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Development of a RADEC-Based E-LKPD Using Liveworkaheets for Thermochemistry Learning

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Abstract: This study aims to develop an Electronic Student Worksheet (E-LKPD) based on the RADEC (Read, Answer, Discuss, Explain, Create) learning model using the Liveworksheets platform to enhance learning quality and student engagement. The study employed the 4-D development model (Define, Design, Develop, Disseminate), limited to the development stage. The research instruments consisted of expert validation sheets and user response questionnaires. Data were analyzed using descriptive quantitative and qualitative techniques. Quantitative data were obtained from expert validation questionnaires and teacher and student response questionnaires, while qualitative data were derived from observations and open-ended responses, analyzed through data reduction, data display, and conclusion drawing. The validation results from two material experts indicated that the E-LKPD achieved validation scores ranging from 91.6% to 95.8%, categorized as "Valid." Meanwhile, media validation by one media expert resulted in a score of 100%, also categorized as "Valid." Trials involving teachers yielded a response score of 90.63%, and trials involving students obtained 92.32%, both classified as "Very Good." Therefore, the RADEC-based E-LKPD was declared valid and received highly positive responses, indicating its potential for use in teaching thermochemistry to Grade XI SMA/MA students.

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Introduction

Technological developments impact various areas of life, including education. Technological advancements in education have produced many new innovations to assist students in learning. One result of this increasingly rapid technological development is the increasing variety of new media and teaching materials utilizing technology. Available media and teaching materials include e-books, digital modules, and electronic student worksheets (Safitri, 2022). In the context of learning, these challenges are increasingly apparent, especially in subjects like chemistry, which contain abstract concepts and require in-depth understanding (Resi Safira, 2023).

Chemistry, a subject that studies matter and its changes, is one of the topics studied in grade 11 of high school (SMA/MA). This topic discusses the changes in energy in the form of heat that accompany chemical reactions (Chang, 2005). Based on interviews with chemistry teachers at SMAN 1 Pinggir and SMAS Cendana Mandau, it was discovered that many students had not yet achieved the Learning Objective Completion Criteria (KKTP) for thermochemistry. The minimum grade point average (KKTP) for each school was 70 for SMAN 1 Pinggir and 78 for SMAS Cendana Mandau. The student learning achievement rate was only in the 50%–56% range. Teachers reported that students had difficulty understanding

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the abstract concepts of calculating heat and enthalpy change, which require logical and numerical skills.

One contributing factor to students' low understanding is the limited use of teaching materials that are not yet aligned with student characteristics. Interviews revealed that teachers still use printed worksheets (LKPD) as learning resources, with unattractive designs, minimal interactivity, and one-way delivery. As a result, students tend to be passive and uninterested in reading textbooks, making the LKPDs ineffective in fostering students' reading and literacy. However, low reading interest directly impacts conceptual understanding and learning outcomes. This finding is reinforced by Wibowo & Ariyatun (2020), who stated that Indonesian students' literacy levels remain relatively low compared to other countries.

Engaging, interactive, and student-centered teaching materials are essential to supporting chemistry learning. One form of teaching material that can accommodate this is the Electronic Student Worksheet (E-LKPD). E-LKPDs are digitally designed and accessible through various devices. Platforms like liveworksheets allow teachers to create interactive LKPDs by inserting images, audio, video, and auto-check features, which enhance students' reading and learning. E-LKPD also supports flexible learning anytime and anywhere, in line with the development of digital technology in education (Resi Safira, 2023).

Effective use of E-LKPD still requires a learning design that encourages active student engagement. Therefore, it needs to be integrated with a learning model that can stimulate student engagement, in-depth understanding, and productivity. Based on interviews, teachers reported that students not only showed low interest in reading but also were less active in discussing and explaining the material they had learned. This indicates that learning did not encourage deep learning. Deep learning is characterized by students' ability to connect concepts, reflect, and apply knowledge meaningfully in new situations (Hastuti et al., 2025).

The RADEC (Read, Answer, Discuss, Explain, and Create) learning model was designed to address these issues. RADEC is student-centered and consists of five stages: reading, answering questions, discussing, explaining, and creating. Each stage is designed to foster reading interest, active engagement, and conceptual understanding of the learning material. This model contributes to building meaningful and in-depth learning by encouraging students to reflect on information, collaborate, and produce their own learning products (Widyarti & Chrysti Suryandari, 2024).

