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Validity of an Interactive E-Student Worksheet (E-LKPD) Based on Structured Inquiry Using Liveworksheets on the Reaction Rate Topic for Phase F Grade XI Senior High School

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Abstract

The reaction rate topic is considered one of the most challenging areas of chemistry because it involves abstract and conceptually complex principles. This study aimed to determine the validity of an interactive electronic student worksheet (E-LKPD) developed for the reaction rate topic using a structured inquiry model and the Liveworksheets platform. The study employed an Educational Design Research approach based on the Plomp model, comprising preliminary research, prototyping, and assessment phases; however, the investigation was limited to the prototyping phase, specifically Prototype III. Validation data obtained from three validators were analyzed using Aiken's V coefficient. The findings showed an overall average Aiken's V value of 0.96. Specifically, the E-LKPD achieved validity coefficients of 0.93 for content, 0.96 for presentation, 0.95 for language, 0.98 for graphics, and 0.99 for computer-based features, with all assessed components categorized as valid. These results indicate that the developed E-LKPD satisfies the required content, instructional, linguistic, visual, and technological validity criteria. The study contributes to the development of structured inquiry-based digital learning materials by providing

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a validated interactive resource for teaching reaction rates. The E-LKPD therefore has the potential to support more interactive chemistry learning and provides a foundation for subsequent studies examining its practicality and effectiveness in classroom implementation.

Keywords: Chemistry Education; Interactive E-LKPD; Liveworksheets; Reaction Rate; Structured Inquiry

INTRODUCTION

The reaction rate topic is part of the Phase F senior high school chemistry curriculum under the Indonesian National Curriculum (Kemendikbud, 2022). This topic is often perceived as difficult by students because it involves abstract and complex concepts. As a result, students tend to memorize formulas and the factors affecting reaction rates without fully understanding the underlying conceptual relationships (Kirani & Azhar, 2023). To overcome these learning difficulties, students need to understand the three levels of chemical representation, namely the macroscopic, submicroscopic, and symbolic levels. Therefore, an instructional model that guides students to construct concepts gradually is required. One suitable model is structured inquiry, in which the teacher provides the problem, procedures, and guiding questions, while students conduct investigations and draw conclusions based on the data they collect (Zion & Mendelovici, 2012). This model is considered appropriate for teaching the reaction rate topic because it helps students understand abstract concepts through the stages of observation, hypothesis formulation, data collection, and conclusion drawing (Iyengar et al., 2018).

To optimize the implementation of structured inquiry, the model should be integrated into instructional materials that systematically guide students throughout the learning process. One such instructional material is the Electronic Student Worksheet (E-LKPD). In addition to serving as a learning resource, an E-LKPD functions as a learning guide that facilitates students in observing phenomena, formulating hypotheses, collecting and analyzing data, and drawing conclusions (Firdaus & Wilujeng, 2018).

The development of E-LKPD should also be supported by the integration of digital technology to promote more interactive learning. One platform that can be utilized is Liveworksheets, a web-based platform that enables E-LKPD to be presented as interactive electronic worksheets equipped with images, videos, exercises, and immediate feedback

(Augia et al., 2025; Shafnahriyah & Sukarmin, 2026). The use of Liveworksheets can make learning more engaging, increase students' participation, and support more active chemistry learning (Anggrahini & Rusmini, 2022).

The results of classroom observations and interviews conducted at SMAN 1 Lembah Melintang revealed that the instructional materials currently used consist mainly of textbooks, printed modules, and printed student worksheets (LKPD). The instructional approaches implemented are still limited to Problem-Based Learning and guided learning. Furthermore, students continue to experience difficulties in understanding the abstract concepts related to the reaction rate topic. Questionnaire results also indicated that students expect instructional materials that are visually attractive, colorful, integrated with technology such as Liveworksheets, incorporate an appropriate learning model, and include the three levels of chemical representation. Therefore, this study aimed to determine the validity of an interactive E-LKPD on the reaction rate topic based on the structured inquiry model using the Liveworksheets platform for Phase F Grade XI senior high school students.

