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Innovative Learning with AR: Experiential LKPD for Electrochemical Cells

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Abstract
Learning is the process of interaction between teachers and students in educational institutions which aims to achieve the expected results, through educational interactions and the goals of knowledge, attitudes and skills. Teachers play an important role in learning by providing appropriate teaching materials. Current learning still prioritizes the role of the teacher and students' activities in class do not develop independently through discovery and thought processes. Therefore, to overcome this, learning resources that are integrated with information technology and based on student-centered learning models are needed. One model that can be applied to chemistry learning is the experiential learning model. This research is development research using a 4-D model. The research aims to produce an integrated augmented reality worksheet based on experiential learning on electrochemical cells material. The results of the LKPD validation by material and media validators were considered valid in terms of content suitability, experiential learning characteristic aspects, linguistic aspects, presentation aspects, graphic aspects, appearance aspects, and software utilization aspects with percentages of 98.87%, 100% respectively. , 87.5%, 96.87%, 96.87%, 97.22% and 100%. The results of the user response trials, namely teachers and students, were assessed as good with respective percentages of 97.22% and 92.82%

1. Introduction

Learning is a process of interaction between teachers and students within an educational institution, aimed at achieving desired outcomes (Pane & Darwis

Dasopang, 2017). The learning process of students in schools occurs due to the educational interaction between teachers and students, driven by objectives such as knowledge, attitudes, and skills. Chemistry learning is required to shift from being teacher-centered to being student-centered (BNSP, 2006). The 21st century is known as the knowledge age, where all efforts to meet life's needs in various contexts are increasingly knowledge-based. These efforts include education based on knowledge (knowledge-based economics), community development and empowerment based on knowledge (knowledge-based social empowerment), and even industry development based on knowledge (knowledge-based industry).

To enhance 21st-century skills, it is essential to have learning resources that support the learning process. Learning resources are tools that can be utilized for the benefit of the learning process, either directly or indirectly, in part or in full. Learning resources are crucial to achieving learning objectives and making learning activities more active. Therefore, teachers must carefully select the necessary learning resources (Septikasari & Frasandy, 2018). The learning resources used by teachers should be tailored to the situation. Learning resources can include textbooks, modules, student worksheets (LKPD), and other materials from which students can learn. Limited interaction with the teacher can be mitigated by using appropriate LKPD. According to Prastowo, the Student Worksheet (LKPD) is a type of teaching material in the form of sheets containing material and instructions for carrying out learning tasks that students must complete to achieve basic competencies (Andi, 2015).

Teaching materials in the form of LKPD should be unique and capable of visualizing the submicroscopic level of abstract chemistry concepts. One emerging technology that can be incorporated into LKPD to visualize an object is augmented reality. Augmented reality is a technology that connects the real world and the virtual world, projected in real-time in both 2D and 3D forms (Mustaqim & Kurniawan, 2017).

Electrochemical cells are one of the chemistry topics studied in the first semester of XII science in SMA/MA student. Based on interviews with chemistry teachers at SMA Negeri 1 Pekanbaru, it was found that electrochemical cell material is considered difficult because students struggle to distinguish between voltaic and electrolytic cells, understand the reactions occurring at the cathode and anode, comprehend the processes in electrochemical cells, and determine the spontaneity of reactions based on the voltaic series. These difficulties often prevent students from fully grasping the concepts in this material. Evidence of this is seen in students' learning outcomes, where many have not yet achieved the minimum competency criteria (KKM) set by the school.

Teachers who have not optimally utilized LKPD in the learning process and who rely solely on printed teaching materials converted into PDFs and PowerPoints may contribute to the aforementioned issues. These methods may fail to engage students and cannot stimulate their interest in learning. Although printed materials and PowerPoints provide visual information, they often fall short of encouraging student participation and critical thinking. The limited use of diverse and interactive teaching models by teachers can also lead to reduced active involvement of students in the learning process. To address these problems, one alternative solution is to develop LKPD integrated with a student-centred learning model, specifically the Experiential Learning model.

According to Rohman, Suryawan, and Priyanto (2019), the Experiential Learning model is an innovative learning model designed to train students' creativity and sensitivity based on their experiences. With this model, students are expected to undergo a more meaningful learning process where they experience what they are learning, thus providing them with new experiences (Rohman et al., 2019). Based on this background, it is important to develop an LKPD integrated with augmented reality based on experiential learning for the electrochemical cell material for SMA/MA students as valid teaching material. This study will explore how to develop an augmented reality-integrated LKPD based on experiential learning for the electrochemical cell material for SMA/MA students as a valid learning resource, considering aspects such as content feasibility, the characteristics of experiential learning, language, presentation, graphics, appearance, and software utilization, as well as determining user responses when the LKPD is used in learning. This research is expected to produce a valid electrochemical cell LKPD, offering teachers a choice of engaging and innovative learning resources for students.