RADEC naturally supports deep learning by providing space for students to experience higher-level cognitive processes such as analyzing, evaluating, and creating. One of the key advantages of the RADEC model is the Read stage, which encourages students to read and understand the material before the main activity begins. This stage is highly effective in improving literacy because it encourages students to actively acquire information and construct understanding independently. By integrating RADEC into Liveworksheets-based e-LKPD, teachers can create more engaging, interactive, and student-centered learning activities.

Previous research related to the development of RADEC-based e-LKPD was conducted by (Rara & Waworuntu, 2023) it showed that the use of the RADEC model in reaction rates effectively improved student learning outcomes, with an N-gain of 0.564 (moderate category) and an effectiveness of 56.4%. Similar results are also supported by a study by (Mardiansari et al., 2022) which showed that the RADEC model was able to improve students' mastery of multiple representations in buffer solutions, although mastery of the submicroscopic aspect still requires strengthening. Previous studies on creating student worksheets usually follow a conventional method and haven't properly included literacy-based learning strategies like RADEC (Read, Answer, Discuss, Explain, and Create). Also, using interactive digital tools like Liveworksheets in worksheet design is not common, especially when teaching Thermochemistry, which is a tough and abstract topic for students. This shows there's a need for better learning materials that can make students more involved and support both literacy and technology-based learning. The unique part of this study is combining the RADEC model with Liveworksheets in an E-LKPD format, which is specially made to help students better understand and connect with Thermochemistry ideas. Based on the information given, this study is focused on creating an E-LKPD using the RADEC learning model on the Liveworksheets platform, specifically for teaching Thermochemistry to students in grade XI of senior high school (SMA/MA) and similar levels. In addition, the study also seeks to evaluate how suitable, easy to use, and well-received the developed E-LKPD is by users.

Research Method

The development of RADEC-based E-LKPD uses a research and development method (R&D). The purpose of R&D is to produce a product that is useful for developing and improving the quality of education and learning effectively. The model used in this development is the 4-D development model which consists of four stages, namely Define, Design, Develop, and Disseminate (Trianto, 2012). The developed product is tested for its feasibility with validity by a validator and the product is tested to determine user responses.

The trial subjects in this study consisted of 3 students with different levels of ability (one-on-one test), 2 chemistry teachers (teacher responses) and 20 students (limited trial) each consisting of 10 students from SMAS Cendana Mandau and 10 students from SMAN 1 Pinggir who had studied thermochemistry material. The limited trial was conducted on 20 eleventh-grade students, as this stage aimed to determine the initial feasibility of the E-LKPD being developed. This number was considered representative to obtain feedback related to comprehensibility, appearance, and ease of use of the product before conducting a larger-scale field trial. At this stage, the students contributed as respondents or initial users who provided direct feedback on the RADEC-based E-LKPD**.** Their contributions included assessing the clarity of the content and instructions, the attractiveness of the design, and the ease of using the E-LKPD both independently and in groups. In addition, the students also provided suggestions and recommendations for improvement, which served as the basis for revising the product to make it more feasible and effective for use in the next trial phase (Sugiyono, 2019). The type of data required is quantitative data obtained from product validation results and user response questionnaire results (teachers and students), while qualitative data is teacher interview data and student questionnaires as well as comments and suggestions for improvement from material expert validators and media experts.

The instruments used in this study were a validity sheet and a user response questionnaire. The validity sheet was used to assess the feasibility of the developed E-LKPD in terms of content, presentation, language, and design, while the user response questionnaire was used to determine students' perceptions of the practicality and attractiveness of the product (Sugiyono, 2019). This instrument was used to determine the validity criteria of the RADEC-based E-LKPD on thermochemistry material. This validation sheet contains general teaching materials that are used as a reference in assessing the RADEC-based E-LKPD based on aspects of content feasibility, RADEC characteristics (Read, Answer, Discuss, Explain,

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Create) linguistic aspects, attractiveness aspects, presentation aspects, graphical aspects, and display feasibility. This instrument was used to determine the user response criteria for the RADEC-based E-LKPD in learning on thermochemistry material based on aspects of content feasibility, effectiveness aspects, and practicality aspects for teachers, as well as aspects of attractiveness, benefits of use, and ease of use for students.