METHODS

This study employed the Educational Design Research (EDR) approach using the Plomp development model (Plomp & Nieveen, 2013), limited to the product validity testing stage. The research design was based on the Plomp model combined with Tessmer's formative evaluation. The preliminary research phase consisted of needs analysis, context analysis, literature review, and the development of a conceptual framework. The prototyping phase involved the design of Prototype I, followed by self-evaluation to produce Prototype II. Subsequently, expert review and one-to-one evaluation were conducted to obtain Prototype III (Nieveen & Folmer, 2013).

The study was conducted over a three-month period, from February to April 2026. The research participants consisted of three expert validators, who were chemistry lecturers, and three Grade XI Phase F students from SMAN 1 Lembah Melintang. The students, representing high, medium, and low academic achievement levels, were involved in the needs analysis stage, while the expert validators participated in the product validation stage. The research instruments included a needs analysis questionnaire, a self-evaluation checklist, an expert validation sheet, and a one-to-one evaluation sheet. Data were collected through interviews, questionnaire administration, expert validation, and trials conducted during the one-to-one evaluation stage. Interview data, validator comments, and student responses were analyzed using qualitative descriptive techniques, whereas the expert validation data were analyzed using Aiken's V coefficient to determine the validity level of the developed E-LKPD. The product was considered valid if the Aiken's V value met the validity criteria established in this study (Aiken, 1985).

RESULTS

This study produced an interactive E-LKPD through the following stages:

1. Preliminary Research

The preliminary research phase was conducted to obtain initial information that served as the basis for developing an interactive E-LKPD based on structured inquiry using the Liveworksheets platform for the reaction rate topic. This phase included needs analysis, context analysis, literature review, and the development of a conceptual framework in accordance with the Plomp development model. The results of the needs analysis, obtained through interviews with a chemistry teacher and questionnaires administered to students at SMAN 1 Lembah Melintang, indicated that the reaction rate topic is still considered difficult because it involves abstract and complex concepts. The learning process was predominantly conducted through lectures and classroom discussions. The instructional materials used were limited to textbooks, printed modules, and printed student worksheets (LKPD). In addition, technology-based instructional media such as Liveworksheets had not yet been utilized optimally. Students also expressed the need for instructional materials that are visually attractive and colorful, integrated with technology such as Liveworksheets, incorporate an appropriate learning model, and include the three levels of chemical representation.

The context analysis, based on the Indonesian National Curriculum, identified the Phase F Learning Outcomes, which require students to be able to analyze the factors affecting reaction rates. Based on these learning outcomes, the learning objectives for the reaction rate topic were formulated. Meanwhile, the literature review indicated that the structured inquiry model can assist students in constructing concepts through guided investigations, while the use of digital learning media such as Liveworksheets has the potential to increase students' engagement in the learning process. Based on the results of the needs analysis, context analysis, and literature review, a conceptual framework was developed as the foundation for designing an interactive E-LKPD based on structured inquiry using the Liveworksheets platform for the reaction rate topic.

2. Prototyping Phase

In this study, the prototyping phase consisted of the development of Prototype I, Prototype II, and Prototype III.

A. Prototype I

Prototype I represents the initial design developed based on the results of the needs analysis, context analysis, literature review, and conceptual framework established during the preliminary research phase. The developed E-LKPD was designed according to the syntax of the structured inquiry learning model, which includes the stages of observation, hypothesis formulation, data collection and organization, and conclusion drawing. This phase resulted in the initial prototype of an interactive E-LKPD using the Liveworksheets platform for the reaction rate topic. The E-LKPD consisted of several components, including the cover, user instructions, learning outcomes and learning objectives, learning activities, interactive exercises, evaluation, and references.

