.90% and an average score of 94.4, and is included in the very good category. The results of the distribution of the ideal percentage of all aspects of the assessment can be seen in Table 3.

Table 3. Percentage of Practicality of Electronic Student Worksheet on All Aspects

Aspects of Teacher Practicality	Idealized Percentage (%)
Product Characteristics	86
Content/Material	91.33
Language	87.20
Presentation	90
Graphics	93

Overall, the highest percentage of ideality is owned by the graphical aspect. This result indicates that the electronic student worksheet developed is physically presented in the form of an attractive appearance, easy to read and use, and the use of the right size, font, image illustrations, and layout.

Based on the teacher's assessment of the aspect of product characteristics, the PBL context indicator gets an average score of 4.4, which shows that the electronic worksheet developed uses the syntax of the PBL learning model, which requires students to solve a contextual problem related to electrochemical material. Each learning activity in the newly developed electronic worksheet uses contextual problems presented in problem orientation. This is in accordance with what is mentioned by Apriliasari (2017), that at the problem orientation stage, a problem description is described in the form of a case to motivate students to solve problems. The PBL syntax used in worksheet includes problem orientation, organizing students, guiding group activities, developing and presenting work, and analysis and evaluation (Rahmadani, 2019). Students are faced with a problem that is displayed in problem orientation, then directed to provide solutions to these problems through analysis and evaluation.

In the content/material aspect, it shows that the content in the worksheet is in accordance with everyday life, so that it is easier for students to make observations and analyze problems to find solutions. This result is in accordance with the statements by Jannah et al. (2017), and Sari & Seprianto (2018), who said that the existence of real phenomena in the worksheet can provide several advantages, including better understanding the relationship between chemistry and events in the surrounding environment, solving problems independently through critical thinking processes, increasing activity, learning independence and motivation, and building concepts independently.

Based on the assessment for the language aspect, it shows that the terms used are familiar to students. The content in the PBL-based electronic worksheet on electrochemical material uses language that is commonly used in everyday life so that students can understand the material easily. This is supported by the assessment results, which get an average score of 4.2 in the Very Good category. This is in accordance with the opinion of Asfiah et al. (2013),which states that the use of terms in the school environment or the world of work should use terms that are common and have been widely used. Furthermore, the suitability of sentences with Indonesian language rules shows that the PBL-based electronic LKPD on electrochemical material developed has minimal errors, especially in spelling, diction, and use of words, sentences, or paragraphs according to Indonesian language rules. LKPD needs to be written and compiled by experts in related fields, fulfill Indonesian language rules, be guided by EYD (refined spelling), and be made so that readers can more easily understand the contents listed in it (Giyanti et al., 2019; Raharjo et al., 2017).

The presentation aspect shows that the worksheet is structured coherently and can increase learning independence and students' scientific attitudes through the PBL model used. Scientific attitudes are all behaviors, responses, and responses that must exist in a scientist when facing scientific problems and are a form of intelligence possessed by each individual (Asnaeni et al., 2011; Faberta et al., 2022; Khuserawati et al., 2020). Scientific attitudes include honesty and objectivity, not rushing to conclusions, openness, caution, and high curiosity. Scientific attitudes are developed through scientific activities such as investigations or project activities (Hendracipta, 2015; Suryantari, Ni Made Ayu Pudjawan & Wibawa, 2019; Wahyudi & Lestari, 2019). The PBL model in chemistry learning can train students' scientific attitudes because they need to solve problems with structured procedures with strong evidence support. This is in accordance with the results of research conducted by Fitriani et al. (2014), which showed that the PBL model enhanced with POE had a significant effect on scientific attitudes.

The graphical aspect shows that the illustrations and the use of colors, sizes, and fonts are appropriate. This shows that the PBL-based electronic worksheet on electrochemical material that has been developed uses attractive image illustrations, can support the content in the worksheet, and makes it easier for students to understand the content and material of the worksheet. The format and physical form of the developed electronic worksheet are very instrumental in fostering student interest in reading, studying, and carrying out activities on worksheet. The images presented must also contain something that is full of information and data, so that the image is not just something that has no meaning (Rahmi & Sudirman, 2021).

Students' Response and Readability to PBL-based Electronic Student Worksheet

The response and readability of students to PBL-based electronic student worksheet on electrochemical

material as a whole get an idealized percentage of 87.5% and an average score of 52.2. Based on this average score, it shows that the response and readability of students to PBL-based electronic student worksheet on electrochemical material is included in the "Very Good" category. The results of the distribution of the ideal percentage of all aspects of the assessment can be seen in Table 4.

