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Game-Based Learning in Chemistry: Development of "Win Redox" Media on Reduction and Oxidation Reactions

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ABSTRACT

Purpose of the study: This study aims to determine the feasibility of chemistry learning media on the main material of the concept of reduction and oxidation reactions.

Methodology: This study uses the Research and Development development method, with the Sugiyono model which includes potential problems, information gathering, product design, design validation, design revision, product trial, product revision, product. Interactive game-based learning media named the win redox game contains material on the concept of reduction and oxidation reactions. The feasibility test of the win redox game is based on the learning outcomes and understanding of Class X students of Madrasah Aliyah Negeri 2 Semarang who have helped in the use of the win redox game and provided feedback on the game.

Main Findings: The cognitive learning outcomes of students are included in the moderate category with an increase in learning outcomes (N-gain) of 0.67. The affective aspect learning outcomes of 82.33% are included in the very good category, while the results of student responses of 77.40% are included in the good category, so this interactive game is suitable for use as an alternative learning medium.

Novelty/Originality of this study: This study presents "Win Redox" as a game-based learning medium specifically designed to enhance understanding of the concept of redox reactions, a concept rarely developed specifically. Unlike previous research, this medium integrates validated pedagogical design with interactive game elements. This research enriches the existing research by producing a learning medium that is not only engaging but also conceptually feasible and effective.

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1. INTRODUCTION

Chemistry learning at the secondary school level often faces challenges in improving students' understanding of abstract concepts that are difficult for them to visualize [1], [2]. One of the materials that is classified as complex is the concept of reduction and oxidation reactions which require a deep understanding of changes in oxidation numbers and electron transfer [3], [4]. Many students have difficulty in distinguishing between reduction and oxidation processes and applying them in solving problems [5], [6]. This condition shows

that conventional teacher-centered learning methods are still less effective in helping students build conceptual understanding [7], [8]. Therefore, it is necessary to innovate learning media that can actively increase student involvement and understanding..

Along with the development of educational technology, the Game-Based Learning approach is starting to be widely applied as an alternative interactive and fun learning strategy [9], [10]. This approach integrates game elements into the learning process to increase student motivation and participation [11], [12]. Educational games allow students to learn through hands-on experience, challenges, and instant feedback [13], [14]. This can help students understand difficult concepts in a more contextual and applicable way [15], [16]. Thus, Game-Based Learning has the potential to be a solution to overcome learning difficulties in abstract chemical material.

Game-based learning media has the advantage of creating a learning environment that is less monotonous and more engaging for students [17], [18]. The use of elements such as scores, levels, and competitions can increase learning interest and encourage active student participation [19], [20]. Furthermore, educational games can also train students' critical thinking and problem-solving skills [21], [22]. In the context of chemistry learning, games can be used to visualize concepts that are difficult to grasp directly. Therefore, the development of game-based learning media is crucial to support a more effective learning process.

One form of innovative learning media that can be developed is the educational game "Win Redox," designed specifically for reduction and oxidation reactions. This game is expected to help students understand redox concepts through structured and educational play activities [23], [24]. By integrating conceptual problems and challenges into the game, students can learn while playing without feeling overwhelmed [25], [26]. Furthermore, the use of this game can also increase student interaction with the learning material. Thus, "Win Redox" can be an innovative and relevant alternative learning medium.

Although various studies have examined the use of game-based learning in chemistry learning, most have focused on its impact on motivation and overall learning outcomes [27], [28]. Research specifically developing game media for the concept of reduction and oxidation reactions is still limited [29], [30]. Furthermore, not many media have been designed with consideration for content suitability, pedagogical aspects, and validity as learning media. This indicates a gap between learning needs and the availability of appropriate media. Therefore, research is needed to develop valid game-based learning media that aligns with the characteristics of redox material.