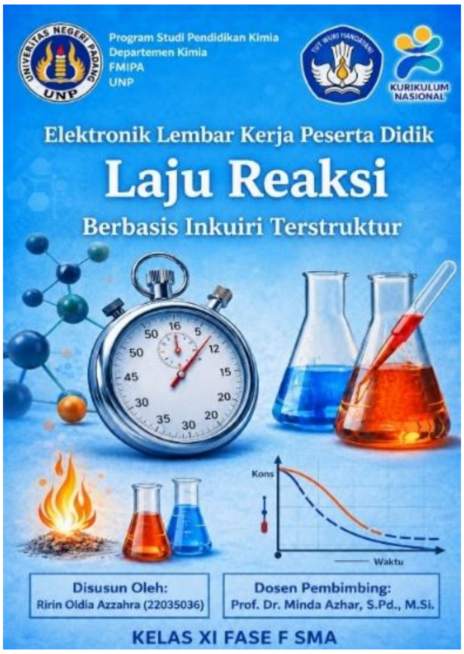

Figure 1. Cover of the E-LKPD

Materi Prasyarat : Reaksi cepat dan reaksi lambat

Observasi

Perhatikan gambar 1 & 2 berikut ini !

Dalam kehidupan sehari-hari, reaksi kimia dapat berlangsung dengan laju yang berbeda-beda. Kembang api merupakan contoh reaksi yang berlangsung sangat cepat karena dalam waktu singkat menghasilkan cahaya, panas, dan suara. Sebaliknya, proses perkaratan besi berlangsung sangat lambat karena membutuhkan waktu yang cukup lama hingga terbentuk karat pada permukaan besi.

Gambar 1. Kembang Api
Sumber : Theodore, 2012

Gambar 2. korosi pada besi
Sumber : Theodore, 2012

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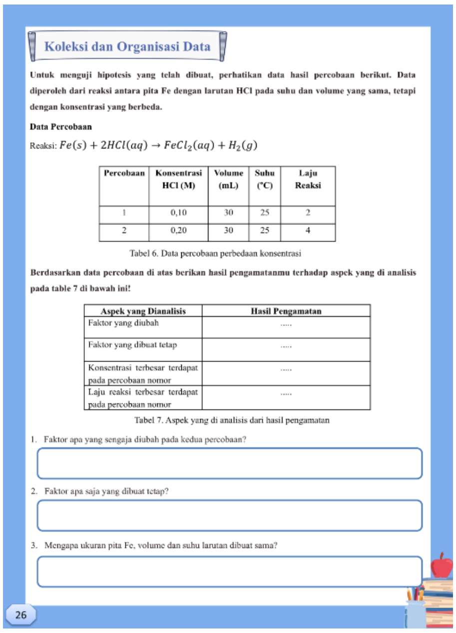
Figure 2. Observation Stage



Koleksi dan Organisasi Data

Untuk menguji hipotesis yang telah dibuat, perhatikan data hasil percobaan berikut. Data diperoleh dari reaksi antara pita Fe dengan larutan HCl pada suhu dan volume yang sama, tetapi dengan konsentrasi yang berbeda.

Data Percobaan

Reaksi: $Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

Percobaan	Konsentrasi HCl (M)	Volume (mL)	Suhu (°C)	Laju Reaksi
1	0,10	30	25	2
2	0,20	30	25	4

Tabel 6. Data percobaan perbedaan konsentrasi

Berdasarkan data percobaan di atas berikan hasil pengamatanmu terhadap aspek yang di analisis pada table 7 di bawah ini!

Aspek yang Dianalisis	Hasil Pengamatan
Faktor yang diubah	.....
Faktor yang dibuat tetap	.....
Konsentrasi terbesar terdapat pada percobaan nomor	.....
Laju reaksi terbesar terdapat pada percobaan nomor	.....

Tabel 7. Aspek yang di analisis dari hasil pengamatan

1. Faktor apa yang sengaja diubah pada kedua percobaan?
2. Faktor apa saja yang dibuat tetap?
3. Mengapa ukuran pita Fe, volume dan suhu larutan dibuat sama?

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Figure 3. Data Collection and Organization Stage

As shown in Figures 1–3, the interactive E-LKPD based on structured inquiry using the Liveworksheets platform was designed with a systematic and visually appealing layout to support the learning process on the reaction rate topic. Figure 1 presents the cover of the E-LKPD, which includes the identity of the instructional material, the topic, and an attractive visual design intended to capture students' attention. Figure 2 illustrates the observation stage, which serves as the initial phase of learning by guiding students to observe a phenomenon or problem related to reaction rates as a basis for stimulating their curiosity.

