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Development of an Interactive Digital Learning Media "E-MIREDOKS" on Redox Reaction Material

Aisyah Verolita Firdauz, *Sukarmin
Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. Jl. Ketintang Campus, Surabaya 60231, Indonesia

*Corresponding Author e-mail: sukarmin@unesa.ac.id

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Abstract

This study aims to develop and evaluate the feasibility of E-MIREDOKS (Redox Reaction Interactive E-Module) as a digital and interactive learning tool for teaching redox reactions in chemistry. The research methodology employed is the Research and Development approach developed by Sukmadinata, which involves three main stages: preliminary study, media development, and media testing, culminating in a limited-scale trial. This methodology was chosen due to its alignment with the goal of developing a learning tool. The validity of the developed medium was assessed using validity sheets, pretest and posttest sheets, student feedback, and observation sheets. The medium was found to be feasible based on its content and construct validity, with validity percentages of 85.56% and 85.93% respectively, falling within the category of exceptionally valid. The effectiveness of the medium was evaluated through a comparison of pretest and posttest scores, resulting in a sig.(2-tailed) value of 0.00 < 0.05 (α), indicating a significant difference in mean scores between the pretest and posttest. Out of 36 students, 31 achieved individual learning accuracy, while 86.11% attained classical learning accuracy. The practicality of the medium was assessed using student feedback, which yielded a percentage of 92.63%, and observations of student behavior, which scored 96.67%, both falling within the category of exceptionally practical. These findings provide evidence that E-MIREDOKS can serve as an effective digital and interactive learning tool for chemistry education.

Keywords: Interactive Learning Media; E-Module; Digital; Redox Reaction

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INTRODUCTION

The natural sciences encompass a wide range of disciplines, with chemistry occupying a prominent position among them. Chemistry is concerned with the composition, arrangement, and transformations of matter, as well as the accompanying phenomena (Nissa et al., 2019). As a fundamental element of scientific inquiry, chemistry serves as an essential link between science, technology, engineering, and mathematics, playing a crucial role in various fields such as biology, geology, environmental science, and others (Flowers et al., 2015). Given its continual advancement and significant contributions to various scientific and technological domains, the study of chemistry is vital both presently and for the future.

Chemistry consists of three fundamental components, namely microscopic, macroscopic, and symbolic (Qibtiyah & Sukarmin, 2022). According to Flowers et al. (2015), the microscopic aspects pertain to subjects on a micro-scale, such as molecules, atoms, ions, electrons, protons, neutrons, and chemical bonds. These components are not visible to the naked eye. On the other hand, macroscopic aspects can be observed through sight and touch, often manifesting as physical and chemical properties in everyday life. Symbolic representations, such as elements, formulas, and chemical equations, are used to depict both the microscopic and macroscopic aspects. Therefore, the teaching of chemistry presents a challenge due to the abundance of abstract concepts that may be unfamiliar or rarely encountered by students (Treagust & Chittleborough, 2001). Nakhleh (1994), as cited in Treagust and Chittleborough (2001), suggests that students struggle with chemistry primarily because they lack a proper understanding of basic concepts. Mastery of these foundational concepts is crucial as they form the basis for comprehending more advanced material (Treagust & Chittleborough, 2001). Consequently, chemistry can be viewed as a complex discipline that progresses from elementary concepts to higher-level notions (Sastrawijaya, 1988). One such challenging basic concept is that of reduction-oxidation reactions, also known as redox reactions. This concept holds significant importance as it forms the basis for the study of advanced topics such as electrochemical cell materials, balancing of redox reactions, and their applications in everyday life, such as the use of whitening fluids for clothing, hair bleaching products, and the application of paint to prevent rust on iron.