The novelty of this research lies in the development of the game-based learning media "Win Redox," specifically designed to facilitate understanding of the concepts of reduction and oxidation. This media not only integrates game elements but is also designed based on the principles of systematic and structured chemistry learning. Furthermore, this research emphasizes the feasibility of the media through a validation process by experts. Thus, the resulting media is not only engaging but also possesses academically sound quality. This novelty is expected to contribute to the development of innovative chemistry learning media.

The urgency of this research is based on the need for learning media that can improve the quality of chemistry learning, particularly in materials that students find difficult. The development of the "Win Redox" media is expected to be a solution to increase student engagement and understanding of the redox concept. Furthermore, this research is also important as it provides a reference for teachers in selecting and using effective learning media. With appropriate media, it is hoped that the learning process can proceed more optimally. Therefore, the main objective of this research is to determine the suitability of chemistry learning media for the main topic of the concepts of reduction and oxidation reactions.

2. RESEARCH METHOD

2.1. Development Model

This study used the Research and Development (R&D) method to develop an interactive game-based chemistry learning media for the concept of reduction and oxidation reactions [31], [32]. This method was chosen because it aimed to produce a suitable learning product while simultaneously testing its quality in supporting the learning process. The development model used refers to the research and development stages according to Sugiyono, which are systematic and appropriate for developing learning media. Through this model, the development process not only focuses on creating a new product but also aims to provide solutions to learning problems encountered in the field.

The resulting product in this study is the interactive game "Win Redox," designed as a learning medium to help 10th-grade students understand the concept of reduction and oxidation reactions. The development of this media was carried out through several structured stages, starting from identifying potential and problems to product validation. Each stage was designed to ensure that the developed media aligns with student needs and chemistry learning objectives. Therefore, the resulting learning media is expected to be of good quality and suitable for use in the learning process.

2.2. Development Procedures

The development procedure in this research was implemented through several main stages: preliminary study, prototype development, field testing, and dissemination and socialization. Each stage was carried out systematically to produce high-quality learning media that met students' needs. This process refers to research and development steps, aimed not only at producing a product but also at ensuring its feasibility and usefulness in learning. However, in this research, the stages were adjusted to time constraints and research conditions. Therefore, not all stages could be implemented thoroughly until the final stage.

The first stage was a preliminary study aimed at identifying potential and existing problems in chemistry learning, particularly in the topic of reduction and oxidation reactions. This potential can become problematic if not utilized effectively in the learning process. Therefore, data collection was necessary to provide a basis for designing the product to be developed. Data was obtained through the distribution of needs questionnaires to students and interviews with teachers to identify student difficulties and learning needs [33], [34]. The results of this preliminary study served as the basis for designing relevant and targeted learning media. Furthermore, this stage also aimed to strengthen the theoretical basis so that the developed product had a strong scientific basis. The second stage is prototype development, which includes product design, design validation, and design revision. In the product design stage, researchers designed a learning medium in the form of an interactive game, "Win Redox," tailored to the characteristics of the material and the needs of the students. This product design encompassed the game structure, content, and interaction mechanisms within the game. Next, the designed product was validated by experts to rationally assess the feasibility and suitability of the design. This validation process aims to identify the product's strengths and weaknesses before it is tested. Based on the validation results, design revisions are made to optimize the product.

The third stage is field testing, which aims to determine the product's effectiveness and feasibility in real-world conditions. Field testing is conducted after the product has gone through the validation and revision stages, ensuring it is suitable for testing. In this study, field testing was only conducted in the initial stage (limited field testing) due to time constraints. The testing was conducted on small groups of students with varying ability levels: low, medium, and high. Through this testing, data was obtained regarding student responses and the media's effectiveness in enhancing conceptual understanding. The results of the field testing were then used as a basis for further product improvements.

The next stage is product revision, which is conducted after the field testing. This revision aims to address any deficiencies identified during the trial process. Improvements are made to ensure the product meets the eligibility standards for effective and efficient learning media. The revision process is a crucial step in ensuring that the developed media truly meets user needs. Revisions are expected to improve product quality. The final result of this stage is a refined learning medium that is ready for use.