Figure 3 depicts the data collection and organization stage, in which students gather, classify, and analyze information obtained from various sources or observations to identify relationships among concepts. These three sections demonstrate that the E-LKPD effectively integrates the stages of the structured inquiry model with the interactive features of Liveworksheets, thereby facilitating active, systematic, and independent learning.

B. Prototype II

Prototype II was developed from Prototype I through the self-evaluation stage as part of the formative evaluation process. At this stage, the researcher independently reviewed the E-LKPD to examine the completeness of its components, the appropriateness of the content, language, presentation, visual design, and the functionality of the interactive features provided by the Liveworksheets platform. The evaluation results indicated that the E-LKPD already contained the main components required in the student worksheet development guidelines, including the identity of the instructional material, user instructions, Learning Outcomes (CP), Learning Objectives (TP), learning materials, learning activities, and assessment. However, several aspects still required improvement, including writing accuracy, layout, image quality, and the functionality of hyperlinks and interactive features. Revisions made based on the findings of this stage resulted in Prototype II, which was subsequently ready for expert validation. The self-evaluation was conducted based on the aspects presented in Table 1.

Table 1. Self-Evaluation Results

Aspect	Deficiency		Description
	Yes	No	
Cover	✓		The layout of the title, images, and product identity still needs improvement.
User Instructions	✓		The instructions for using the E-LKPD and the Liveworksheets features need to be clarified.
Table of Contents	✓		The organization and formatting of the table of contents need improvement.
Learning Outcomes (CP) and Learning Objectives (TP)	✓		The wording needs to be aligned with the Indonesian National Curriculum.
Concept Map	✓		The relationships among the concepts need to be presented more clearly.
Learning Activities	✓		The organization of the learning activities and activity instructions needs to be improved.
Structured Inquiry Stages	✓		Several guiding questions in the hypothesis formulation, data collection, and conclusion stages need revision.

Aspect	Deficiency		Description
Exercises and Assessment	✓		Several questions need to be revised in terms of language and alignment with the learning objectives.
Language	✓		Typographical errors and several ineffective sentences were still identified.
Graphics	✓		The layout, font size, color selection, and image quality require improvement.
Liveworksheets Features	✓		Several interactive features and the answer submission instructions need further refinement.

Based on Table 1, the self-evaluation results indicated that the developed E-LKPD still had several shortcomings across all evaluated aspects and therefore required revision before proceeding to the expert validation stage. Improvements were made to the cover design, user instructions, table of contents, the alignment of the Learning Outcomes (CP) and Learning Objectives (TP) with the Indonesian National Curriculum, the concept map, and the organization of the learning activities to ensure a more systematic structure. In addition, revisions were carried out on the structured inquiry stages, particularly by refining the guiding questions used during the hypothesis formulation, data collection, and conclusion stages to better support students throughout the inquiry process. Regarding the assessment component, several questions were revised to improve their language and alignment with the learning objectives. Language revisions included correcting typographical errors and improving ineffective sentence structures. Improvements were also made to the graphical aspects, including layout, font size, color selection, and image quality, as well as to the Liveworksheets component by refining the interactive features and submission instructions. The results of this self-evaluation served as the basis for the initial revision process, thereby improving the overall quality of the E-LKPD and preparing it for the subsequent expert validation stage.

C. Prototype III

Prototype III was evaluated through expert review and one-to-one evaluation. During the expert review stage, the E-LKPD was validated by experts based on five aspects: content, presentation, language, graphics, and computer-based features to determine the validity of the product. Feedback provided by the validators served as the basis for revising the E-LKPD. Subsequently, the one-to-one evaluation involved three Grade XI Phase F students from SMAN 1 Lembah Melintang representing high, medium, and low academic achievement levels to obtain preliminary feedback regarding the clarity, attractiveness, and ease of use of the developed E-LKPD.

