



Development of E-LKPD Based on Guided Inquiry on Electrolyte and Non-Electrolyte Solution Material for Grade XII Senior High School

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Abstract: Development of E-LKPD Based on Guided Inquiry on Electrolyte and Non-Electrolyte Solution Material for Grade XII Senior High School. This study was conducted with the aim of producing a guided-inquiry-based E-LKPD suitable for the topic of electrolyte and nonelectrolyte solutions for Grade XII high school students, and which meets the criteria of being valid, practical, and effective in supporting learning activities. The development of the E-LKPD followed the ADDIE model, but was limited only to the development stage. In addition, the development process was integrated with Tessmer's formative evaluation stages, which include self-evaluation, expert review, one-to-one evaluation, small-group evaluation, and field testing. The validation results from the expert review stage showed that the pedagogical aspect obtained a score of 0.83 (high category), the material aspect 0.83 (high category), and the design aspect 0.88 (high category). The average validation score across the three aspects was 0.84, which falls into the high category. The practicality of the product was rated very practical, with an average percentage of 98.41% in the one-to-one evaluation stage and 98.94% in the small-group evaluation stage. Meanwhile, regarding effectiveness in the field test stage, the N-Gain calculation showed a value of 0.84, which is categorized as high.

Keywords: Guided Inquiry, Electrolyte and Nonelectrolyte Solutions, E-LKPD Development.

Abstrak: Pengembangan E-LKPD Berbasis Inkuiri Terbimbing Materi Larutan Elektrolit dan Non-Elektrolit Kelas XII SMA. Penelitian ini dilaksanakan dengan tujuan menghasilkan E-LKPD berbasis inkuiri terbimbing yang sesuai untuk materi larutan elektrolit dan non-elektrolit kelas XII SMA, dan memenuhi kriteria valid, praktis, dan efektif dalam mendukung kegiatan pembelajaran. Pengembangan E-LKPD dilakukan melalui model ADDIE, namun dibatasi hanya sampai tahap development. Selain itu, pengembangan ini juga dipadukan dengan tahapan evaluasi formatif Tessmer, yang mencakup self-evaluation, penilaian oleh ahli (expert review), evaluasi individual (one-to-one evaluation), evaluasi kelompok kecil (small group evaluation), serta uji lapangan (field test). Hasil validasi pada tahap expert review menunjukkan bahwa aspek pedagogik memperoleh skor sebesar 0,83 dengan kategori tinggi, aspek materi sebesar 0,83 dengan kategori tinggi, dan aspek desain sebesar 0,88 yang juga termasuk dalam kategori tinggi. Rata-rata skor validasi dari ketiga aspek tersebut sebesar 0,84 yang tergolong dalam kategori tinggi. Kepraktisan produk dinilai sangat praktis, dengan rata-rata persentase 98,41% pada tahap one-to-one evaluation, dan 98,94% pada tahap small group evaluation. Sementara itu, untuk aspek efektivitas pada tahap field test, hasil perhitungan menggunakan rumus N-Gain menunjukkan nilai sebesar 0,84 yang termasuk dalam kategori tinggi.

Kata kunci: Inkuiri Terbimbing, Larutan Elektrolit dan Non-Elektrolit, Pengembangan E-LKPD

■ INTRODUCTION

Education in Indonesia continues to develop, particularly since the implementation of the Merdeka Curriculum, which aims to improve the quality of learning and adapt it to the needs and characteristics of learners (Sutimah & Tyas, 2024). The transition from the 2013 Curriculum to the Merdeka Curriculum requires teachers to apply more innovative and student-centered learning models (Sipayung et al., 2025). In line with this spirit, one learning model that is relevant to implement is guided inquiry, which emphasizes students' active involvement in searching, exploring, and understanding learning materials through direct learning experiences (Harjilah et al., 2019).

The guided inquiry model emphasizes students' active engagement in problem-solving by connecting new concepts with prior knowledge, thereby fostering meaningful learning (Yudhanegara et al., 2019). With appropriate teacher guidance, students are involved in a structured scientific investigation process, enabling learning objectives to be achieved more effectively (Mahyuna et al., 2024). Without adequate guidance, inquiry activities may create difficulties for students, particularly when dealing with complex topics, which can lead to confusion and reduced learning effectiveness (Agustina et al., 2025). Student activeness in this model encourages questioning, critical thinking, and problem-solving skills, in line with the Merdeka Curriculum's emphasis on the development of higher-order thinking skills (Prasetya et al., 2025).