The final stage in the development model is product dissemination and socialization. At this stage, the product, once deemed feasible, should be introduced to teachers and students for widespread use in learning. Dissemination of learning media can be conducted through various platforms, such as the internet, for easy user access. However, the dissemination and socialization stages were not implemented in this study due to time and scope constraints. Nevertheless, the resulting product still has potential for development and dissemination in further research. Therefore, this study focuses on the development and feasibility testing of the game-based learning media "Win Redox."

2.3. Research Subjects

The subjects in this study were 10th grade science students at Madrasah Aliyah Negeri 2 Semarang. Subject selection was based on the suitability of the material studied, namely the concept of reduction and oxidation reactions taught at that level. This study involved students as the primary users of the developed learning media, the interactive game "Win Redox." Student involvement aimed to obtain data regarding the feasibility and response to the media used in learning. Thus, research subjects played a crucial role in providing a concrete picture of the effectiveness of the developed media.

The trial in this study was conducted on a small group of nine students. This number of subjects was chosen in accordance with the initial trial phase of the development research. The students involved had varying levels of ability—low, medium, and high—to provide a more representative range of data. Through this variation in ability, researchers were able to assess the extent to which the learning media could be used by various categories of students. The results of this trial are expected to provide comprehensive information regarding the feasibility of the developed learning media.

2.4. Data Collection Techniques

Data collection techniques are a crucial step in research to obtain accurate and relevant information for the research objectives. In this study, data were collected through several methods, including questionnaires, observations, and tests. The use of these various techniques aims to obtain comprehensive data from various sources. The data obtained is then analyzed to assess the feasibility of the developed learning media. Thus, the

research results are expected to provide an objective picture of the quality of the game-based learning media "Win Redox."

The first method used was a questionnaire. This is an indirect data collection technique through a series of questions or statements given to respondents. In this study, the questionnaire was used to obtain data related to student needs and an assessment of the developed learning media. A product validation questionnaire was administered to subject matter experts and media experts to assess the feasibility of the interactive game-based learning media [35], [36]. The questionnaire instrument consisted of a rating column with a specific scale and space for comments, criticisms, and suggestions.

The measurement scale used in the questionnaire was a Likert scale, allowing respondents to provide ratings ranging from very positive to very negative. Each indicator in the questionnaire was structured based on predetermined variables, thus measuring aspects relevant to the research objectives. Through this questionnaire, researchers were able to obtain quantitative and qualitative data regarding respondents' perceptions of the learning media. The data obtained was then used to determine the suitability of the media being developed. Furthermore, the questionnaire was used to determine students' needs for game-based learning media.

The second method was direct observation during the learning process. Observations were conducted by observing students' use of the "Win Redox" game in class. This activity aimed to clearly observe how students interacted with the learning media. Furthermore, observations were also used to assess students' cognitive and affective aspects during the learning process. The observation data provided additional information that supported the results of the questionnaire and test.

The third method was a test used to measure students' abilities before and after using the learning media. The tests used in this study consisted of a pretest and a posttest in the form of written questions. The pretest was administered before using the media to determine students' initial abilities. Meanwhile, the posttest was administered after using the media to determine improvements in conceptual understanding. The results of these two tests were then compared to determine the effectiveness of the developed learning media. Thus, the testing method provides objective data regarding student learning outcomes.

2.5. Data Analysis Techniques

The data analysis methods used in this study were used to process and interpret data obtained from various data collection techniques. The analysis was conducted quantitatively and qualitatively to provide a comprehensive overview of the instrument's quality, media suitability, and effectiveness in learning. The data analyzed included instrument test results, expert validation, effectiveness testing, and student responses. Each analysis was conducted using specific formulas and criteria to ensure the results were accountable. Thus, the data analysis served as the basis for drawing research conclusions.

