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Development of Electronic Student Worksheets (E-LKPD) Based on Discovery Learning for Chemistry Material for High School Students

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Abstract: In chemistry learning, the application of technology, experimental activities, case studies, class discussions, and direct involvement in the application of concepts play a crucial role. Students struggle to understand chemistry material not only due to a lack of teacher skills but also due to the teachers' limited resources. The purpose of this research was to determine the needs analysis, feasibility level, and teacher and student responses to the discovery learning-based E-LKPD on acid-base material. This type of research is a Development Research (R&D) using the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation) but the implementation was only carried out up to the development phase. The subjects of this study included Material Experts, Media Experts, and chemistry teachers, grade XII Bio 1 students. The results of the study proved that the discovery learning-based E-LKPD that had been developed obtained a feasibility percentage of 86% from the material experts, which was included in the very feasible criteria, and 87% from the media experts, which was included in the very feasible criteria. Chemistry teachers' responses to the developed e-LKPD also showed positive results, with 94% categorizing it as very appropriate. Meanwhile, students' responses to the discovery learning-based e-LKPD were categorized as very interesting at 90%. Based on these results, the developed e-LKPD was deemed appropriate and met the criteria for use in the chemistry teaching and learning process for acids and bases.

Keywords: Acid Base; ADDIE; Discovery Learning; E-LKPD Development

Introduction

Indonesia has set educational goals as stipulated in Law No. 20 of 2003 concerning the National Education System, which states that the function of National Education is to shape national character and civilization to improve the nation's life, develop students' potential, and develop them into individuals with noble morals, health, knowledge, good self-control, independence, and democratic and responsible citizens (Gultom & Amdayani, 2023). Education is a necessity for all Indonesians. The quality of education is crucial in the implementation of education (Karatsiori, 2023; Wang & Shih, 2022). As the 21st century progresses, the world of education faces a number of significant challenges. These challenges are increasingly evident amidst rapid technological advancements, globalization, and ever-changing social dynamics. All of this is pushing the education sector to address various complex issues closely related to the demands of the modern era (Isma et al., 2023). With the emergence of the Industrial Revolution 4.0, the 21st century is marked by globalization and openness. In this context, Indonesia is currently undergoing an industrial revolution, yet the country's education level remains relatively low compared to other countries. This way, Indonesia can compete globally and remain relevant to changing times (Anas et al., 2022; Surya et al., 2021).

The most important activities in the educational process are teaching and learning. Both are systematically designed to achieve predetermined goals, involving various components. Planning various components and learning tools is part of the ongoing process of teaching and learning (Crompton & Sykora, 2021; González-Pérez & Ramírez-Montoya, 2022). When education relies solely on conventional teaching materials or media without creativity in developing innovative teaching materials, it can lead to low learning quality (Haleem et al., 2022; R. Rahayu & Khairi, 2025). Therefore, teachers are required to be proficient in creating learning media and writing teaching materials. Chemistry is one of the most important subjects taught to students. Chemistry is also a subject that is disliked by

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students, as most students consider it a difficult and boring subject (Priliyanti et al., 2021). In chemistry learning, the application of technology, experimental activities, case studies, class discussions, and direct involvement in the application of concepts play a crucial role (Eviota & Liangco, 2020). Students struggle to understand chemistry material not only due to a lack of teacher skills but also due to the limited resources available. In addition to these factors, inadequate infrastructure and facilities contribute to student disinterest and low interest in learning chemistry (Ningsih et al., 2023).

Interviews with chemistry teachers at SMA Negeri 18 Medan, which uses the independent curriculum, identified several problems. Among them, teachers use limited teaching materials, such as chemistry textbooks found in the school library. The limited number of books and their relatively thick size contribute to low student interest in chemistry. Learning methods used include discussions and lectures, which are still teacher-centered. Students use practice questions from textbooks and teacher-created questions in class. Teacher creativity and innovation in utilizing technology are still lacking, resulting in a decline in the quality of student learning in the classroom. Learning media can be defined as a tool used to support the teaching and learning process as a channel for messages that are useful for achieving learning objectives. The use of learning media in the teaching and learning process can develop students' interests and curiosity (Wulandari et al., 2023). Technology plays a crucial role in the learning process because its use can directly influence the achievement of curriculum objectives. One crucial element in the learning process is the Student Worksheet (LKPD) (Rahmayani & Atmazaki, 2025).