1) Expert Review

The expert review stage was conducted to ensure that the developed E-LKPD was aligned with the learning objectives, students' characteristics, and the principles of digital instructional material development. The validators' assessments were analyzed using Aiken's V coefficient to determine the product's validity. An aspect was considered valid if its Aiken's V value was ≥ 0.92, whereas a value < 0.92 indicated that the aspect was not valid.

The content aspect obtained an Aiken's V value of 0.93, which was categorized as valid. This aspect evaluated the alignment of the E-LKPD content with the Learning Outcomes (CP), Learning Objectives (TP), conceptual accuracy, and the implementation of the structured inquiry model.

The presentation aspect obtained an Aiken's V value of 0.96, which was categorized as valid. This aspect assessed the systematic organization of the E-LKPD, the integration of the structured inquiry stages, and the clarity of the learning activity sequence.

The language aspect obtained an Aiken's V value of 0.95, which was categorized as valid. This aspect evaluated the clarity of the language, the accuracy of scientific terminology, and the appropriateness of the sentence structures used in the E-LKPD.

The graphical aspect obtained an Aiken's V value of 0.98, which was categorized as valid. This aspect assessed the visual appearance of the E-LKPD, including the layout, font selection, color usage, and the clarity of images and illustrations.

The computer-based aspect obtained the highest Aiken's V value of 0.99, which was categorized as valid. This aspect evaluated the utilization of digital features within the E-LKPD, including ease of navigation, interactivity, visual integration, and the functionality of features available on the Liveworksheets platform.

The overall results of the E-LKPD validation are presented in Table 2.

Table 2. E-LKPD Validation Results

No.	Evaluated Aspect	Aiken's V	Category
1	Content	0.93	Valid
2	Presentation	0.96	Valid
3	Language	0.95	Valid
4	Graphics	0.98	Valid
5	Computer-Based	0.99	Valid

As shown in Table 2, all five evaluated aspects achieved valid categories, indicating that the developed E-LKPD met the established validity criteria.

Revisions made to several parts of the E-LKPD based on the feedback provided by the expert validators are presented in Figure 4, which compares the appearance of the E-LKPD before and after revision.

Hipotesis

Berdasarkan hasil pengamatan yang telah Ananda lakukan, buatlah dugaan sementara mengenai pengaruh ragi terhadap proses pengembangan adonan dengan melengkapi pernyataan berikut.

Berdasarkan hasil observasi, saya menduga bahwa penambahan .... dapat mempercepat proses pengembangan adonan. Semakin banyak zat tersebut membantu proses pengembangan, maka perubahan yang terjadi pada adonan akan berlangsung lebih .... dibandingkan adonan tanpa penambahan zat tersebut.

Koleksi dan Organisasi Data

C. Faktor- faktor yang mempengaruhi laju reaksi

4. Katalis

Pada kegiatan sebelumnya, Ananda telah menduga bahwa penambahan ragi dapat mempercepat suatu proses perubahan. Lalu, bagaimana suatu zat dapat mempercepat laju reaksi tanpa ikut habis bereaksi? Untuk lebih memahami perhatikan gambar 12 di bawah ini!!

Gambar 12. Pengaruh katalis terhadap hidrogen peroksida menjadi air dan gas oksigen.
Sumber : Theodore, 2012

Gambar 12 tersebut menunjukkan pengaruh katalis terhadap reaksi penguraian hidrogen peroksida ((H_2O_2) menjadi air (H_2O) dan gas oksigen (O_2). Pada awalnya, partikel-partikel hidrogen peroksida bereaksi dengan lambat. Setelah katalis ditambahkan, reaksi berlangsung lebih cepat sehingga gas oksigen lebih cepat terbentuk.