The concept of a redox reaction originally involved a chemical reaction with oxygen, but it has now expanded to include electron transfer. The defining characteristic of a redox reaction is the change in oxidation state (Flowers et al., 2015). Redox reactions involve reducing agents and oxidizing agents. A reducing agent is a substance that undergoes oxidation by releasing electrons, gaining oxygen, or increasing its oxidation state. Conversely, an oxidizing agent is a substance that undergoes reduction by acquiring electrons, releasing oxygen, or decreasing its oxidation state. These reactions occur at a microscopic level (Suryati et al., 2022) and are represented using chemical symbols. However, understanding the microscopic aspect and using chemical symbols can present challenges when compared to the more observable phenomena at a macroscopic level (Sudria et al., 2011)

Based on the preliminary survey conducted, it was determined that 81.25% of the students experienced difficulties in comprehending the redox reaction material (Astutik, Fariati, & Herunata, 2017). Several concepts within the material were identified as posing challenges for students, including: (a) reduction-oxidation reactions based on the concept of oxygen, (b) reduction-oxidation reactions based on the concept of electron transfer, (c) the concept of the oxidizer, (d) the concept of the reducer, and (e) the comprehension of oxidation numbers. These difficulties can lead to a lack of interest and motivation in studying the material, ultimately resulting in inadequate learning outcomes. Furthermore, when the redox reaction material is taught using uninspiring and monotonous learning materials that solely present text, it becomes even more difficult for students to grasp the concepts. Hence, it is crucial to employ visually appealing learning materials that effectively present the material through the use of real-life examples, interactive content, and exercises to enhance students' comprehension and assess their learning outcomes. One potential approach to achieve this is by providing engaging learning materials (Astutik et al., 2017).

Learning media is a crucial component of the instructional approach, where it is prepared and presented to students (Tafonao, 2018). It has been observed that learning media greatly impacts the learning process, as it positively influences student learning achievements (Nida et al., 2020). Moreover, learning media has proven to be effective in enhancing students' motivation to learn (Tafonao, 2018). Among the various learning media options available, the e-module stands out as a viable choice. An e-module is essentially an electronic module displayed on a computer (Laili et al., 2019).

E-modules are designed to be easily accessible, portable, and durable (Istiqoma et al., 2023). The creation of an e-module can be facilitated by using a professional flip builder, which is a software that enables the development of an e-book in the form of an interactive flipbook. This software incorporates various features such as video, audio, animation, and images (Sirait, 2021). These features enhance the attractiveness and interactivity of the e-module, thereby encouraging active student participation in the classroom learning process (Prabu et al., 2023). The utilization of interactive e-modules in chemistry education represents a means of harnessing technological advancements. The ongoing progress in technology facilitates interactive learning, both in the interaction between teachers and students, as well as in the utilization of learning materials (Awwalina & Indana, 2022). This digital-based learning medium has gained widespread popularity during the fourth industrial revolution, and it has been implemented across various educational technologies (Annisa, 2021). The advancement of information and communication technology in the field of education is an outcome of the fourth industrial revolution, and it is anticipated to serve as a tool and infrastructure that facilitates the learning process (Putriani et al., 2021). This ensures that the study of chemistry remains up-to-date and comprehensive.

Based on the available data, the objective of this research is to develop an interactive digital learning tool called E-MIREDOKS (Redox Reaction Interactive E-Module) for the redox reaction subject (Herawati & Muhtadi, 2018). E-MIREDOKS distinguishes itself from general interactive e-modules due to its captivating appearance and presentation of more intricate features. It includes learning videos, animated gifs with accompanying audio that support the redox reaction material, repeatable quizzes, and exercises. The videos and images in E-MIREDOKS are intended to assist students in comprehending macroscopic aspects by introducing the material and showcasing redox phenomena in everyday life. The animated gifs, along with audio and quizzes, are utilized to aid students in understanding microscopic aspects and symbols in redox reactions. These features offer an audiovisual and interactive learning experience. Research conducted by Herawati and Muhtadi (2018) indicates that interactive e-modules yield positive and effective results in learning, as evidenced by significant differences between the pretest and posttest scores of the students. E-MIREDOKS will undergo testing to assess its validity, effectiveness, and practicality. The development of the E-MIREDOKS tool is expected to facilitate the learning process for the redox material.

METHOD

This study adopts the Research and Development Method by Sukmadinata, incorporating modifications to the research and development stages proposed by Borg and Gall (Sukmadinata, 2016). This method is employed for the purpose of developing a new learning product, specifically the E-MIREDOKS. The method encompasses three main stages, each consisting of significant operational stages: preliminary study (including literature review and field study), media development, and media testing (including expert validation, limited testing, and extensive testing). Currently, the research is ongoing, with the limited testing stage being the current focus. During the preliminary study, material studies, classroom observations, and interviews were conducted. The data collected were carefully organized and utilized in the creation of E-MIREDOKS (Redox Reaction Interactive E-Module). Subsequently, the media will undergo evaluation for validity (content and structure), effectiveness, and practicality as a learning medium.