Inquiry-based learning that actively involves students in discovering concepts can be optimized through the systematic development of student worksheets (LKPD). This integration aims to enhance critical thinking and learning independence. Worksheet development should be adapted to learning conditions. Along with the growing trend of digital learning, electronic student worksheets (E-LKPD) are increasingly needed to facilitate access and digital learning processes (Hasanah & Agustini, 2023). Printed LKPD can be transformed into electronic versions that are more engaging, interactive, and capable of fostering student creativity. E-LKPD present learning materials and exercises that can be accessed through electronic devices such as computers or smartphones (Lathifah et al., 2021). However, in practice, the LKPD currently used have not fully supported learning processes that deepen students' conceptual understanding, resulting in less optimal learning outcomes (Hamidah et al., 2018). In addition, the continued use of printed LKPD is considered less relevant, as students' interests increasingly lean toward the use of information technology in learning activities (Triana et al., 2022).

Chemistry is an important subject taught at the senior high school level; however, many students still experience learning difficulties in this subject. Students often face challenges in understanding chemistry due to its abstract and complex concepts. Effective mastery of chemistry content requires deep conceptual understanding and appropriate learning approaches (Sariati et al., 2020). One chemistry topic that is particularly difficult for students to understand is electrolyte and non-electrolyte solutions. Students tend to experience difficulties because this topic involves concepts that cannot be directly observed, such as particles in solutions, making them difficult to visualize concretely (Fitriyani et al., 2019). In addition, teachers often apply less effective instructional approaches, resulting in monotonous learning processes. Monotonous instruction typically involves lengthy lectures with minimal student involvement, which can cause students to feel bored, lose interest, and become less motivated to learn (Susanti et al., 2024).

Based on interviews conducted with a chemistry teacher at SMA Negeri 19 Palembang, it was found that many students still experience difficulties in understanding electrolyte and non-electrolyte solution material. Currently, the school relies primarily on textbooks as the main learning resource. One common challenge in learning is the need for repeated explanations because some students have not yet fully understood the material. Limited variation in learning materials can reduce learning effectiveness and limit students' active involvement in understanding concepts. Therefore, it is important to develop guided inquiry-based E-LKPD on electrolyte and non-electrolyte solutions as an alternative solution. This development is expected to help students achieve deeper conceptual understanding and encourage more active participation in independently exploring learning concepts.

Based on the above description, this study aims to develop guided inquiry-based E-LKPD on electrolyte and non-electrolyte solution material for Grade XII senior high school students that are valid, practical, and effective, thereby supporting deeper conceptual understanding and increasing students' active involvement in the learning process.

■ **METHOD**

1. Type of Research and Research Subjects

This study is a Research and Development (R&D) study aimed at designing and producing guided inquiry-based electronic student worksheets (E-LKPD) on electrolyte and nonelectrolyte solutions for Grade XII senior high school students. The developed product was intended to meet the criteria of validity, practicality, and effectiveness. The development process employed the ADDIE model, which includes the stages of Analyze, Design, Development, Implement, and Evaluate, and was integrated with Tessmer's formative evaluation. The ADDIE model is designed to ensure a systematic instructional development process (Safitri & Aziz, 2022). To ensure the effectiveness of the product and its alignment with users' needs, Tessmer's formative evaluation was conducted through the stages of self-evaluation, expert review, one-to-one, small group, and field test. Each stage aimed to identify and gradually revise any shortcomings of the product (Tessmer, 1993). Therefore, integrating Tessmer's formative evaluation into the ADDIE-based development is expected to enhance the validity, practicality, and effectiveness of the instructional product.

The subjects of this study included chemistry lecturers as validators or experts, chemistry teachers as respondents to obtain data during the needs analysis stage, and Grade XII students. The object of this study was the guided inquiry-based E-LKPD.

2. Research Procedures

At the analysis stage, the researcher conducted a review of the needs for developing instructional materials. This analysis included several aspects, such as needs analysis and the identification of relevant learning materials. The design stage involved determining the digital media platform and format, collecting relevant images, videos, and supporting materials, as well as developing evaluation instruments.