The instrument test was conducted to determine the quality of the items used in the study. Validity analysis was used to determine the instrument's validity using the product-moment correlation between item scores and the total score [37]. Furthermore, a difficulty analysis was conducted to determine whether the item was classified as easy, moderate, or difficult based on the difficulty index. A good item is one with a moderate level of difficulty, thus optimally measuring student abilities. This analysis helps ensure that the instrument used is truly appropriate for measuring learning outcomes.

Next, a reliability analysis was conducted to determine the instrument's consistency as a measuring tool. An instrument is considered reliable if it has a high level of reliability and produces consistent results. Reliability calculations are performed using a specific formula that considers the proportion of correct and incorrect answers for each item. The calculation results are then compared with the values in the product-moment correlation table. If the reliability value is greater than the table value, the instrument is considered reliable. Thus, the instrument can be used to consistently measure student abilities.

In addition, a discriminatory power analysis was conducted to determine the question's ability to differentiate between high-ability and low-ability students. Discriminatory power was calculated based on the ratio of the number of students in the upper and lower groups who answered correctly. The discriminatory power values were then classified into very poor, poor, fair, good, and very good categories. Questions with good discriminatory power indicate that they are able to effectively measure differences in student abilities. This analysis is crucial to ensure the quality of the questions used in the research.

An expert validation test was conducted to assess the feasibility of the "Win Redox" game-based learning media. This validation involved material experts and media experts who provided assessments based on a questionnaire instrument. The data obtained were then calculated as percentages to determine the media's feasibility category. The feasibility categories are very good, good, fair, and poor, based on a specific percentage range. The results of this validation are used as a basis for making improvements to the developed media. Thus, the resulting media meets the expected quality standards.

The effectiveness of the learning media is tested based on two aspects: cognitive and affective. In the cognitive aspect, effectiveness is measured through improvements in student learning outcomes using the N-gain calculation based on pretest and posttest scores. The N-gain value is then categorized as low, medium, and high to

determine the level of improvement in student understanding. Meanwhile, the affective aspect is measured through observations of student activity during the learning process. The data obtained are then analyzed as percentages to determine the success category. These two aspects provide a comprehensive overview of the effectiveness of the learning media.

Furthermore, analysis is also conducted on student responses to the developed learning media. Response data is obtained through a questionnaire and then calculated as a percentage. This percentage indicates the level of student acceptance and assessment of the interactive game-based learning media. The percentage results are categorized as very good, good, fair, and poor. This analysis aims to determine the extent to which the learning media is accepted by users. Thus, the results of the analysis of student responses become one indicator of the suitability of the media being developed.

3. RESULTS AND DISCUSSION

The learning media developed in this research is an interactive game-based learning medium for the concept of reduction and oxidation reactions. This media is designed as an educational game with the aim of helping students understand the concept of redox in a more engaging and interactive way. The use of games as a learning medium is expected to increase student motivation and engagement in the learning process. The inclusion of game elements makes learning more enjoyable and less monotonous. Therefore, this media was developed as an innovative alternative in chemistry teaching.

The research method used is the Research and Development (R&D) method, which aims to produce a product while testing its effectiveness. The development model used refers to the Sugiyono model, which consists of several systematic stages. These stages include potential problems, information gathering, product design, design validation, design revision, product trials, and product revision. In this research, the development stage focused on small-scale trials. Each stage was carried out sequentially to ensure the quality of the resulting product.

The initial step in developing this media was analyzing potential problems and gathering information. This stage aimed to identify various difficulties experienced by students in learning the topic of reduction and oxidation reactions. Furthermore, information was collected to determine students' needs for the desired learning media. Data was obtained through a needs questionnaire and interviews with teachers. The analysis showed that students needed more engaging and interactive learning media. Therefore, game-based learning media was developed as an alternative solution.

The developed learning media is expected to create a fun learning atmosphere and increase students' interest and motivation to learn. Educational games provide a different learning experience than conventional methods. Students can learn while playing, making it easier to understand abstract concepts. Furthermore, this media is also designed to foster students' enthusiasm for learning and curiosity. Therefore, the interactive game "Win Redox" is expected to be an effective learning medium.