Validity Test

The validity test was conducted by three validators: two chemistry lecturers from Surabaya State University and one chemistry teacher from SMAN 20 Surabaya. The data resulting from the media validity test obtained is accumulated using calculations (Formula 1) (Suyono, 2015). The scores are then interpreted using a percentage of the Likert Scale validity (Table 1) (Riduwan, 2015).

$$P(\%) = \frac{\sum Score\ obtained}{Criterion\ score}\ x\ 100\% \quad \text{(Formula 1)}$$

With Criterion score = highest score of each item x Σ items x Σ validator

Table 1. Interpretation of Likert Scale Validity

Percentage (%)	Assessment Category
0 – 20	Exceptionally Invalid
21 – 40	Invalid
41 – 60	Enough

Percentage (%)	Assessment Category
61 – 80	Valid
81 – 100	Exceptionally Valid

The validity of E-MIREDOKS is determined by calculating the average percentage result from the evaluations of three validators. For a document to be considered valid, the average percentage must be equal to or greater than 61% or fall within the valid or exceptionally valid category. Moreover, each aspect assessed on the validity sheet must receive a score equal to or greater than 3.

Effectiveness Test

E-MIREDOKS was tested on 36 students from grade XI IPA 3, SMAN 20 Surabaya, who had received prior instruction on redox reactions. Employing a one-group pretest-posttest design, the students were initially assessed through a pretest. Subsequently, they engaged in learning activities facilitated by E-MIREDOKS and subsequently underwent a posttest. The data collected encompassed the pretest scores, which served to gauge the students' learning outcomes prior to using E-MIREDOKS, as well as the posttest scores, which reflected their learning outcomes subsequent to using E-MIREDOKS. The pretest and posttest scores will be subjected to analysis using the SPSS software. Specifically, the SPSS software will be employed to assess the normal distribution of the pretest and posttest data through normality tests. The hypothesis formulated for normality is as follows:

If H_0: The data is derived from a population with a normal distribution.
If H_1: The data is derived from a population with an abnormal distribution.

Then the normality hypothesis is tested using the P-value, criteria: If the P-value > α, then H_0 is accepted if the P-value < α, then H_0 is rejected. When the p-value of the pretest and posttest data is greater than 0.05 (α), the null hypothesis (H0) is accepted, indicating that the obtained data is normally distributed. Furthermore, the hypothesis is tested and the data is examined using SPSS through a Paired Sample t-test. This test is performed to determine the disparities between the pretest and post-test scores of the students, based on the following hypotheses:

If H_0: There is no significant difference in the pretest and posttest scores.
If H_1: There is a significant difference in the pretest and posttest scores.

Then test the hypothesis t-test (Paired Sample t-test) using the P-value criteria: If the P-value > α, then H_0 is received if the P-value < α, then H_0 is rejected. In the results of the paired sample t-test, the significance (2-tailed) value is 0.00. When the value of the pretest and posttest data is <0.05 (α), it indicates that the null hypothesis (H0) was rejected and the alternative hypothesis (H1) was accepted. This signifies a difference between the average scores based on the pretest and posttest results. Significant differences between the pretest-posttest results suggest that E-MIREDOKS is an effective learning medium. To determine the criteria for individual accuracy and the percentage of classical accuracy, calculations using Formula 2 (Erni, 2016) and Formula 3 (Depdiknas, 2004) are used.

Individual Accuracy = $\frac{\sum \text{Amount of the correct answer}}{\text{Amount of all questions}} x\ 100$ .... (Formula 2)

Classical Accuracy = $\frac{\sum \text{Amount of students who got scores} \geq 75}{\text{Amount of all students}} x\ 100\%$ .... (Formula 3)

Students are considered to have passed individual accuracy when they achieve a minimum score of 75 or higher. In a classroom context, it has been observed that at least 85% of students reach the specified score for classical accuracy.

Practicality Test

The students will complete student response sheets at the conclusion of the learning process utilizing E-MIREDOKS. Each aspect within the response sheets contains a statement. When assigning a score, the students must select either 'yes' or 'no' in the corresponding column. Furthermore, there exists a student observation sheet that is filled out throughout the learning process, with scores given by the observers. The observers will closely monitor the entirety of the student activity during the learning process and choose either 'yes' or 'no' in the score column for each aspect. The Guttman scale criteria (see Table 2) are employed to determine the score, which is then calculated using formulas (see Formula 4).