The technical data analysis in this study uses a scale called the Likert scale with a score of 1-4

Tabel 1. Likert scale

Rating Scale	Information
4	Strongly agree
3	agree
2	Disagree
1	Don't agree

The results of the Likert scale assessment categories will be calculated as the average percentage of each component using the formula:

$$P = \frac{\Sigma x}{\Sigma xi} \times 100\%$$

Description:
P: Percentage score
Σx: Score obtained
Σxi: Maximum score

Result and Discussion

Development of RADEC-based E-LKPD (Read, Answer, Discuss, Explain, and Create) on thermochemistry material for grade XI SMA/MA which can be used by teachers and students. E-LKPD is designed as attractive as possible with the aim of making it easier for students to understand thermochemistry material in class and individual learning. This E-LKPD has been validated by 2 material expert validators and 1 media expert validator. The development of this E-LKPD consists of several development stages used, namely the 4-D development model which will be explained as follows.

Tabel 2. Subject Matter Expert Validation Assessment

Assessment Aspects	Validation I	Information	Validation II	Information
Content eligibility	65%	Quite Valid	92,5%	Valid
Language qualifications	75%	Valid	95%	Valid
Presentation Eligibility	75%	Quite Valid	95,8%	Valid
Characteristic feasibility REDEC	72,5%	Quite Valid	95%	Valid
Graphic qualification	75%	Quite Valid	95,8%	Valid
Orderliness of Concept Presentation	66,66%	Quite Valid	91,6%	Valid

Tabel 3. Media Expert Validation Assessment

Assessment Aspects	Validation I	Information	Validation II	Information
Display feasibility	87,5%	Valid	100%	Valid
Eligibility of software utilization	100%	Valid	100%	Valid

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1) Define

The definition stage is the initial step in developing learning media or other products. This stage aims to identify and formulate needs and limitations in development, including initial analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives (Seruni et al., 2019). This stage aims to identify the problems, needs, and objectives of the learning media to be developed. The process began with a front-end analysis through interviews with chemistry teachers at SMAS Cendana Mandau and SMAN 1 Pinggir. The interviews revealed that the printed LKPD currently in use has not been able to optimally improve student understanding due to its brief presentation, lack of interactivity, and not fully meeting LKPD creation standards.

These issues underlie the need to develop a more engaging RADEC-based e-LKPD that promotes literacy and supports active learning. The RADEC model provides space for students to read, answer questions, discuss, re-explain, and create learning products, thereby making the learning process more meaningful.

Next, an analysis was conducted of the target students for the e-LKPD: 11th-grade high school students aged 16–18. At this age, students are beginning to think abstractly, but still experience difficulties in understanding chemical concepts, particularly thermochemistry. Therefore, the developed e-LKPD must be appropriate for their cognitive development and help explain the material in a more visual and interactive manner.

The next stage is task analysis, which begins with a content structure analysis. The thermochemistry material developed is aligned with the Learning Objectives Flow (ATP) and covers topics such as systems and environments, Hess's law, calorimeters, and enthalpy changes. A concept analysis is then conducted to map the main material and the relationships between concepts. This is followed by a procedural analysis, which structures the learning steps based on the RADEC model, where each stage is interrelated and must be carried out sequentially.

The final stage of definition is the formulation of learning objectives, designed based on established learning outcomes and indicators. These objectives serve as a reference for developing the content and activities in the e-LKPD to align with student needs and the demands of the Independent Curriculum.

2) Design

The product design stage involves developing a conceptual framework and detailed design of the product to be created (Mulyatiningsih, 2015). This stage involves developing an initial design for the E-LKPD, a validation sheet, and a user response questionnaire. The E-LKPD is designed based on the results of a content structure analysis, concept analysis, procedural analysis, and objective analysis. Based on this analysis, the thermochemistry material consists of eight worksheets divided into four learning activities. The RADEC-based E-LKPD (Read, Answer, Discuss, Explain, and Create) contains the title, user instructions, learning objectives and learning flow, materials, RADEC components, practice questions for students to answer, and a bibliography.

The RADEC-based E-LKPD for thermochemistry is tailored to student needs, specifically by providing a more attractive E-LKPD display than existing school worksheets. The attractive appearance of the E-LKPD includes illustrations or images relevant to the thermochemistry material, bright colors, a neat layout of the material, and practice questions. The RADEC-based E-LKPD (Read, Answer, Discuss, Explain, and

Create) is designed to consist of steps or components aligned with the RADEC learning model. The E-LKPD also provides sufficient space to allow students to answer questions directly and facilitates students in expressing their thoughts based on the answers obtained. The validation sheet instrument, resulting from the design phase, was compiled by compiling relevant literature to obtain a validation sheet and assessment rubric, which refer to the Ministry of National Education (2008) and are tailored to the development needs of the RADEC-based E-LKPD.