E-LKPD is a digital version of the LKPD used as a learning tool to support the learning process through various innovations using electronic media. E-LKPD is used to deliver lesson materials aimed at improving students' thinking skills. This integration of LKPDs has resulted in the development of E-LKPD, which can encourage teachers and students to be flexible in accessing materials and practice questions from various locations during the learning process, supporting more active, dynamic interactions (Huang & Lajoie, 2023; Nguyen & Tran, 2025). A well-chosen and implemented learning model can significantly improve students' understanding, critical thinking skills, and motivation in learning a subject if it is chosen and implemented correctly. According Tong et al. (2022); Zamiri & Esmaeili (2024), the discovery learning model, used during instruction, is useful for enabling students to play a more active role in exploring and discovering concepts within the topic being studied. More active learning activities can also be achieved when using the discovery learning model. This model also indirectly helps students develop critical thinking and creativity. This allows them to be more independent in finding their own conclusions and developing learning materials.

There are previous findings such as those carried out in research by Syahputri et al. (2023), entitled "Development of Discovery Learning-Based Chemistry E-LKPD to Improve Students' Understanding of Redox Reaction Material" showing that the success of the research that has been carried out in developing discovery learning-based chemistry E-LKPD with the average results of the feasibility test of material experts and media experts of 83.91% and 91.17% is in the very feasible category.

Method

This research was conducted at SMA Negeri 18 Medan. The subjects were 12th-grade Biochemistry students at SMA Negeri 18 Medan. Three chemistry lecturers and two chemistry teachers served as validators. The object of this research was a Discovery Learning-based electronic student worksheet (LKPD) covering the topic of acids and bases. Validation was carried out by material and media experts, while teacher and student responses were analyzed through questionnaires to assess its feasibility and attractiveness. This research employed a modified ADDIE model-based R&D method, focusing on implementation through the development stage, with the goal of producing educational products such as electronic LKPD. The development of the discovery learning-based chemistry e-LKPD at SMA Negeri 18 Medan followed the ADDIE model, which includes analysis and design stages, limited to the development stage. This concept was applied to develop basic learning performance, namely in designing effective learning products (Azairok & Fathurohman, 2023). The stages implemented in this development research and development are outlined as follows.

Analysis

This stage aims to assess the need for teaching materials development. Interviews with chemistry teachers and several students were conducted to identify issues that occurred during the teaching and learning process. The researcher conducted a needs analysis to identify students' needs regarding learning media that could support their understanding of the material. The existing curriculum at the school was analyzed. Material analysis was conducted to determine what materials were needed to develop the teaching materials.

Design Stage

This stage involved collecting data and information related to the development of the e-LKPD, designing the

learning media framework, and designing the instruments to be used during the research process, including validation questionnaires and responses from teachers and students.

Development Stage

The development stage is the stage of creating the learning media designed in the previous stage. During this development stage, a discovery learning-based e-LKPD was developed. The developed e-LKPD was then assessed by validators, subject matter and media experts, using validation sheets.

Teacher and Student Responses

A limited trial of the developed e-LKPD was conducted at this stage. The e-LKPD, which had been assessed for feasibility by experts, was then subjected to teacher and student feedback on the developed electronic LKPD through a teacher and student response questionnaire. The feasibility level was assessed using a scoring system on a validation sheet to evaluate the e-LKPD's feasibility through assessments by subject matter experts and media experts. Each response was then analyzed using a Likert scale of 1 to 4 according to applicable assessment guidelines:

Table 1. Feasibility Assessment Scoring

Value Criteria	Description
4	Very good
3	Good
2	Not good
1	Not good

The formula for calculating the level of eligibility is:

$$V = \frac{\text{TS}}{\text{Smax}} \text{X } 100\ \% \quad (1)$$

Description:
V: Validity / Feasibility
TS: Total score obtained
Smax: Total of maximum scores

Table 2. E-LKPD Feasibility Test Criteria

Criteria (%)	Eligibility Level
81-100	Very Eligible
61-80	Eligible
41-60	Quite Eligible
21-40	Less Eligible
<20	Not Eligible

Source: (Andayani & Fathahillah, 2024)

The table above shows that the product was deemed suitable and very suitable based on the assessments given by the material and media expert validators. The student and teacher response questionnaires were used to describe the effectiveness of the learning media. The questionnaires were analyzed using a Likert scale with predetermined scoring rules, as follows:

Table 3. Assessment Scoring

Value Criteria	Description
4	Very good
3	Good
2	Not good
1	Not good

Rumus menghitung respon guru dan peserta didik digunakan rumus:

$$R = \frac{\text{TS}}{\text{Smax}} \text{X } 100\ \% \quad (2)$$

Description:
R: Teacher or student response
TS: Total score obtained
Smax: Total of maximum scores

Table 4. Teacher and Student Response Criteria

Criteria (%)	Eligibility Level
81-100	Very Interesting
61-80	Interesting
41-60	Quite Interesting
21-40	Not Interesting
<20	Not Interesting

From the table above, the discovery learning-based E-LKPD is considered interesting and can be used if the average score or assessment obtained falls into the "interesting" or "very interesting" category.

Result and Discussion

Analysis

At State Senior High School 18 Medan, the school uses the Merdeka curriculum. A needs questionnaire distributed to 36 grade XI Bio 1 students at State Senior High School 18 Medan revealed that 99% of students stated that the only teaching materials used by teachers in chemistry teaching and learning were printed textbooks. Ninety-seven percent of students stated that teachers did not use supplementary media or electronic worksheets (LKPD) during chemistry lessons. Furthermore, 90% of students stated that the development of electronic worksheets (LKPD) integrated into the acid-base material for use in chemistry teaching and learning in class was necessary.

Design

Based on interviews conducted by researchers, it was discovered that chemistry, particularly acid-base material, is often considered difficult for students to understand. This electronic student worksheet (E-LKPD) was designed to meet the objectives, objectives, and learning materials that refer to the Merdeka

curriculum. Instructions for use, material information, and activities carried out during the learning process are packaged in a continuous manner, with discovery learning stages integrated into the acid-base material.

Development

From this research, the discovery learning-based e-LKPD developed for acid-base material has been adjusted to meet the criteria for a good LKPD and to adapt the LKPD to the learning materials. It was then validated by five expert material and media experts, including three chemistry lecturers from the Faculty of Mathematics and Natural Sciences, UNIMED, and two chemistry teachers from SMA Negeri 18 Medan. Using the feasibility calculation formula, the following conclusions were obtained:

Table 5. Assessment Results by Material Validation

In the aspects of	Average Percentage (%) V1	V2	V3	V4	V5	Average (%)
Content Suitability	97	91	84	72	94	88
Language	75	96	75	63	96	81
Presentation	92	100	92	75	100	92
Average (%)						86
Result Criteria						Very Worthy

The results obtained from the assessment for the feasibility of content averaged a percentage value of 88%, categorized as very feasible. For the feasibility of language, the average percentage value was 81%, categorized as very feasible, and for the feasibility of presentation the average percentage value was 92%, categorized as very feasible. From the overall assessment of material experts on electronic LKPD based on discovery learning on acid-base material, the average percentage value was 86%, indicating that the product that has been developed is categorized as "very feasible" based on the feasibility criteria.

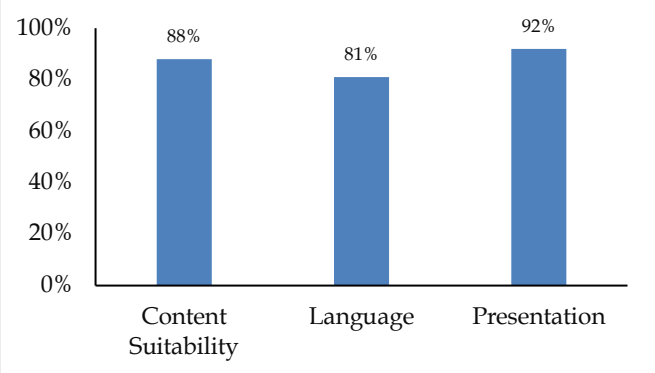

Figure 1. Diagram of Material Expert Assessment Results

Table 6. Assessment Results by Media Validation

In terms of	Average Percentage (%) V1	V2	V3	V4	V5	Average (%)
Cover Design	79	92	79	71	100	84
Content Design	75	100	88	75	100	88
Content Typography	75	100	100	65	100	88
Presentation	85	95	100	75	90	89
Average (%)						87
Result Criteria						Very Worthy

The assessment results obtained for cover design, an average percentage of 84% is categorized as very feasible. For content design, an average percentage of 88% is categorized as very feasible, and for content typography, an average percentage of 88% is categorized as very feasible, as well as for the presentation aspect, an average and percentage of 89% are categorized as very feasible. From the overall assessment of media experts on electronic LKPD based on discovery learning on acid-base material, an average percentage of 87% is obtained, indicating that the product that has been developed is categorized as "very feasible" based on the feasibility criteria.