The product produced in this research is the "Win Redox" learning game, which can be used as a companion medium in chemistry learning. Before being tested on students, the product was first validated by experts to assess its feasibility. This validation process aimed to identify the strengths and weaknesses of the developed product. The validation results indicated that several aspects still needed improvement. This served as the basis for the researchers to refine the product.

Based on the expert validation results, several suggestions and input were obtained for improving the learning media. These improvements included adjusting the font size to make it easier for users to read. Additionally, improvements were made to the presentation of chemical reactions and the structure of questions to make them more systematic and aligned with learning objectives. Expert input is crucial for improving the quality of the developed media. These revisions are expected to make the media more feasible and effective for use.

After revisions based on expert advice, the product is ready for student trials. This stage aims to determine user response and the media's effectiveness in learning. This systematic development process is expected to produce high-quality learning media. The "Win Redox" game is expected to help students better understand the concepts of reduction and oxidation reactions. Thus, the developed media can make a positive contribution to chemistry learning. The results of the criticism and suggestions by the expert validators are shown in Table 1.

Table 1. Results of Criticism and Suggestions by Material Expert Validators

No.	Revisions/Suggestions	Repair
1.	Font size changes are needed.	The letters have been changed as requested by the validator.
2.	Displays facts or phenomena from everyday life.	Facts and phenomena are displayed at each level, such as the browning of peeled apples, lightning, and so on.
3.	There is still an incorrect reaction written in the answer choice for question number 9.	The correct spelling of compounds has been changed according to the rules, namely by adding brackets to the iron sulfate compound.

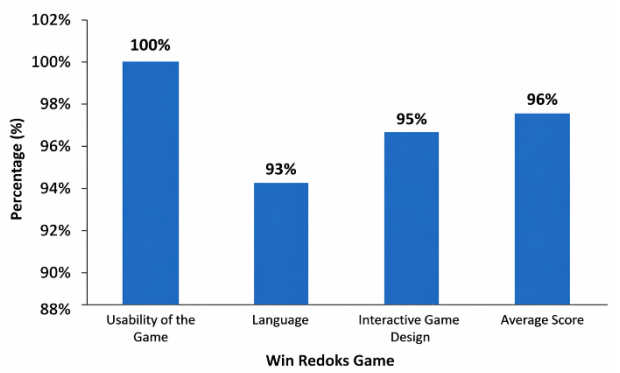

Figure 1. Media Content Assessment Graph by Validator

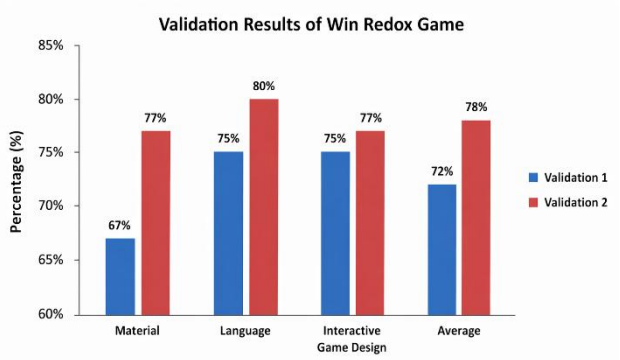

Figure 2. Graph of Material Content Assessment by Validator

Figure 1 shows a variation in the validator's assessment percentages for each indicator. The Win Redox game received a score of 20% for its usefulness, 25% for its language, and 50.66% for its interactive game design. The overall average score from the media expert validators reached 96%, falling within the "very good" category. These results indicate that the developed media meets the principles of multimedia learning, which integrates more than one type of media. Furthermore, the media expert validators did not provide any suggestions for improvement, so the product does not require further revision in this aspect.