The validation sheet instrument, conducted by material experts, consists of six aspects: content suitability, RADEC learning model characteristics suitability, language suitability, presentation suitability, graphic suitability, and presentation orderliness. The media expert validation sheet instrument consists of two aspects: the appearance feasibility aspect and the software usability aspect. The user response questionnaire instrument was designed by collecting several relevant literatures that met the research needs, resulting in a user response questionnaire for chemistry teachers and students.

3) Develop

The development stage is useful for determining the feasibility of a product with certain criteria (Lastri, 2023). This development stage produces a learning tool, namely the RADEC-based E-LKPD (Read, Answer, Discuss, Explain, and Create) on the topic of thermochemistry that has been designed in the design stage, then revised based on suggestions and input from the validator. The E-LKPD revision is carried out to correct errors contained in the E-LKPD so that the resulting E-LKPD is valid or suitable for use. The revised and valid E-LKPD is then tested on users, namely chemistry teachers and grade XII students of SMA/MA.

a. Expert Validation Results

Validation is the process of assessing the design or product of teaching materials that have been developed, to ensure that the teaching materials are suitable and effective for use in the learning process (Fikrina et al., 2023). Validation of the E-LKPD was carried out from July 25 to August 8, 2025, by three validators, consisting of two material experts and one media expert. Each validator conducted validation twice to ensure that the developed E-LKPD was truly suitable for use. The validation process was carried out by filling out an assessment sheet covering six aspects: content suitability, RADEC model characteristics, language, presentation, graphics, and presentation order. In addition to providing assessments, the validators also provided suggestions and input for product improvements. After improvements were made based on these suggestions, the E-LKPD was returned to the validators for re-assessment. This process was carried out until the E-LKPD was declared valid and ready for use in learning.

The first validation, for the content feasibility aspect, yielded a feasibility score of 65%, categorized as "fairly valid." Although it fell into the valid or suitable category, the validator still received suggestions and input for further improvement of the E-LKPD. The validator assessed that the E-LKPD was generally aligned with the learning outcomes and learning objectives. It also met students' needs and guided them in developing learning concepts.

For the content feasibility aspect, the validator assessed and recommended that the material in the E-LKPD be deepened by linking it to everyday life contexts, including prominent chemists who developed the concept of thermochemistry, adding supporting narratives to the example questions, and adding more example questions. After revisions were made based on the validator's suggestions and input, a second validation was

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conducted. The second validation, for the content feasibility aspect, increased to 92.5%, categorizing it as "valid." The validator assessed that the E-LKPD met the aspects assessed in the content feasibility aspect.

Validation of the language suitability aspect consists of five assessment components aimed at improving the use of language in accordance with Indonesian language rules in the e-LKPD. The first validation resulted in an average score of 75%, meeting the criteria for "fairly valid." The validator commented that the language used in the e-LKPD met the criteria for good, clear, and effective language.

The validator also suggested improvements to the language used for ease of understanding. After revisions were made based on the validator's suggestions and input, a second validation was conducted. The second validation resulted in a score of 95% for the language suitability aspect, which was categorized as valid. The validator assessed that the e-LKPD met the aspects assessed in the language suitability aspect.

The first validation result, for the presentation feasibility aspect, achieved a feasibility score of 75%, categorized as "fairly valid." Therefore, improvements are still needed to produce a better E-LKPD. Regarding the presentation feasibility aspect, the validator suggested adding instructions for use to the E-LKPD's complete format.

After revisions based on the validator's suggestions, the feasibility score for the presentation aspect increased to 95.8%, categorized as valid. The validator assessed the overall format of the E-LKPD (title, instructions for use, learning objectives and learning objective flow, materials, RADEC components, practice questions to be answered by students, and bibliography) as appropriate, and the E-LKPD design adequately reflected its content. The following images show the results before and after the presentation feasibility revision.

The first stage of validation of the characteristics of the RADEC (Read, Answer, Discuss, Explain, and Create) learning model achieved a score of 72.5%, meeting the "fairly valid" criteria. Improvements were made to refine the ELKPD. The assessment component in RADEC (Read, Answer, Discuss, Explain, and Create) learning encompasses five stages. In the "Read" stage, students read and understand the material. In the "Answer" stage, they answer basic questions posed by the teacher. Next, in the "Discuss" stage, students discuss their answers in the "Answer" stage. In the "Explain" stage, the results of the discussion are presented. Finally, in the "Create" stage, students create a product to demonstrate their understanding of the concept.