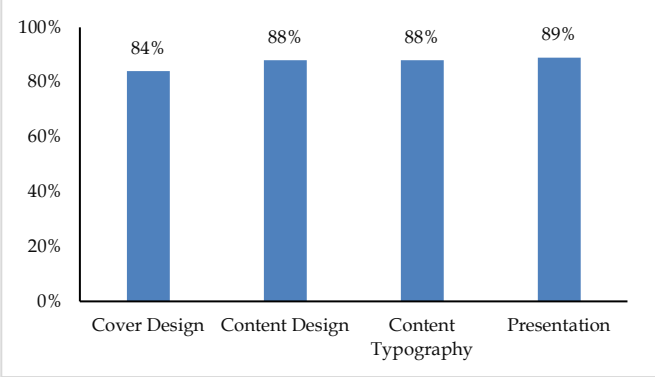

Figure 2. Diagram of Media Expert Assessment Results

Teacher and Student Responses

The percentage of teacher responses is obtained by dividing the total score obtained by the chemistry teacher respondents by the total maximum score, then multiplying by 100%. The average percentage is calculated by dividing the total percentage of respondents by the number of respondents, then using the result to determine the attractiveness criteria. The data from the chemistry teacher responses are presented below.

Table 7. Chemistry Teacher Response Results

In the Aspects of	Average Percentage (%) Teacher 1	Teacher 2	Teacher u 3	Percentage (%)
Content Suitability	90	100	95	95
Presentation	98	91	84	91
Language	88	100	88	92
Graphics	100	100	100	100
Average (%)				94
Result Criteria questionnaire				Very interesting

The table above shows that chemistry teachers responded to the discovery learning-based electronic worksheets (LKPD) with the acid-base topic that had been developed, with an average percentage of 94%. These results demonstrate that the final product is highly attractive for use as an electronic LKPD teaching material for teaching acid-base topics in chemistry.

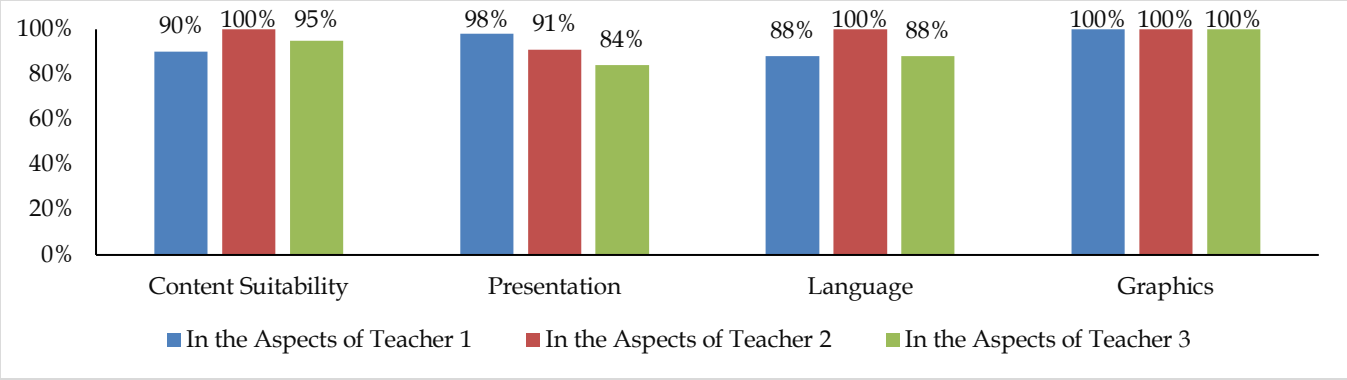

Figure 3. Chemistry Teacher Response Results Diagram

After the discovery learning-based electronic worksheet on the acid-base subtopic had been validated by expert material and media validators and declared suitable, and after reviewing the results of chemistry teacher responses, it was revealed that the e-LKPD was interesting for use in chemistry subjects, the next step was to administer a questionnaire to 35 grade XII Bio 1 students.