At the development stage, the researcher developed the E-LKPD using the TopWorksheets, Canva, and Wordwall applications. The subsequent stage was Tessmer's formative evaluation, which consisted of self-evaluation, expert review, one-to-one evaluation, small group evaluation, and field testing.

3. Data Analysis Techniques

1) Interview Data Analysis

The results of the interviews were presented in sheets containing structured questions and the responses from teachers and students, and then analyzed to obtain relevant information as a basis for drawing conclusions. The analysis of the interview results was conducted during the needs analysis stage, one-to-one evaluation, and small group evaluation to determine students' responses to the E-LKPD.

2) Validation Sheet Data Analysis

At the development stage, the E-LKPD was validated by experts in pedagogy, content, and design to assess its validity. The assessment used a Likert scale (1–5) and was then analyzed using the V'Aiken formula as follows:

$$V = \frac{\sum s}{[n(c-1)]}$$

(Aiken, 1985)

Explanation:

V = Agreement index of item validity raters

s = r – lo

r = Score given by the rater

lo = Lowest possible score (e.g., 1)

n = Number of raters

c = Highest possible score (e.g., 5)

The following is the classification of the validity level of the developed instructional materials:

Table 1. V'Aiken Assessment Categories

No	Coefficient Score Range	Category
1	0,68 – 1,00	High
2	0,34 – 0,67	Medium
3	0 – 0,33	Low

(Aiken, 1985)

3) Questionnaire Data Analysis

The data were collected during the needs analysis stage, one-to-one evaluation, and small group evaluation. The questionnaire was assessed using a Guttman scale with “yes” (score 1) and “no” (score 0). Data from each questionnaire item were analyzed in the form of percentages using the following formula:

$$\% = \frac{\text{Total score of each question}}{\text{Number of respondents}} \times 100\%$$

(Irsalina & Dwiningsih, 2018)

The level of practicality based on the questionnaire results is determined according to the following categories.

Table 2. Practicality Questionnaire Score Categories

Percentage (%)	Category
0-20	Not practical
21-40	Less practical

Percentage (%)	Category
41-60	Fairly practical
61-80	Practical
81-100	Very practical

(Irsalina & Dwiningsih, 2018)

4) Test Data Analysis

The pretest and posttest results from the field test stage were analyzed using the N-Gain formula to measure the improvement in understanding and the effectiveness of the E-LKPD in supporting learning. The N-Gain formula used is as follows:

$$\langle g \rangle = \frac{\langle s \text{ post} \rangle - \langle s \text{ pre} \rangle}{\text{skor maks} - \langle s \text{ pre} \rangle}$$

(Hake, 1998)

Explanation:

s pre = average pretest score

s post = average posttest score

$\langle g \rangle$ = average normalized gain score

Table 3. Categories of Normalized N-Gain Scores

Kriteria	Poin Gain
High	$g \geq 0,7$
Medium	$0,3 < g \leq 0,7$
Low	$g \leq 0,3$

(Hake, 1998)

■ RESULT AND DISCUSSION

Analysis Stage

The analysis stage was conducted by examining the needs and analyzing the learning materials. Based on the interviews conducted, teachers used lecture, question-and-answer, and discussion methods; however, some students were still less active and had difficulty understanding the material on electrolyte and nonelectrolyte solutions, requiring repeated explanations. The guided inquiry model was recommended for this material. Most students own smartphones and are allowed to use them during learning. From the results of the student needs questionnaire, it was found that they still have difficulty understanding chemistry and are more interested when digital media is used. Some students were already familiar with E-LKPD and hoped for its broader use.

The implementation of the Merdeka Curriculum at SMA Negeri 19 Palembang, particularly in the Chemistry subject for Grade XII, covers electrolyte and nonelectrolyte solutions in the odd semester. The material for the E-LKPD was developed from various references such as the internet, textbooks, and other reliable sources, which were analyzed and adapted to meet the needs and achieve the learning objectives. The results of this analysis served as the basis for preparing systematic and relevant E-LKPD content, with the material aligned with the chemistry learning outcomes of phase F.