Meanwhile, the validation results from the material experts showed an increase between the first and second stages. In the first stage of validation, the average score was 72%, with several suggestions for improvement. After revisions, the second stage of validation increased to 78%. This increase indicates that the improvements made to the Win Redox game have successfully improved the quality of the learning media. These results align with the principle that material in learning media should be relevant to the curriculum and provide benefits to students. Thus, the material presented in this game is deemed appropriate for the chemistry lessons being taught.

Based on the assessment of material experts, the quality of the material in this learning media falls into the good category, both during the first validation and after the second revision. However, this media has not yet reached the very good category due to the limited number of questions available, covering only 10 levels, which does not represent the full scope of the material. Furthermore, limitations are also influenced by the software used in development. The Construct software used requires a relatively in-depth understanding of programming, potentially leading to errors in the game's flow. Nevertheless, this software still has the advantage of being easy enough to use for creating simple games.

This learning media was also converted to the Android platform using Intel XDK for greater user accessibility. Next, the media was validated by educators to assess its suitability for use in learning. Educator assessment is crucial because they have direct understanding of classroom learning conditions. The educators' assessment results showed a percentage of 76%, which falls into the good category. Based on these results, the media does not require further revision and is considered suitable for use in learning. The next stage was a small group trial involving nine tenth-grade students. Students were divided into three groups based on their ability levels: low, medium, and high. This trial aimed to assess the effectiveness of the learning media in real-world situations. Media effectiveness was measured through student activity and engagement during the learning process. The results of this trial provide an initial overview of the success of using the Win Redox game as an interactive learning medium.

The effectiveness of interactive game-based learning media can be assessed from student learning outcomes in the small-class trial. Assessment was conducted by comparing pretest and posttest scores to determine improvements in conceptual understanding after using the media. This comparison provides an overview of the extent to which the media was able to assist students in understanding the material on reduction and oxidation reactions. The obtained scores were then processed to obtain an average student achievement. This average result is presented in Figure 3 as a visualization of the improvement in learning outcomes.

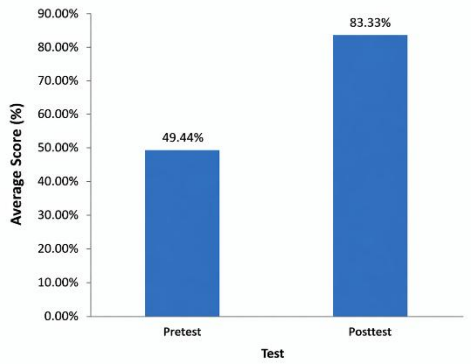

Figure 3. Pretest and Posttest Results (Cognitive)

Based on the graph in Figure 3, it can be seen that student learning outcomes in the small-class test experienced a significant improvement. The average pretest score obtained by nine students was 49.44%, while the average posttest score increased to 87.77%. The data was then further analyzed using the N-gain calculation to determine the level of improvement in learning outcomes. The calculation results showed an N-gain value of 0.67, which is considered moderate. This value indicates that the learning media used was quite effective in improving student understanding and learning outcomes on the same material.

This cognitive aspect testing aimed to assess the effectiveness of interactive game-based learning media in improving student conceptual understanding. This was demonstrated through a comparison of pretest and posttest results, which reflected improved learning abilities. Next, the affective aspect was analyzed to determine student attitudes, interests, and motivations during the learning process. Assessment of this aspect was conducted using an observation sheet used throughout the learning process. The results of the affective aspect assessment are presented in Figure 4.