2. Methods

This research was conducted in the Chemistry Education Study Program at the Faculty of Teacher Training and Education (FKIP), University of Riau, Pekanbaru, with trials conducted at SMAN 1 Pekanbaru and MAN 2 Pekanbaru.This research is designed using a research and development (R&D) approach, employing the 4-D model. The chosen model is the 4-D development model, which is a framework for developing educational tools. This model was introduced by Thiagarajan, Dorothy S., and Melvyn I. Semmel in 1974. The 4-D model consists of four main stages: Define, Design, Develop, and Disseminate. The rationale for choosing the 4-D model is that it provides detailed explanations of each step in the development process, guiding researchers in developing educational materials, books, or other instructional resources. The flow of LKPD development is presented in Figure 1 below:

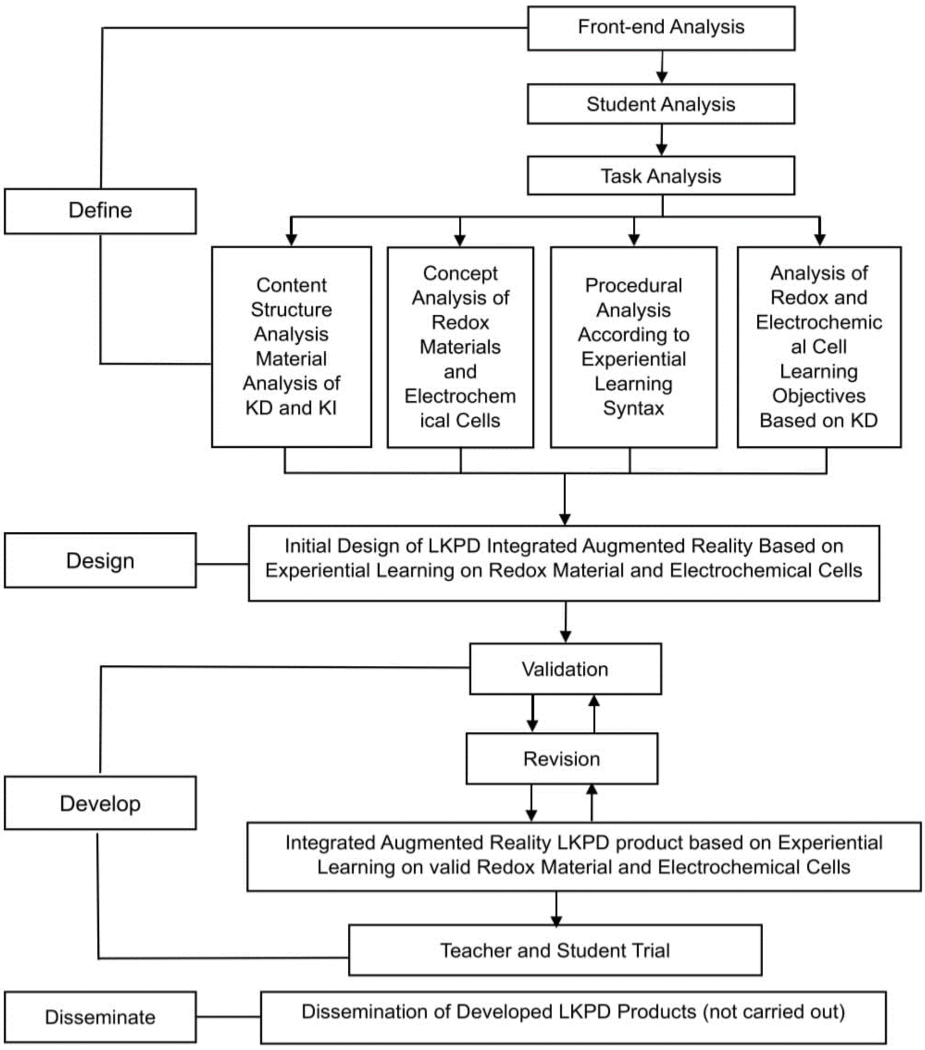

Figure 1. LKPD Development Flow

Research Instruments

This study's data collection instruments include validation sheets and user response questionnaires (for teachers and students). The validation sheet obtains assessments and feedback from validators on the LKPD. According to (Sugiyono, 2016), product validation can be done by involving several experts or experienced professionals to evaluate the newly designed product. The user response questionnaire determines the criteria for responses or feedback from respondents regarding the LKPD when used in learning.