Table 2. The Guttman Scale Criteria (Riduwan, 2015)

Answer	**Score**	
	Positive statement	**Negative statement**
Yes	1	0
No	0	1

$$P(\%) = \frac{\sum Student\ answer\ score}{\text{Amount of all students}} \times 100\% \qquad \text{(Formula 4)}$$

Table 3. Likert Scale Practical Interpretation (Riduwan,2015)

Percentage (%)	**Assessment Category**
0 – 20	Exceptionally Less Practical
21 – 40	Less Practical
41 – 60	Enough
61 – 80	Practical
81 – 100	Exceptionally Practical

The result of the calculation is interpreted using a Likert scale to facilitate practical interpretation (see Table 3). E-MIREDOKS is deemed practical if the percentage result is ≥ 61% or falls within the range of practical or exceptionally practical categories.

RESULTS AND DISCUSSION

This study focuses on the development of E-MIREDOKS as a digital-based interactive learning tool specifically designed for the topic of redox reactions. It includes three main phases: an initial investigation, the development of the digital tool, and a limited testing of the tool.

Preparatory Study

The literature study involves studying materials pertaining to redox reactions and gathering data from various scholarly sources. The field investigation was carried out by administering pre-research surveys to the students. A total of 81.25% of students reported encountering difficulties with redox reaction materials. Moreover, the utilization of monotonous learning resources contributes to students experiencing boredom. According to interviews with chemistry teachers, the learning materials utilized at SMAN 20 Surabaya encompass books, workbooks, PowerPoint presentations, videos, animations, and whiteboards. A total of 93.75% of students expressed a willingness to seek assistance from their teachers when facing learning challenges, yet 93.76% indicated a preference for independent learning given the availability of engaging, interactive, and comprehensive learning materials. One exemplification of such materials is interactive e-modules, which not only incorporate text but also encompass images, videos, animated gifs, voice recordings, and navigational tools that foster student interaction with the content (Murod et al., 2021). Moreover, there are quizzes and competency assessments provided to enable students to practice and evaluate their learning outcomes.

Media Development

Media development begins with the selection and design of the layout, followed by the preparation of content for each chapter of the interactive e-module (see Figure 1). This process involves designing and displaying the content, preparing the materials using Canva, and ultimately creating the final product in PDF format. Afterward, the PDF is converted using Flip Builder Professional, resulting in an interactive e-module. By utilizing Flip Builder Professional, the e-module has the ability to integrate videos, animations, GIFs, navigation, quizzes, and competency tests that are linked to Google Forms (see Figure 1).