Design Stage

The initial design stage of the E-LKPD began by selecting TopWorksheets as the main platform, which is easily accessible on various devices and integrated with Google Drive. The media used included text, images, videos, and interactive elements to create

an engaging learning experience. Images and videos were selected to clarify concepts and provide more in-depth explanations. Furthermore, evaluation instruments were developed using Wordwall to support the assessment of students' learning outcomes.

Development Stage

At this stage, the researcher carried out the development of the learning media in the form of an E-LKPD designed using a guided inquiry approach. The product produced was still in the form of an initial draft and was arranged based on the syntax of guided inquiry learning. The completed product was then evaluated through a formative approach according to Tessmer, with the following stages:

Self-Evaluation

Self-evaluation was conducted by the researcher through personal assessment and discussion with the supervising lecturer, which helped to improve deficiencies before further validation.

Expert Review

Product validation at this stage involved two expert validators who assessed the product in the areas of pedagogy, content, and design. To determine the validity level of the product, the experts' assessments were calculated using V Aiken's index (1985), and the processed data results are presented in the table below.

Table 4. Validation Assessment of Pedagogy, Content, and Design

Aspect	Rater		S1	S2	Σs	n (c-1)	V	Description
	1	2						
Pedagogy (Items 1-22)	8 8	10 2	66	80	146	176	0,83	High
Content (Items 1-21)	8 0	10 1	59	80	139	168	0,83	High
Design (Items 1-18)	7 2	90	54	72	126	144	0,88	High
Average Score							0,84	High

The validation results showed that the guided inquiry-based E-LKPD obtained a validity index of 0.83 for pedagogy, 0.83 for content, and 0.88 for design, all classified as high. The average validity score was 0.84, indicating that the E-LKPD is highly valid according to expert evaluation.

One-to-One

The one-to-one stage involved three Grade XII students from SMA Negeri 19 Palembang, representing high, medium, and low ability levels. The students provided feedback on the content and appearance of the E-LKPD to help refine the product. After giving suggestions and comments, they were also asked to evaluate the E-LKPD. The results of their evaluation are presented below.

Table 5. One-to-One Stage Evaluation Results

Respondent	Percentage (%)	Category
ZA	100	Very Practical
RZA	95,24	Very Practical
AFA	100	Very Practical
Average	98,41%	Very Practical

Based on the evaluation results provided by the three students during the one-to-one stage, the practicality percentage of the E-LKPD was 98.41%. This figure indicates that the E-LKPD is categorized as very practical for use in the learning process.

Small Group

The small group stage involved nine Grade XII students from SMA Negeri 19 Palembang, representing various academic ability levels. Feedback in the form of comments and suggestions provided by these nine students served as a basis for refining the E-LKPD. After giving suggestions and comments, they were also asked to evaluate the E-LKPD. The results of their evaluations are presented below.

Table 6. Small Group Stage Evaluation Results

Respondent	Percentage (%)	Category
EAM	100	Very Practical
NA	100	Very Practical
MFM	100	Very Practical
DA	100	Very Practical
SW	95,24	Very Practical
KPW	100	Very Practical
MPA	100	Very Practical
FA	95,24	Very Practical
NS	100	Very Practical
Average	98,94	Very Practical

Based on the evaluation results provided by the nine students during the Small Group stage, the practicality percentage of the E-LKPD was 98.94%. This figure indicates that the E-LKPD is categorized as **very practical** for use in the learning process.

Field Test

The effectiveness of the E-LKPD was tested through a field test with 36 Grade XII students from SMA Negeri 19 Palembang, using pretests and posttests. The improvement in learning outcomes was analyzed using the N-Gain formula, as shown in the table below.

Table 7. Effectiveness Test Results of the E-LKPD Using the N-Gain Formula

Average Pretest Score	Average Posttest Score	N-Gain	Category
40,42	89,17	0,84	High

Based on the data presented, the N-Gain score was 0.84. According to the evaluation categories, this score is classified as high, indicating that the use of the E-LKPD in the learning process is considered effective.

This study is a research and development (R&D) study aimed at producing a guided inquiry based Electronic Student Worksheet (E-LKPD) for the topic of electrolyte and non-electrolyte solutions for Grade XII senior high school students. The development model used was ADDIE, limited to three main stages: analysis, design, and development, and integrated with Tessmer's formative evaluation to ensure product quality.