Data Analysis

Qualitative data analysis is used to describe the results of observations, validator suggestions, user responses, and documentation notes. Quantitative data analysis is performed based on the results of the validity assessment and user response evaluation. The validity of the LKPD product is assessed based on aspects such as content feasibility, experiential learning model, language, presentation, graphics, appearance, and software utilization. The analysis technique involves calculating the percentage of validator assessments on the validation sheet, which uses a 4-point Likert scale in checklist form (√). Positive attitude statements are converted into scores using the four-point Likert scale to obtain quantitative data, as shown in Table 1. The criteria for the percentage analysis feasibility can be seen in Table 2. The four-point Likert scale is chosen to avoid neutral responses. Each score corresponds to specific evaluation criteria, similar to the rubric that will be attached.

Table 1. Likert Scale for Validation Stage

Attitude Atatement	Score
Agree	4
Somewhat Agree	3
Somewhat Disagree	2
Disagree	1

(Sugiyono, 2019)

Table 2. Criteria for Percentage Analysis Feasibility

Percentage	Description
80,00 – 100	Valid
60,00 – 79,99	Fairly Valid
50,00 – 59,99	Less Valid
0,00 – 49,99	Not Valid

(Riduwan, 2012)

The analysis of user responses to the LKPD uses a response questionnaire to evaluate aspects such as appearance, effectiveness, and usability. The analysis technique involves calculating the percentage of user evaluations (teachers and students) using the response questionnaire, which employs a 4-point Likert scale in checklist form (√). Positive attitude statements are converted into scores using the four-point Likert scale to obtain quantitative data, as shown in Table 3.

Table 3. Likert Scale for Validation Stage

Attitude Atatement	**Score**
Agree	4
Somewhat Agree	3
Somewhat Disagree	2
Disagree	1

(Sugiyono, 2019)

Calculating the percentage of user scores for alternative positive attitude statements involves converting the average score into a qualitative value based on the four-point Likert scale evaluation criteria, resulting in the criteria shown in Table 4.

Table 4. User Response Criteria

Percentage	**Description**
80,00 – 100	Good
60,00 – 79,99	Fairly Good
50,00 – 59,99	Less Good
0,00 – 49,99	Not Good

(Arikunto, 2016)

3. Results

The development research that has been conducted resulted in a product in the form of an LKPD integrated with augmented reality technology, based on experiential learning, focusing on redox reactions and electrochemical cells for XII SMA/MA students. This LKPD has been validated and tested. The research was carried out using a research and development (R&D) design with the 4-D model (Define, Design, Develop, Disseminate). However, in this study, the 4-D model was used only up to the third stage, which is the development stage, considering that the research objective was limited to the development phase. The learning resource developed is a student worksheet (LKPD) focused on redox reactions and electrochemical cells. The LKPD was created following recommended instructional principles, starting from instructional analysis and syllabus development, leading to the creation of an effective learning resource. The ease of use of this learning resource shows a positive impact on teachers, providing them with more time to guide students during the learning process. It also helps students acquire new knowledge from various sources or references used in the teaching materials, reducing the teacher's role as the sole source of knowledge. This learning resource is designed as an LKPD to support the concept of independent learning for students, as they inherently possess the ability to work independently and take more responsibility for their actions. Below is an image of the cover of the developed LKPD.

Figure 2. Cover of LKPD

The developed LKPD (Student Worksheet) on electrochemical cells, based on experiential learning, is divided into six sub-learning activities. Each activity is supported by augmented reality applications:

1. LKPD 1: Redox Reactions
2. LKPD 2: Voltaic Cells
3. LKPD 3: Cell Potential and Spontaneity of Reactions
4. LKPD 4: Corrosion
5. LKPD 5: Electrolytic Cells

6. LKPD 6: Faraday's Laws

Each learning activity begins with a real-world experience to introduce the topic, aimed at enhancing critical thinking skills. Group discussions and opinion exchanges are included to boost collaboration and communication skills.