The validator suggested that the project be 3D-readable for the "Create" stage. This makes the project more realistic and easier to understand. This also helps students develop creativity. Improvements were made based on the validator's suggestions and input. The second stage of validation, based on the characteristics of the RADEC (Read, Answer, Discuss, Explain, and Create) learning model, achieved a score of 95%, meeting the "valid" criteria. The following image shows the results before and after the revision of the feasibility aspects of the RADEC characteristics (Read, Answer, Discuss, Explain, and Create).

The graphical feasibility aspect in validation I obtained a feasibility value of 75% and was included in the fairly valid category, improvements were made to produce a better E-LKPD. The validator suggested that the layout be improved to make it more attractive. After improvements were made, validation II obtained an increase in the feasibility value in the graphical aspect, namely 95.8% and was included in the valid category. This shows

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that overall the E-LKPD developed uses good font types and sizes, an attractive layout, and has clear illustrations/images/photos.

Validation of the feasibility aspect of the regularity of the concept presentation consists of 3 assessment components that aim to support the understanding of difficult concepts. The feasibility aspect of the regularity of the concept presentation in validation I obtained a feasibility value of 66.66% and is included in the category of quite valid, improvements were made to produce a better E-LKPD. The validator suggested that the solution to the example questions be detailed to make it easier to understand. After improvements were made, validation II obtained an increase in the feasibility value in the aspect of the regularity of the concept presentation, namely 91.6% and included in the category of valid. This shows that overall the developed E-LKPD has supported good conceptual understanding. The following is a picture of the results before and after the revision of the feasibility aspect of the regularity of the concept presentation.

The display feasibility test has eight assessment indicators aimed at assessing the attractiveness of the e-LKPD's appearance. The first validation test yielded an average score of 87.5%, meeting the valid criteria. However, the validator provided suggestions and improvements, necessitating revisions. The validator suggested adding the author's identity to the front cover of the e-LKPD. Furthermore, the validator suggested adding a YouTube link to the learning video.

The e-LKPD, which received suggestions and input, underwent a second revision and validation. The second validation test yielded a 100% display feasibility score, categorized as valid. According to Aulya et al. (2021), the use of teaching materials designed with a well-proportioned display will attract students' interest in learning. Overall, the validator assessed that the e-LKPD met the indicators used to assess the display feasibility of the e-LKPD. The following images illustrate the results before and after the revision of the display feasibility aspect.

The feasibility of software utilization has four assessment indicators aimed at assessing the operational ease of the E-LKPD software. The first validation test yielded an average score of 100%, meeting the valid criteria. The validator commented that accessing and exiting the E-LKPD was very easy and that the developed E-LKPD was very practical to use.

Research conducted by (Pendidikan et al., 2025) explains that by utilizing computer software in learning, students' learning needs are facilitated, resulting in ease and enjoyment, which impacts optimal learning outcomes. Overall, the validator assessed that the E-LKPD software met the indicators used to assess the feasibility of using the software.

b. Teacher Response Analysis

Teacher responses were conducted to obtain assessments, comments, and input from chemistry teachers regarding the product developed by Silvanny & Yerimadesi (2023). A teacher trial was conducted with two chemistry teachers from SMAS Cendana Mandau and SMAN 1 Pinggir by providing them with an e-LKPD (Educational Worksheet) and a teacher response questionnaire. The trial with SMAS Cendana Mandau teachers was conducted on September 1, 2025, and with SMAN 1 Pinggir teachers on September 2, 2025. The e-LKPD was given to the teachers and asked to view, read, provide suggestions, input, and evaluate the developed e-LKPD by assessing the provided questionnaire.