Table 8. Student Response Results

In the aspects of	Average Percentage %
Appearance	92
Content	89
Usefulness	89
Average	90
Questionnaire Result Criteria	Very Interesting

The table above shows that students responded positively to the discovery learning-based electronic worksheet on acids and bases. This is demonstrated by an average percentage of 90%. Based on these results, this percentage falls into the very interesting category.

Overall, the assessment by material expert validators for the E-LKPD on acid-base material achieved an average percentage of 86%, categorized as very appropriate. This demonstrates that the material in the developed E-LKPD can be used as teaching materials for chemistry on the topic of acids and bases (Ratih & Putri, 2024). Research by (Monib et al., 2025; Wahyudi & Mz, 2022; Yulia et al., 2023) obtained a material expert validation percentage of 82.22% overall, categorized as very valid. The purpose of material expert validation is to test the presentation of the material based on predetermined aspects (Putri & Hartati, 2025; Sholikhah et al., 2025). Overall, the assessment results from all media expert validators for the E-LKPD on acid-base material showed an average percentage of 87%, categorized as very appropriate.

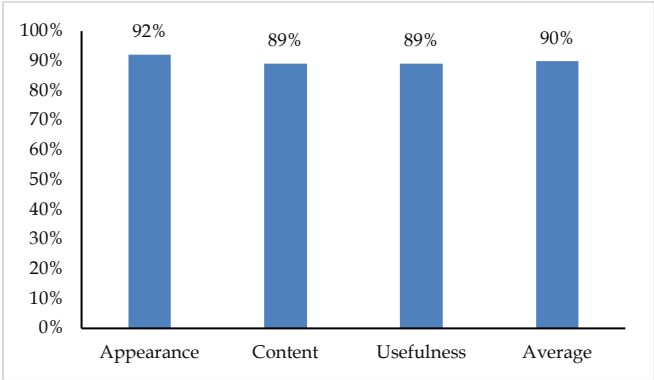

Figure 4. Student Response Results Diagram

This is in line with research conducted by Suprapto et al. (2023); Zikri & Handayani (2024), which obtained an average percentage assessment of 81% from two media expert validators, categorized as very appropriate. These results indicate that the developed student worksheets can be deemed appropriate and can be tested (Lisa et al., 2023; I. M. P. Rahayu et al., 2023). Assessments obtained from teachers I, II, and III showed an average assessment percentage of 94%. The results

obtained show that the electronic LKPD based on discovery learning that has been developed is categorized as very interesting (Anggraini & Susilowati, 2022; Nurkhasanah & Rohaeti, 2024; Sholikhah et al., 2025). This shows that the E-LKPD learning media based on discovery learning on acid-base material is indeed suitable for use in the chemistry learning process (Ayyıldız et al., 2023). From the results of the responses of 35 students, an average percentage of 90% was obtained with a very interesting category.

Thus, it can be concluded that the E-LKPD based on discovery learning on acid-base material that was developed has a high appeal and attracts students' interest in the teaching and learning process. In previous findings from (Hayyun & Winarni, 2024), entitled "Development of E-LKPD Based on Discovery Learning to Improve Students' Understanding of Redox Reactions Material", the assessment results were obtained at 88.66%, which is included in the very interesting category. From these findings, it can be concluded that the electronic LKPD learning media that has been developed is suitable for use as a learning resource in learning redox reactions material (Ainillana & Louise, 2024; Goes et al., 2020; Nehring & Schanze, 2025).

Conclusion

This development research demonstrated a strong need for innovative supplementary teaching materials, as evidenced by 90% student approval. The Discovery Learning-based e-LKPD for acid-base topics was declared Highly Feasible based on expert validation results: Material Experts: 86% (Very Feasible Category); Media Experts: 87% (Very Feasible Category). Furthermore, the e-LKPD received very positive user feedback, indicating its suitability for use in the learning process: Teacher Responses: 94% (Very Interesting/Very Practical Category); Student Responses: 90% (Very Interesting Category). Overall, this Discovery Learning-based e-LKPD proved feasible and engaging for use as a supplementary learning resource in chemistry.

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Conceptualization; methodology; formal analysis; investigation; resources; writing—preparation of original draft; W. S.; writing—reviewing and editing; visualization; supervision; project administration; obtaining funding A. S. All authors have read and approved the published version of the manuscript,

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Conflicts of Interest
In this study there is no conflict of interest.

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