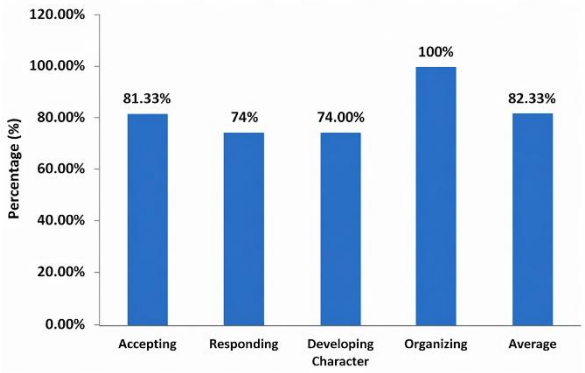

Figure 4. Affective Aspect Assessment Graph

Figure 4, in the affective aspect, shows the percentage variation for each indicator assessed. The highest score was found in the organizing indicator, with a percentage reaching 100%, indicating that students were able to build and manage their understanding and attitudes toward learning very well. The accepting indicator scored 89%, indicating that students were able to follow the learning process and choose the correct answers when using the Win Redok game. Meanwhile, the responding indicator scored 83%, indicating that students were not only able to answer questions well but also able to help friends who were having difficulty using the learning media. This indicator falls into the very good category.

On the other hand, the developing character indicator scored 78%, the lowest percentage compared to the other indicators. This relates to attitudinal aspects such as honesty, discipline, and self-confidence, which still need improvement. Some students tended to lack confidence and relied more on friends' answers, even though they were not necessarily correct. Nevertheless, the overall results of the four indicators indicate that this interactive game-based learning media is effective for small class learning. Furthermore, student responses were assessed

through a questionnaire. The purpose of this questionnaire was to determine students' responses to the use of the Win Redox game in learning. The results of these responses are presented in graphical form, as shown in Figure 5.

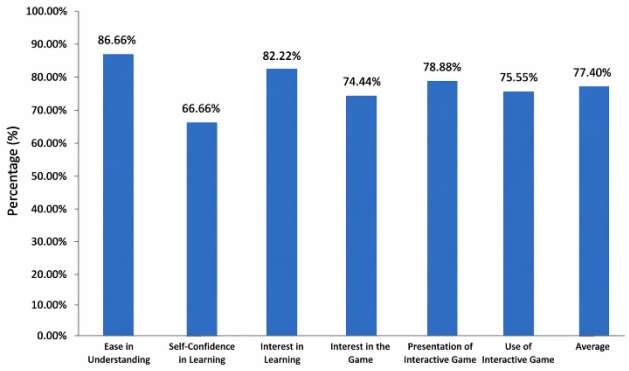

Figure 5. Graph of Student Responses to the Win Redox Game Media

Student responses showed varying percentages for each indicator assessed. The ease of understanding indicator scored 86.66%, categorized as very good. Meanwhile, the learning independence indicator scored 66.66%, categorized as good. The learning activeness indicator scored 82.22%, also categorized as very good. The indicators for learning interest, interest in interactive games, and use of interactive games were all categorized as good.

Among all indicators, learning independence had the lowest percentage. This indicates that students still require guidance or explanation from the teacher to better understand the redox concept. Nevertheless, overall, the average student response was categorized as good, thus deeming this learning medium suitable for use. Furthermore, the developed medium was deemed easy to understand, engaging, and supportive of independent learning, both inside and outside the classroom.

The use of game-based learning media in this study can be explained through the perspective of constructivism theory, where students actively construct conceptual understanding through interactive learning experiences [38], [39]. In the context of chemistry learning, particularly in the abstract topic of reduction and oxidation reactions, direct involvement through game activities allows students to connect concepts to more concrete situations. This process helps reduce the cognitive load that typically arises when students only receive verbal explanations. Thus, game-based media functions not only as a visual aid but also as a learning environment that encourages independent knowledge construction [40].

Furthermore, the effectiveness of this learning media can also be linked to the principles of multimedia learning, which emphasize the integration of various information representations, such as text, visuals, and interactions. In chemistry learning, multiple representations (macroscopic, submicroscopic, and symbolic) are a crucial aspect that often causes difficulties for students [41], [42]. Through interactive game design, students can more easily understand the relationships between these concepts because they are presented in a gradual and contextual manner. This aligns with the principle that learning involving more than one form of representation can foster deeper conceptual understanding.