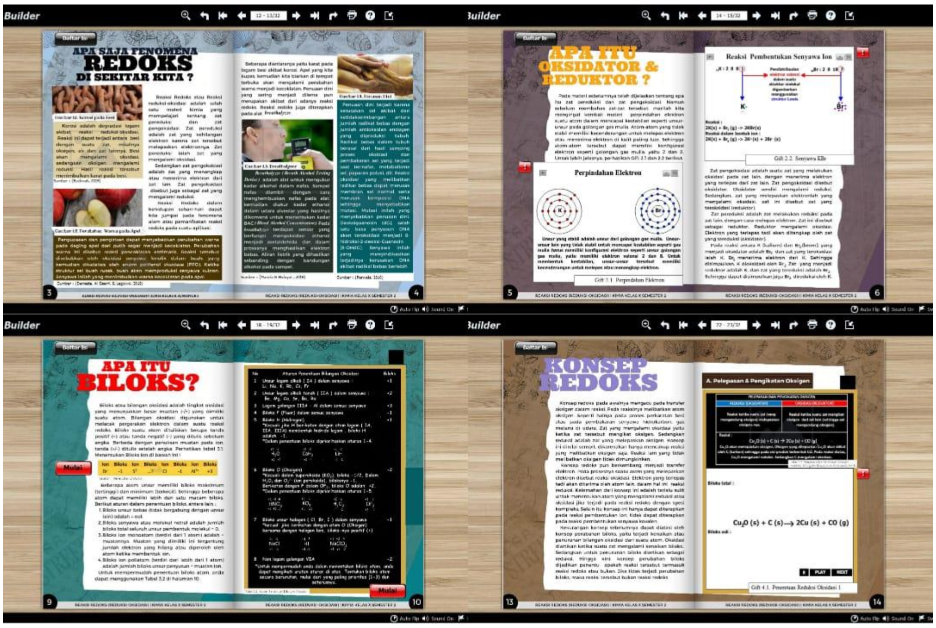

Figure 1. E-MIREDOKS, the material in each chapter

Figure 2. E-MIREDOKS Content

E-MIREDOKS was subjected to scrutiny by a chemistry professor, who graciously provided suggestions to enhance its quality. The professor's recommendations encompassed incorporating shortcuts on every page, employing brighter background colors, integrating play, stop, and next buttons into the animation gifts, refining the word usage in both the content and animation gifts' sentences, and modifying the quiz format by utilizing the resources accessible through Flip Builder Corporation. These suggestions were effectively implemented to bolster the overall performance of E-MIREDOKS. Notably, E-MIREDOKS (Figure 2) comprises various components such as content lists, images, tables, animated gifts, user instructions, fundamental competencies, indicators of competency attainment, supportive material videos, and redox reaction explanations accompanied by visual aids and animated gifts. Additionally, it includes exercises in the form of quizzes, serving to reinforce learning and competence assessments.

Media Test

Media testing consists of two main components, namely a validity test and a limited test. In the limited test, the effectiveness and practicality of the media are assessed

Validity Test

There are three validators involved in assessing the validity of E-MIREDOKS. These validators include two chemistry lecturers from Surabaya State University and one chemistry teacher from SMAN 20 Surabaya. The validity sheet includes evaluation aspects that assess the media in terms of content and structure. The results of this assessment are presented in Table 4.

Table 4. E-MIREDOKS Validity Results

Assessment Aspect	Percentage (%)	Category
The Content Validity		
Compatibility of material and concept	86.67	Exceptionally Valid
Compatibility of questions with material	83.33	Exceptionally Valid
Compability in improving student learning outcomes and motivation	86.67	Exceptionally Valid
Average	**85.56**	**Exceptionally Valid**
The Construct Validity		
Presentation of material, content, features, a nd instructions for use	88.89	Exceptionally Valid
Language usage	84.44	Exceptionally Valid
Graphical quality	84.44	Exceptionally Valid
Average	**85.93**	**Exceptionally Valid**

The content validity result demonstrates the compatibility of the material, concepts, and questions in E-MIREDOKS, as well as the media's effectiveness in enhancing students' learning outcomes and motivation, with an overall average percentage of 85.56%, which falls within the highly valid category. This is corroborated by Kamila's (2018) research, which found that interactive e-modules accompanied by images, videos, and animations were successful in aiding students' understanding of the subject. In terms of construct validity, the presentation of material, content, features, and instructions on media usage, as well as language utilization and graphic quality, achieved an overall average percentage of 85.93%, also falling within the highly valid category. The material in E-MIREDOKS is presented in a comprehensive and structured manner, beginning with general information and progressing to more specific details, akin to an encyclopedia. The captivating media elements have the ability to capture students' interest in engaging with the material (Mumpuni, 2019). Moreover, the use of clear and everyday language fosters an interactive effect, creating a sense of interaction between the student and the teacher (Wulandari et al., 2021).

The above description aligns with research conducted by Asri (2022), which affirms the efficacy of interactive e-modules as learning tools. The validity of these modules was assessed based on content and construct, and during this phase, feedback from validators was sought to enhance the video layout, animation, and alignment of competence test questions with competence achievement indicators. The proposed improvements were subsequently tested in a limited trial, following validation approval.

Limited Test

Limited tests were tested on 36 students in XI grade, IPA 3, SMAN 20, and Surabaya. This stage is done to find out the effectiveness and practicality of E-MIREDOKS.

Effectiveness test

The effectiveness of E-MIREDOKS is assessed through the analysis of pretest and posttest data gathered from students. The test comprises 15 multiple-choice questions, each serving as an indicator of competency attainment. An understanding of the material by students is regarded as indicative of E-MIREDOKS' efficacy as a learning medium, ultimately influencing their formative evaluation (Plomp & Nieveen, 2010). Formative evaluation is utilized to determine the level of accomplishment attained through the planned learning process (Zahir et al., 2021). The collected data underwent a normality test (Table 5) and a paired sample t-test (Table 6).