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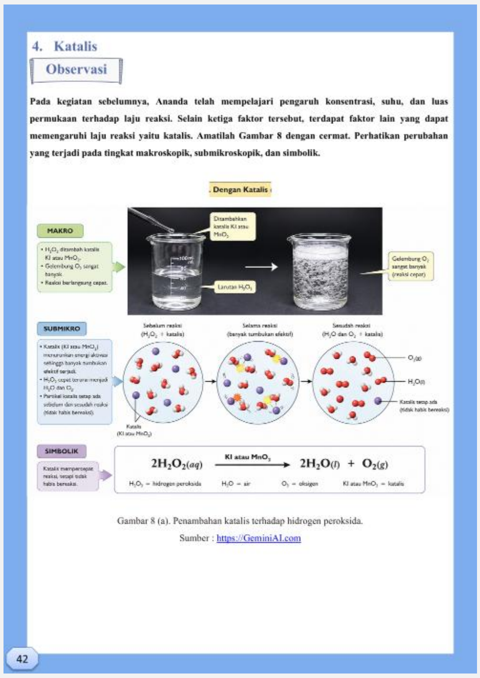
Figure 4. (a) Before Revision



4. Katalis

Observasi

Pada kegiatan sebelumnya, Ananda telah mempelajari pengaruh konsentrasi, suhu, dan luas permukaan terhadap laju reaksi. Selain ketiga faktor tersebut, terdapat faktor lain yang dapat memengaruhi laju reaksi yaitu katalis. Amatilah Gambar 8 dengan cermat. Perhatikan perubahan yang terjadi pada tingkat makroskopik, submikroskopik, dan simbolik.

Gambar 8 (a). Penambahan katalis terhadap hidrogen peroksida.
Sumber : https://GeminiAI.com

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Figure 4. (b) After Revision Based on the Validators' Suggestions

As shown in Figures 4(a) and 4(b), the differences between the two versions indicate that the revisions made based on the validators' suggestions resulted in a more attractive, well-organized, and detailed appearance of the E-LKPD.

2) One-to-One Evaluation

The one-to-one evaluation stage was conducted to obtain preliminary feedback on the developed E-LKPD, particularly regarding the clarity of its content, ease of use, and visual attractiveness.

The results of the one-to-one evaluation indicated that the interactive E-LKPD based on the structured inquiry model using the Liveworksheets platform was well understood by the students and had an attractive visual design. The observation results showed that the students provided positive feedback on the developed E-LKPD. They stated that the user instructions, presentation of the learning materials, and learning activities were sufficiently clear and easy to follow. However, several aspects still required improvement, including revisions to the wording, clearer instructions for several learning activities, and adjustments to the display of certain interactive features. The feedback provided by the students was used as the basis for revising Prototype II, resulting in an improved Prototype III that was ready for the next stage of development.

DISCUSSION

The validation results indicate that the interactive E-LKPD based on the structured inquiry model using the Liveworksheets platform for the reaction rate topic in Phase F Grade XI Senior High School met the validity criteria across all evaluated aspects, namely content, presentation, language, graphics, and computer-based features. These findings demonstrate that the developed E-LKPD is aligned with the learning objectives, the characteristics of the reaction rate topic, and students' needs for interactive digital instructional materials.

The content aspect obtained a validity score of 0.93, indicating that the materials presented in the E-LKPD are aligned with the Learning Outcomes (CP), Learning Objectives (TP), the concepts of reaction rate, and the stages of the structured inquiry model. This is important because content validity reflects the accuracy of the instructional materials and their alignment with the curriculum and learning objectives (Plomp & Nieveen, 2013). These findings are consistent with the study conducted by (Hidayah et al., 2023), which reported that an E-LKPD developed by ensuring alignment between the instructional materials, learning outcomes, indicators, and learning objectives achieved a very high level of content validity and was therefore considered appropriate for use in the learning process.

The presentation aspect, which obtained a validity score of 0.96, indicates that the E-LKPD was organized systematically and coherently, enabling students to follow the learning process from observation to conclusion drawing. This well-structured presentation is consistent with the characteristics of the structured inquiry model, which guides students in constructing conceptual understanding through a gradual learning process (Zion & Mendelovici, 2012; Amalia et al., 2022).