From a pedagogical perspective, the use of game elements such as challenges, levels, and instant feedback plays a role in increasing student engagement during the learning process. Immediate feedback allows students to immediately identify errors and improve their understanding. This differs from conventional learning, which tends to provide delayed feedback. With continuous interaction between students and the media, the learning process becomes more dynamic and responsive to individual learning needs.

However, the effectiveness of game-based learning media is influenced not only by the media design itself, but also by other factors such as student readiness and the teacher's role in guiding the learning process [43], [44]. This study still indicates that students require guidance to understand concepts more deeply. This suggests that game-based learning media should be used as a learning support, not as the sole learning resource. The teacher's role remains crucial in providing conceptual explanations and guiding discussions to ensure optimal learning.

Furthermore, limitations in the amount of content and scope of material in the developed media are also factors that need to be considered. The material on redox reactions is highly complex and encompasses various interrelated concepts, necessitating the development of more comprehensive media to encompass all aspects of learning. Further development can be done by adding a variety of questions, varying levels of difficulty, and integrating problem-based learning approaches to enhance students' critical thinking skills [45], [46].

Overall, the findings in this study reinforce that technology integration in chemistry learning, particularly through game-based learning, has significant potential to improve learning quality. However, optimal

implementation requires media design based on strong learning theory and supported by appropriate learning strategies. Therefore, future development of learning media needs to place greater emphasis on conceptual and pedagogical aspects to make a broader contribution to chemistry education [47], [48].

In terms of impact, the development of this game-based learning media provides a practical contribution to chemistry learning, particularly in the area of reduction and oxidation reactions, which are notoriously difficult for students. The "Win Redox" media can be an alternative learning strategy that can increase student engagement and learning experiences through a more interactive and contextual approach. Furthermore, the use of this media has the potential to assist teachers in presenting abstract material in a more understandable way, thus supporting student-centered learning [49], [50]. In the long term, the integration of game-based learning into chemistry learning can encourage the development of 21st-century skills, such as critical thinking, problem-solving, and independent learning.

However, this study has several limitations that must be considered when interpreting the results. One major limitation lies in the relatively small number of study subjects and the limited group trials, which means the results cannot be broadly generalized. Furthermore, the scope of the material in the developed media is still limited and does not comprehensively cover all concepts of redox reactions. Another limitation is the lack of large-scale trials or effectiveness tests with a control group, so the media's effectiveness cannot be compared in depth with other learning methods. Therefore, further research is recommended to involve a larger sample size, a more robust experimental design, and more comprehensive media development to obtain more valid and generalizable results.

4. CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that the interactive game-based learning media developed is effective for use in learning on a small class scale. This effectiveness is seen from the increase in students' cognitive aspects, as indicated by the N-gain value of 0.67 which is in the moderate category, so the media is considered quite effective in improving the understanding of the concept of reduction and oxidation reactions. In addition, in the affective aspect, the level of student activity reached 82.33% which is included in the very good category, thus indicating that the media is able to increase student involvement during the learning process. Meanwhile, based on the feasibility test through student responses, an average percentage of 77.40% was obtained which is in the good category. These results indicate that the Win Redox game is feasible and effective for use as a learning medium. Based on these limitations, further research is recommended to develop game-based learning media with broader and more in-depth material coverage, enabling a comprehensive representation of all concepts of reduction and oxidation reactions. Furthermore, further research should involve a larger and more diverse number of subjects to better generalize the results.

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AUTHOR CONTRIBUTIONS

Conceptualization, S.S. and A.T.; Methodology, S.S.; Software, S.S.; Validation, S.S. and A.T.; Formal Analysis, S.S.; Investigation, S.S.; Resources, S.S.; Data Curation, S.S.; Writing – Original Draft Preparation, S.S.; Writing – Review & Editing, S.S. and A.T.; Visualization, S.S.; Supervision, A.T.; Project Administration, S.S.; Funding Acquisition, A.T.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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