Table 5. Normality Test Results

	Kolmogorov-Smirnov[a]		
	Statistic	**Df**	**Sig.**
Pretest	.144	36	.058
Postest	.145	36	.055

Table 6. Paired sample t-test test results

		T	Df	Sig. (2-tailed)
Pair 1	**Pretest – Postest**	-28.134	35	.000

In the results of the normality test (Table 5), the p-value is labeled as "Sig," which represents the significance value. The obtained values are 0.058 for the pretest and 0.055 for the posttest. Both values are greater than 0.05 (α), indicating that the null hypothesis (H0) is accepted and the data (pretest and posttest) follows a normal distribution. This observation aligns with H0, which posits that the data originates from populations with a normal distribution. With the confirmation of normality, the paired sample t-test method can be employed to examine potential significant differences between the pretest and posttest data. In the paired sample t-test result (Table 6), the two-tailed significance (sig.) value is determined to be 0.00. This value is less than 0.05 (α), suggesting that the null hypothesis (H0) is rejected in favor of the alternative hypothesis (H1). H1 asserts that there exists an average contrast in the pretest and posttest scores, indicating a disparity in the average scores based on the results of the pretest and the posttest. Additionally, the analysis of the pretest and posttest results will serve the purpose of evaluating the individual accuracy of the students as well as the classical accuracy. This process aims to assess the efficacy of E-MIREDOKS in facilitating the learning process of students on the topic of redox reactions. The detailed outcomes of this analysis can be found in Table 7.

Table 7. Students learning outcomes

Aspect	Pretest	Posttest
Amount of The Students	36	36
Lowest Score	0.00	66.67
Highest Score	53.33	100.00
Average Score	**22.01**	**86.11**

Based on Table 7, which presents the improvement in student learning outcomes based on the pretest and posttest averages, it can be observed that the pretest average of 22.01 increased to 86.11 in the posttest average. Out of the 36 students who achieved the specified score, a total of 31 students were included in the individual accuracy assessment after implementing E-MIREDOKS. The percentage of classical accuracy increased from 0.00% to 86.11%. As a result, class XI IPA 3 was deemed to be classically accurate as more than 85% of the students accurately completed the study. The individual and classical accuracy results indicate that E-MIREDOKS has a significant impact on students' learning outcomes. This is consistent with the findings of Istiqoma's research (2023), which suggests that e-modules can enhance students' learning outcomes, as evidenced by the significant difference in learning outcomes between the pretest and posttest results with sig values of less than 0.05. The systematic and interactive presentation, along with the use of easily understandable language, helps students comprehend the material better, leading to positive results in terms of their learning outcomes (Herawati & Muhtadi, 2018).

E-MIREDOKS encompasses a range of features including text, images, learning videos, animated gift animations with audio, repeatable quizzes, and exercises. These features serve to enhance students' comprehension of redox reactions from various perspectives. They offer an introductory understanding of the subject matter and illustrate the occurrence of redox phenomena in everyday life. Additionally, they demonstrate the microscopic and symbolic aspects by showcasing the movement of electrons and atoms, as well as changes in oxidation numbers that transpire during redox reactions. E-MIREDOKS provides a learning experience that is both audiovisual and interactive. The interactive materials actively engage students, rendering the learning process more dynamic and captivating. Quizzes and exercises available on E-MIREDOKS can be undertaken multiple times. By engaging in continuous practice, the knowledge acquired throughout the learning process becomes embedded in long-term memory (Suryana et al., 2022). Consequently, when students encounter similar questions, they are able to answer them with ease due to their familiarity with the material. The noteworthy enhancement in average student learning outcomes, individual learning accuracy, and classical learning accuracy has substantiated the effectiveness of E-MIREDOKS as an interactive and digital-based learning medium for redox reaction materials.

Practicality Test

The student response sheets are utilized to ascertain the students' perceptions and perspectives regarding E-MIREDOKS as a practical learning medium. The obtained data is presented in Table 8 to illustrate the outcomes.