Validity of LKPD

Validation of LKPD is a very important process to ensure that the worksheet is effective, accurate, and meets the intended educational purpose. The LKPD validation process is carried out by validators using an assessment instrument, namely a validation sheet. Validation was carried out by 3 validators consisting of 2 material expert validators and 1 media expert validator. The validity of the LKPD was assessed across various aspects, with results as follows:

Table 7. Validation result

No	Aspect	Percentage (%)	Criteria
1	Content Feasibility	96,87	Valid
2	Experiential Learning Model	100	Valid
3	Language Feasibility	87,5	Valid
4	Presentation Feasibility	96,87	Valid
5	Graphics Feasibility	96,87	Valid
6	Display Feasibility	97,22	Valid
7	Software Utilization	100	Valid
	Average Validity Percentage	**96,47**	**Valid**

The content suitability aspect assessment aims to assess the suitability of the LKPD content with basic competencies and material indicators, suitability for the substance of the material, suitability for the needs of students and its usefulness. The average percentage obtained from validating the content feasibility aspect is 96.87%, with valid criteria. The assessment of the feasibility aspect of experiential learning aims to assess the suitability of the syntax of the experiential learning model, namely the stages of real experience, reflective observation, conceptualisation and active experimentation. The average percentage result for this aspect is 100% with valid criteria. The grammatical aspect assessment aims to assess the accuracy and correctness of the grammar in the LKPD. The average validation result is 87.5% with valid criteria. The presentation aspect assessment aims to assess the completeness, availability of columns, cover design, and presentation of illustrative images in the presentation of the LKPD. The validation percentage result is 96.87% with valid criteria. The graphic aspect assessment aims to assess the suitability of the typography and design on the LKPD. The average percentage result is 96.87% with valid criteria. Assessment of display aspects aims to assess ease of access, proportionalization, clarity of letters, graphic and video quality, colour composition, and layout of the LKPD. The average percentage result is 97.22%, with valid criteria. The assessment of the software utilisation aspect aims to look at the augmented reality aspect which includes the response and ease of use of the LKPD. The average percentage result is 100%, with valid criteria. The average percentage of all validated aspects is 96.47% and is in the P score range > 80% with valid criteria so that trials can be carried out.

User Responses

User response results were obtained through testing stages, namely one-on-one testing, limited testing and teacher response testing. One-on-one trials were carried out on 3 class XII students at SMAN 1 Pekanbaru with different levels of ability, namely high, medium and low. Details of the work results are presented in table 5 below:

Table 5. LKPD Work Value

LKPD	**Result**			**Average**
	SD-01	**SD-02**	**SD-03**	
1	90	90	80	86,66
2	100	100	75	91,66
3	90	85	80	85
4	100	90	90	93,33
5	85	90	80	85
6	90	80	90	86,66
Average	**92,5**	**89,16**	**82,5**	**88,05**

SD=Student

The testing was continued with a limited trial involving 20 students from grade XII at SMAN 1 Pekanbaru and MAN 2 Pekanbaru. The students provided feedback on the LKPD when used in teaching. Aspects assessed by students include appearance aspects and effectiveness aspects with assessment indicators including attractiveness, presentation, language, clarity of information, making it easier for users, helping the learning process, motivating and communication. The results of this feedback are presented in Table 6 below.

Table 6. Recap of Student Feedback Results

Aspect	Respondent		Average Respondent Score
	SMAN 1 Pekanbaru	**MAN 2 Pekanbaru**	
Display	96,9	90,6	93,75
Usefulness	90,7	90,9	90,8
Average Percentage	93,8	90,75	92,27
Criteria	**Good**	**Good**	**Baik**

Based on the table, it can be seen that the average percentage of limited trial response results obtained was 92.27% with good criteria.

Teacher response trials were carried out on two chemistry teachers to provide responses, comments and suggestions on the LKPD through a teacher response questionnaire. Aspects assessed by teachers include aspects of appearance, effectiveness and usability, which contain ten indicators. The results are presented in Table 7.

Table 7. Recapitulation of teacher response results

Aspect	Percentage (%)	Criteria
Display	100%	Good
Effectiveness	100%	Good
Usefulness	91,66%	Good
Average Percentage	**97,22%**	**Good**

Based on the table it can be seen that the average score percentage of teacher responses is 97.22% with good criteria.

4. Discussion

The development research that has been conducted resulted in a product in the form of a Student Worksheet (LKPD) integrated with augmented reality technology based on experiential learning, focusing on redox and electrochemical cells for XII

SMA/MA students. This LKPD has been validated and tested. The research was carried out using a research and development design (R&D) based on the 4-D model (Define, Design, Develop, Disseminate). However, in this study, the 4-D model was only applied up to the third stage, Development, considering that the research objective was limited to the development stage.