Table 4. Percentage of Idealized Response and Readability of Electronic Student Worksheet on All Aspects

Aspects of Students Response and Readability	Idealized Percentage (%)
Cognitive	89.37
Affective	84.75
Conative	83.67

Aspects assessed by students include cognitive, affective, and conative aspects. The cognitive aspect of this study is related to students' knowledge and understanding of the use of PBL-based electronic worksheet on electrochemical materials (Juniarti et al., 2018). The results of the analysis show that the electronic LKPD developed can increase students' knowledge and understanding of electrochemical materials, which were previously quite difficult for some students. This is supported by research conducted by Rahayu et al. (2011), which states that the level of understanding of concepts in electrochemical materials in Indonesian students is only 44% and in Japanese students is 35%. Asnawi et al. (2017) also stated that electrochemical material consists of abstract concepts that in learning, involve chemical observations, the way chemical reactions take place, and symbols. Electrochemical materials are considered difficult because students have difficulty understanding the reactions that occur at the cathode and anode and the processes that occur in electrochemical cells, so there are often misconceptions in this material(Sari, 2021; Yerimadesi et al., 2018). In addition, the analysis also shows that the instructions for use and the information contained in the LKPD are quite easy to understand and help students use this LKPD.

The affective aspect is related to the ability of attitudes, feelings, interests, emotions, and values (Hutapea, 2019; Mangei et al., 2021). The results show that the developed electronic worksheet can increase student motivation, interest, and curiosity, as seen from the average score of indicators that are included in the excellent category. Curiosity is one of the scientific attitudes that students must have. Scientific investigations that explore how curiosity will affect student memory because high curiosity not only makes students interested in the information provided but also challenged to learn the information (Faberta et al., 2022). Furthermore, the conative aspect is a dimension related to real behavior, which includes habits and actions as a response to a given stimulus (Mangei et al., 2021; Manisa et al., 2018). The conative aspect of this study aims to determine the behavioral tendencies of students who have carried out learning activities using PBL-based electronic worksheets on electrochemistry material. The results of the analysis show that it is still necessary to develop electronic worksheets that can further increase learning independence and student activeness in asking and responding to questions. However, there are some suggestions for improvement presented in Table 5.

Table 5. Electronic Student Worksheet Repair Results

Suggestions	Follow-Up
Improvements to the cover	Revised
Correction of errors in the use and writing of words, sentences, and symbols	Revised
Improvements to the user manual	Revised
Adding audio	Revised

There were several errors in the use of words, sentences, and symbols in the worksheets. Improvements were made so that the worksheets were easier for students to understand. The use of language in the worksheet needs to be presented according to Indonesian language rules, with the sentences used being effective and communicative (L. Sari et al., 2020). In addition, the instructions for use are made more detailed and clear so as not to confuse students when using them.

This worksheet is equipped with a video that can be played by students to better understand the content of the material presented. Expert validators suggested adding audio regarding the explanation of the material. This is used to facilitate students who have an auditory learning style who learn by speaking and listening (Febriana & Muhaimin, 2020).

The content in the worksheet is also related to everyday life, so it makes it easier for students to make observations, analyze problems, and find solutions. Real phenomena presented in the electronic worksheet provide several advantages, among others: students can better understand the relationship between chemistry and events in the surrounding environment; students can also solve problems independently through critical thinking processes; increase activity; increase learning independence and motivation; and build concepts independently(Jannah et al., 2017; R. P. Sari & Seprianto, 2018).

PBL-based electronic worksheet is developed with the Flip PDF Professional application, with the addition of audio, video, and several quiz links. The presentation of PBL-based electronic worksheet has utilized

technology so that it is in accordance with the characteristics of learning in the 21st century. This is in accordance with the opinion of Arwanda et al. (2020), which states that in 21st century learning, teachers must use technology-based media or learning resources to be able to create 4C competencies (critical thinking and problem solving, creativity, collaboration, and communication) in students.

Conclusion

Based on the results of the development research that has been carried out, the following conclusions can be obtained: (1) PBL-based electronic worksheet on electrochemical material is declared feasible with some revisions according to peer reviewer input and chemistry learning expert validators based on an assessment of the feasibility aspects of substance, presentation, language, and product characteristics; (2) the characteristics of PBL-based electronic worksheet on electrochemistry material developed in this study include a page size equivalent to A4 paper and consists of 62 pages. The worksheet consists of four learning activities with the syntax of the PBL learning model and is equipped with images, videos, and audio, as well as evaluation questions that test all learning activities carried out by students; (3) the practicality of PBL-based electronic worksheet on electrochemical material based on teacher assessment obtained an average score of 94.4 from a maximum score of 105 and an idealized percentage of 89.90%. PBL-based electronic worksheet on electrochemical material is included in the "Very Good" category; (4) response and readability of PBL-based electronic worksheet on electrochemical material by students obtained an average score of 52.2 from a maximum score of 60, an idealized percentage of 87.50%, and were included in the "Very Good" category.

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The first author, Meliana Fajri Nurkhasanah, contributed to designing the research, conducting the research, and writing the publication. The second author, Eli Rohaeti, played a role in guiding the research implementation process and writing the publication article.

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Conflicts of Interest
The authors declare no conflict of interest.

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