Table 8. Results of the student response sheets

No	Practicality Aspects	Percentage (%) and Category
1.	Students' interest in the use of media	95.83 (Exceptionally Practical)
2.	Ease of use of media	89.81 (Exceptionally Practical)
3.	Students' activity in the use of media	95.83 (Exceptionally Practical)
4.	Language usage	90.00 (Exceptionally Practical)
5.	Media benefits	91.67 (Exceptionally Practical)
Average		**92.63 (Exceptionally Practical)**

Based on the data presented in Table 8, the practical aspect achieved an average overall percentage of 92.63%, placing it in the category of exceptionally practical. This finding is consistent with the research conducted by Purwati (2015), which suggests that materials presented in e-modules in the form of text, images, video, or audio can enhance the learning process, with an average of 87% of students responding positively. Interactive e-modules encourage students to actively engage in learning, thereby promoting self-directed learning (Prabu et al., 2023). These findings indicate that students are interested in learning using E-MIREDOKS, as evidenced by the student observation sheet that documents the entire learning process (Table 9).

Table 9. The Results of Students' Observation Sheets

No	Student Activity	Percentage (%) and Category
1	Installing and accessing E-MIREDOKS	66.67 (Practical)
2	Using features, videos, gift animations, and navigation	100.00 (Exceptionally Practical)

No	Student Activity	Percentage (%) and Category
3	The quiz and competence test operated well	100.00 (Exceptionally Practical)
4	Ease of use and no error found	100.00 (Exceptionally Practical)
5	Students can answer questions from researchers well during learning using the media	100.00 (Exceptionally Practical)
6	Interactive students during learning	100.00 (Exceptionally Practical)
7	Enthusiastic students during learning	100.00 (Exceptionally Practical)
Average		**96.67 (Exceptionally Practical)**

Table 9, point number 1, demonstrates that the percentage of individuals installing and accessing E-MIREDOKS is 66.67%, falling under the practical category. This percentage is attributed to certain limitations encountered during data retrieval, such as students lacking access to a laptop, thus impeding their use of E-MIREDOKS. A viable solution to this issue is to divide the students into small groups, allowing 2-3 students to share a single laptop. Additionally, the chemistry teacher offered valuable suggestions, proposing that learning activities be conducted in the school's computer lab, where students can engage more actively with E-MIREDOKS, fostering a more focused learning experience. This highlights that learning need not always be confined to the traditional classroom setting. The observation results of the students, as displayed in Table 9, indicate that they achieved an average overall percentage of 96.67%. These findings are supported by studies that exhibit a rise in student engagement in learning from 66.80% to 80.86% following the implementation of the e-module (Purwati, 2015). Consequently, the E-MIREDOKS medium is deemed highly practical and worthwhile as an instructional tool in the chemistry learning process.

CONCLUSION

The conclusion of the research conducted by E-MIREDOKS suggests that it is possible to utilize it as an interactive and digital-based medium for learning about redox reaction materials in the field of chemistry. This assertion is supported by the results obtained from assessing content validity and construct validity, which yielded percentages of 85.56% and 85.93% respectively, placing them in the highly valid category. The effectiveness of E-MIREDOKS is further substantiated by a sig. (2-tailed) value of $0.00 < 0.05$ (α) on the paired sample t-test, indicating a significant difference in average scores between the pretest and posttest. Individual learning accuracy was achieved by 31 out of 36 students, while 86.11% achieved classical learning accuracy. The practicality of E-MIREDOKS is also reinforced by the positive response received from students, as observed percentages of 92.63% and 96.67% fall within the highly practical range. Furthermore, this interactive and digital-based learning medium can be effectively applied to other chemical materials, enabling a broader scope of learning and facilitating various learning techniques due to its support of audio, visual, and interactive elements. Consequently, there exists a significant potential for E-MIREDOKS to be employed as a chemistry learning medium in the future, particularly in the digital era we currently reside in.

RECOMMENDATION

E-MIREDOKS as an interactive learning medium, serves as a versatile tool for both offline and online learning, including distance education, and also functions as a valuable resource for independent learning. Its utilization can greatly enhance student learning in educational institutions that offer online and hybrid programs. E-MIREDOKS provides support for audio, visual, and interactive learning, and is anticipated to offer an even wider range of multimedia materials across various subjects. It is essential to train educators in the effective utilization of diverse learning media, thereby promoting student engagement and active participation during the learning process.

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