The evaluation of the content feasibility aspect aimed to assess the alignment of the LKPD with the basic competencies and indicators of electrochemical cell material, the suitability of the material's substance, its relevance to student needs, and its usefulness. The LKPD received a validation score of 96.87%, categorized as valid. This indicates that the content presented in the LKPD aligns with the applicable curriculum. Using this LKPD in teaching can help achieve the Core Competencies (KI) and Basic Competencies (KD) outlined in the learning indicators. Learning materials that align with the curriculum will facilitate students' learning (Nisa, 2020). The accuracy of the learning material content in this LKPD is crucial to prevent students from experiencing conceptual misunderstandings (Herawati & Muhtadi, 2018).

The evaluation of the experiential learning model aimed to assess the appropriateness of the experiential learning model characteristics. The validation result was a score of 100%, categorized as valid. This demonstrates that the LKPD material aligns with the experiential learning syntax. The valid criteria for this aspect also show that the LKPD effectively engages students in developing new concepts, understanding, and insights based on factual information obtained.

The language aspect evaluation aimed to assess the coherence and accuracy of the language used in the LKPD. The validation result was a score of 87.5%, categorized as valid. The validity score of the language aspect shows that the LKPD uses proper and correct Indonesian. Proper and correct language in the LKPD facilitates students' learning (Rahman et al., 2019). This indicates that the language aspect of the LKPD is clear and easy to understand, preventing confusion among students

The presentation aspect evaluation aimed to assess the completeness, availability of columns, cover design, and the presentation of illustrative images in the LKPD. The validation result was a score of 96.87%, categorised as valid. The evaluation of the graphic aspect, which aimed to assess typography, font variation, images, and videos, also received a validation score of 96.87%, categorised as valid. This shows that the LKPD design is good and attractive, including the type and size of the font used, the layout, and a design that attracts students' attention. The use of colour in the LKPD aims to enhance students' attention, motivation, and interest in learning (Oktaviara & Pahlevi, 2019).

The display aspect evaluation aimed to assess the attractiveness of the LKPD design based on typography, spacing, navigation buttons, design display, and LKPD layout. The validation result was 97.22%, categorized as valid. This indicates that the LKPD is easy to access and contains high-quality images, videos, and animations. This ease of access helps students use the LKPD during learning sessions.

The software utilization aspect evaluation aimed to assess the ease of use and interactivity of the augmented reality features in the LKPD. The validation score for software utilization was 100%, categorized as valid. Revisions at this stage were minimal, as validators only suggested improving operational ease. This shows that the LKPD has a positive response from users and is easy to navigate, helping students access information during learning sessions (Ricu Sidiq & Najuah, 2020). The overall average percentage of validated aspects is 96.47%, falling within the range of $P > 80\%$ with a very valid criterion, indicating that it is ready for trial implementation.

The one-on-one trial was conducted to gather feedback from users of the developed product, where students were asked to work on the LKPD while paying attention to the content, images, narratives, videos, instructions, questions, and presentation of the LKPD. Based on the one-on-one trial results, high-ability students achieved an average score of 92.5 on all LKPD tasks. Medium-ability students scored an average of 89.16, while low-ability students scored an average of 82.5. Overall, the student's scores exceeded the minimum criteria set by the school

The student response test received positive results, consistent with the validation results. This is supported by the average student response score of 92.27%, categorized as good. Overall, respondents, who were 12th-grade students from SMAN 1 Pekanbaru and MAN 2 Pekanbaru, indicated that the developed LKPD has an attractive design, is easy to understand, helps in learning, and enhances students' interest in learning chemistry. The colour scheme and use of images, videos, and animations were highly praised, capturing students' attention and aiding in their work on the LKPD.

The teacher response test also yielded very positive results, aligning with the validation results on content feasibility, experiential learning characteristics, presentation, language, and graphics. According to chemistry teachers from SMAN 1 Pekanbaru and MAN 2 Pekanbaru, the developed LKPD meets all aspects, as evidenced by the teacher response score of 97.22%, categorized as good. The teacher response results are consistent with the validation results, confirming that the LKPD effectively helps meet students' learning needs. Respondents also agreed that this LKPD can assist both students and teachers during lessons, help students understand the material, and increase their interest in learning chemistry.

5. Conclusions

Based on the results and discussion, it can be concluded that the LKPD (Student Worksheet) based on experiential learning for electrochemical cell material for 12th-grade high school/MA students, which has been developed as a teaching material, has been declared valid by the material and media validators, with an average score of 96.47%. This validation was based on content feasibility, the feasibility of the experiential learning model, presentation, language, graphics, display, and software utilization aspects. The developed LKPD also received very positive feedback from teachers, with an average percentage score of 97.22%, categorized as good. Similarly, the students' responses to the LKPD resulted in an average percentage score of 92.82%, also categorized as good.

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