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The teacher response questionnaire assessment consisted of two aspects: content appropriateness and effectiveness. The lowest score for teacher responses was in the effectiveness aspect, which relates to learning activities and the material in the e-LKPD, which provides opportunities for students to be active. During the teacher trial, teachers also responded positively to the developed e-LKPD. They expressed interest in the RADEC-based (Read, Answer, Discuss, Explain, and Create) e-LKPD, and noted that it facilitated students' understanding of thermochemistry material during the learning process. The teacher trial yielded a score of 90.625%, falling within the very good criteria.

c. Student Trial Results

One-on-one trials were conducted with three 12th-grade students from SMAS Cendana Mandau and SMAN 1 Pinggir. The trials were conducted on September 4-5, 2025, at SMAS Cendana Mandau and September 8-9, at SMAN 1 Pinggir. These trials were conducted to obtain information on the clarity, ease of use, difficulty, and user response to the developed e-LKPD. The results of the one-on-one trials with six students indicated that the RADEC (Read, Answer, Discuss, Explain, and Create)-based e-LKPD was considered quite good because it was easy to access, visually appealing, and helped them understand thermochemistry material through fun project creation. However, several students reported that the answer spaces provided were insufficient and that internet access to the offline PDF version was limited.

The researchers observed student responses when using the e-LKPD, observed the level of ease and difficulty of using the e-LKPD, and observed the time required to complete the e-LKPD. In addition to relatively faster processing time, students with high abilities also showed higher scores than students with medium and low abilities. The highest average score for students was on E-LKPD 1, which discusses systems and environments as well as exothermic and endothermic reactions containing theory. Meanwhile, the lowest average score was on E-LKPD 2, which discusses thermochemical equations and standard enthalpy changes. Students still experienced difficulties in calculating standard enthalpy changes. The average score for the E-LKPD work by the three students was considered good because it was in the range of 88-93.

A limited trial was conducted with 20 students from SMAS Cendana Mandau and SMAN 1 Pinggir. The trial involved dividing the 10 students into four groups. Researchers distributed the E-LKPD along with a user questionnaire. They then provided a brief explanation of the RADEC (Read, Answer, Discuss, Explain, and Create) model and the procedures for completing the user response questionnaire. The trial was conducted in-person, with user response questionnaires completed on September 8-9, 2025, at SMAS Cendana Mandau and September 10-11, 2025, at SMAN 1 Pinggir.

The user response questionnaire was assessed by students in two aspects: attractiveness and effectiveness. Both aspects scored 92.325%, categorizing them as very good. Students also provided suggestions and comments on the developed E-LKPD. Students responded positively to the E-LKPD. Overall, many commented that the developed E-LKPD had an attractive appearance. In terms of content, students found the read phase to be very helpful, as it allowed them to understand the material independently, develop literacy skills, and feel more prepared to participate actively in learning because they had read beforehand. In addition to the read phase, students also felt a deeper understanding of the material through the create phase. In the create phase,

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students were given the opportunity to develop ideas and apply their understanding in the form of tangible products.

Conclusion

The developed e-LKPD was declared valid by a material expert validator. The validation results by the material expert validator, based on aspects of content suitability, language, presentation, characteristics of the RADEC (Read, Answer, Discuss, Explain, and Create) learning model, graphical quality, and the orderliness of concept presentation, obtained scores 92,5%, 95%, 95,8%, 95%, 95,8%, and 91,6% respectively categorized as "Valid." The validation results by the media expert validator, based on aspects of display suitability and software usability, obtained an average score of 100%, categorized as "Valid."

The teacher user response test was conducted by filling out a user response assessment sheet consisting of aspects of content suitability and effectiveness with feasibility percentages of 100% and 81.25%, respectively. The average percentage of the total score of teacher users' responses to E-LKPD was 90.625% with the criteria of "Very good". Then, the student user response consisted of aspects of attractiveness and effectiveness with feasibility percentages of 92.9% and 91.75%, respectively. The average percentage of the total score of the student response sheet was 92.32% with the criteria of "Very good".

Recommendation

Teachers should keep using RADEC-based e-LKPD in their lessons, not just for thermochemistry but for other chemistry topics too. Using this method regularly can help students pay more attention and think more deeply. To do this well, teachers need to keep getting better at using digital tools and learning platforms like Liveworksheets. It's also important for teachers to check how effective their e-LKPD is and keep making improvements. Teachers are encouraged to share their successful ideas through training sessions or by joining groups where they can learn from each other and help others use similar methods.

Future researchers should work on expanding the RADEC-based E-LKPD to other chemistry topics to check if it works well in different areas. They can also look into using more interactive and diverse digital tools. Along with creating better learning materials, using a quasi-experimental method is important to fairly measure how RADEC E-LKPD affects students' learning results, interest, and thinking abilities. Researchers might also focus on making evaluation tools that fit each stage of RADEC and adjust this method for different school levels, like high school or university. This would help spread the RADEC approach more and make a bigger difference in education.

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