The needs analysis stage was conducted through interviews with a Grade XII chemistry teacher and the distribution of questionnaires to 36 students at SMA Negeri 19 Palembang. This is supported by previous findings stating that needs analysis is essential to identify problems in the learning process (Dianti et al., 2024). The interview results indicated that the school has implemented the Merdeka Curriculum, but limitations in learning resources remain a major challenge. Teachers emphasized the need for technology-based learning media such as E-LKPD to enhance student engagement and understanding. This finding is consistent with research indicating that E-LKPD can help students understand learning materials more effectively (Lathifah et al., 2021).

The questionnaire results showed that 72% of students like chemistry, yet 81% still experience difficulties in understanding the material. Additionally, 75% stated that learning becomes more interesting with digital media, and 97% expressed expectations for the development of E-LKPD that can be used both at school and at home. Based on these findings, a guided inquiry-based E-LKPD was developed with the objective of producing a learning tool that is valid, practical, and effective in supporting the learning process.

The design stage involved selecting the TopWorksheets platform because it provides interactive features and is easily accessible across various devices. The E-LKPD incorporates text, images, videos, and interactive elements to enhance student engagement. This is supported by studies reporting that the TopWorksheet application can increase students' learning interest and enrich the variety of worksheet usage in learning (Silmi et al., 2025). The researcher also designed learning evaluation instruments to assess students' learning outcomes. These instruments were developed using Wordwall, an interactive platform that offers various types of engaging and user-friendly digital assessments.

The development process resulted in an E-LKPD draft structured according to the guided inquiry steps: orientation, problem formulation, hypothesis formulation, data collection, hypothesis testing, and conclusion drawing. This draft then underwent Tessmer's formative evaluation, including Self Evaluation, Expert Review, One-to-One, Small Group, and Field Test stages. The Self Evaluation stage produced Prototype I after revisions. Initial evaluation is conducted to assess and refine teaching materials before expert validation (Diniarti, 2025).

During the Expert Review, two experts evaluated the pedagogical, content, and design aspects. Validity testing is conducted to ensure that the research design yields valid and reliable data through the use of validation instruments (Oktariyanti et al., 2021). The average validation score reached 0.84, categorized as high validity, indicating that Prototype I met the validity criteria.

The One-to-One evaluation involved three students with different ability levels. The results showed a practicality score of 98.41% (very practical), producing Prototype II, which was deemed practical for classroom use. These findings align with previous research indicating that developed teaching materials are feasible and practical based on positive student responses (Diniarti, 2025).

In the Small Group evaluation, involving nine students, the practicality score reached 98.94% (very practical), resulting in Prototype III, which was both valid and practical. The evaluation process concluded with the Field Test, aimed at identifying the effectiveness of the developed E-LKPD. The Field Test was conducted with 24 students of Grade XII.8 at SMA Negeri 19 Palembang. The results showed an increase in the average score from 40.42 on the pretest to 89.17 on the posttest, with an N-Gain score of 0.84 (high category).

The improvement in learning outcomes indicates that the guided inquiry-based E-LKPD has a positive impact on students' understanding of electrolyte and non-electrolyte solution concepts. This is because the guided inquiry model actively involves students in concept discovery through systematic learning stages, leading to deeper conceptual understanding.

Based on the validity test through expert review, the E-LKPD was declared valid and suitable for use. The One-to-One and Small Group evaluations demonstrated that the E-LKPD is practical and meets students' needs. Furthermore, the effectiveness test through the Field Test showed that the E-LKPD contributes positively to the learning process. Therefore, it can be concluded that the guided inquiry based E-LKPD on electrolyte and non-electrolyte solutions for Grade XII senior high school students developed in this study meets the criteria of validity, practicality, and effectiveness.

■ CONCLUSION

The results of the study indicate that the guided inquiry-based E-LKPD demonstrates high levels of validity, practicality, and effectiveness, making it feasible for use in chemistry learning. This E-LKPD can be utilized by teachers as an innovative digital teaching material aligned with the Merdeka Curriculum to support the presentation of abstract chemistry concepts in a more interactive manner and to enhance students' engagement and learning independence. Future studies are recommended to develop similar guided inquiry-based E-LKPDs for other chemistry topics, involve a broader range of participants, and examine their impact on students' critical thinking skills, creativity, and scientific literacy.

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