The language aspect obtained a validity score of 0.95, which was categorized as valid. This result indicates that the language used in the E-LKPD is clear, communicative, and appropriate for the students' level of development, making both the instructions and learning materials easier to understand. Clear language is an essential component of instructional materials because it supports independent learning and minimizes the possibility of misinterpreting either the content or the learning procedures. These findings are consistent with the study by (Sari et al., 2021; Andani & Azhar, 2023), which demonstrated that the use of communicative, simple language that is appropriate to students' characteristics contributes to improved readability, better comprehension of learning materials, and the overall feasibility of E-LKPD as digital instructional material.

Furthermore, the graphical aspect obtained a validity score of 0.98, which was categorized as valid. This score indicates that the layout, font selection and size, color usage, as well as the clarity of images and illustrations effectively support both the readability and visual appeal of the E-LKPD. In chemistry learning, an effective visual design is particularly important because it helps students understand abstract concepts through clearer representations. These findings are consistent with the study conducted by (Mardhatillah & Aini, 2025) which reported that high-quality graphical design contributes significantly to the quality and feasibility of E-LKPD as instructional material.

The highest validity score was obtained for the computer-based aspect, with an Aiken's V value of 0.99, which was categorized as valid. This result indicates that the digital features provided by the Liveworksheets platform, including user-friendly navigation, interactivity, immediate feedback, and integrated visual design, effectively support the function of the E-LKPD as an interactive and user-friendly digital learning resource. These characteristics provide students with a more active learning experience by enabling them to interact directly with the instructional materials. These findings are consistent with the study by (Sailer & Homner, 2020), which concluded that the integration of digital technology into learning can improve student engagement, motivation, and the overall quality of learning through more interactive and engaging instructional activities. In addition (Zainuddin et al., 2020; Schmid et al., 2016) reported that the use of interactive digital learning media enhances students' active participation, independent learning, and learning outcomes by providing a more engaging and student-centered learning experience.

Overall, the findings of this study demonstrate that the interactive E-LKPD based on the structured inquiry model using the Liveworksheets platform is valid and appropriate for use as instructional material for the reaction rate topic due to its high level of validity. This study contributes by providing an alternative digital instructional material that integrates the structured inquiry model with an interactive learning platform to support chemistry learning. However, this study was limited to the product validity stage. Therefore, further research is recommended to examine the practicality and effectiveness of the developed E-LKPD in actual chemistry classroom implementation.

CONCLUSION

Based on the findings of this study, it can be concluded that the interactive E-LKPD based on the structured inquiry model using the Liveworksheets platform for the reaction rate topic in Phase F Grade XI Senior High School has met the validity criteria, achieving high validity scores across all evaluation aspects, namely content (0.93), presentation (0.96), language (0.95), graphics (0.98), and computer-based features (0.99). These results indicate that the developed E-LKPD is well aligned with the Learning Outcomes (CP), the characteristics of the reaction rate topic, the principles of the structured inquiry model, and students' needs for interactive digital instructional materials. Therefore, the developed E-LKPD is considered suitable for use as one of the instructional materials to support chemistry learning in Phase F Grade XI Senior High School.

This study contributes to the development of digital instructional materials in chemistry education, particularly through the design of an interactive E-LKPD based on the structured inquiry model using the Liveworksheets platform. The developed E-LKPD not only integrates the stages of structured inquiry learning with interactive digital technology but also provides an alternative instructional resource that is aligned with the demands of twenty-first-century learning and the implementation of the Indonesian National Curriculum. Furthermore, the findings of this study may serve as a reference for teachers, instructional material developers, and researchers in designing valid, engaging, and interactive digital learning media that can enhance students' engagement in chemistry learning.

This study was limited to the product validity stage and, therefore, did not examine the practicality and effectiveness of the developed E-LKPD in classroom implementation. Consequently, future studies are recommended to investigate its practicality through classroom implementation and to evaluate its effectiveness in improving students' learning outcomes, critical thinking skills, science process skills, and learning motivation. In addition, the developed E-LKPD may be adapted for other chemistry topics or integrated with various innovative instructional approaches and emerging digital technologies to produce instructional materials that are more effective, relevant, and responsive to the evolving needs of learning in the digital era.

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