HYDROGEN
JURNAL KEPENDIDIKAN KIMIA
https://e-journal.undikma.ac.id/index.php/hydrogen/index

October 2025. 13(5)
e-ISSN: 2656-3061
p-ISSN: 2338-6487
pp. 1009-1025

Development of Interactive Multimedia on Chemical Bonding Material

Iwan, Eny Enawaty*, Masriani
Department of Chemistry Education, Faculty of Teacher Training and Education, Tanjungpura University, Pontianak, Indonesia
* Corresponding Author e-mail: enyenawati@fkip.untan.ac.id

Article History
Received: 15-10-2025
Revised: 05-11--2025
Published: 19-11-2025

Keywords:
development; multimedia; interactive; chemical bonding.

Abstract
The limited availability of learning media capable of facilitating students' understanding of abstract concepts in chemical bonding prompted this research. This study aims to determine the validity level of the developed interactive multimedia and to assess teachers' and students' responses toward its use. The research employed a Research and Development (R&D) method using a modified ADDIE model, limited to the development stage. The trial subjects consisted of two chemistry teachers and 9 students for the small-scale test, as well as 30 students from grade XI at SMAN 2 Sekadau for the large-scale test.The validation results from experts indicated that the interactive multimedia was highly valid with an average percentage of 94.17%, consisting of 88.33% for the media aspect, 96.25% for the material and language aspects, and 97.92% for the assessment aspect. Student responses reached an average of 90.69% in the small-scale test and 94.53% in the large-scale test, while teacher responses reached 83.07%.The novelty of this research lies in the use of interactive multimedia equipped with a variety of engaging features, such as ice-breaking activities and educational games, which are rarely implemented in chemical bonding learning at the senior high school level. Therefore, the developed interactive multimedia can be used as a learning medium and further tested for its effectiveness.

How to Cite: Iwan, Enawaty, E., & Masriani. (2025). Development of Interactive Multimedia on Chemical Bonding Material. Hydrogen: Jurnal Kependidikan Kimia, 13(5), 1009–1025. https://doi.org/10.33394/hjkk.v13i5.18039

https://doi.org/10.33394/hjkk.v13i5.18039

INTRODUCTION

Chemistry is one of the subjects studied in senior high school. The purpose of chemistry learning is for students to be able to observe and explain chemical concepts in everyday life, write chemical reactions, apply chemical laws, and understand atomic structure. Therefore, it is necessary for students to understand chemical concepts starting from simple to complex and abstract ones to achieve accurate comprehension. One of the key concepts that must be mastered is chemical bonding (Sabrina, 2020)..

The use of interactive multimedia can improve students' learning outcomes, as demonstrated in several studies. Research conducted by Purnamasari et al., (2015) on tenth-grade science students showed that the developed interactive multimedia for chemistry learning was feasible for use, especially on the concept of chemical bonding, resulting in good qualification with an average score of 88.57, exceeding the minimum mastery criteria (KKM) of 80. Similarly, a study by Purnamasari et al., (2015) on eleventh-grade science students at SMAN 1 Prabumulih showed that the use of interactive multimedia increased student learning mastery to 88.24%.

In reality, students' learning outcomes on the topic of chemical bonding are still relatively low. Observations of the examination scores of Grade XI students at SMAN 2 Sekadau show that only 39.25% of students achieved mastery. This indicates that most students have not yet fully understood the concept of chemical bonding. Based on interviews with students at SMAN 2 Sekadau, many of them admitted that they still feel confused about the material. Additionally,

teachers predominantly use conventional learning media that are one-directional, linear, and only present material without providing opportunities for students to interact or directly assess their understanding. The static delivery of content makes students passive, easily lose focus, and struggle to visualize abstract concepts such as ionic, covalent, and metallic bonds. In fact, technological facilities such as internet access and Wi-Fi are already available at school but have not been utilized optimally in the learning process.Conversely, interactive multimedia is capable of overcoming these limitations because it can present animated visualizations of abstract concepts, provide flexible navigation according to students' learning needs, offer direct feedback through practice exercises, and build emotional engagement through features such as ice-breaking activities and educational games. Previous studies have also stated that interactive multimedia is effective not only in face-to-face learning but also in digital learning, as it enhances students' cognitive and affective engagement (Rahmawati, 2021).

Interactive elements in multimedia-based learning are essential to make the material easier to absorb and understand, as well as to prevent student boredom. Currently, learning tends to lack interaction, causing students to become passive participants. Therefore, multimedia should provide actions or responses that engage students through the presented content (Lestari, 2020). Meanwhile, according to Wiyana et al. in Dewi et al., (2018), multimedia is a learning system equipped with control tools operated by the user, allowing learners to choose what they need. This makes the learning process more engaging and can improve students' learning outcomes.

The problems addressed in this research are: (1) how valid is the interactive multimedia developed for the topic of chemical bonding, and (2) how do Grade XI students and chemistry teachers respond to the developed interactive multimedia. Considering these issues, it is necessary to improve the learning process and implement strategies that can enhance student learning outcomes. One potential strategy is the use of interactive multimedia tailored to students' needs.Based on this background, the purpose of this study is to develop interactive multimedia on the topic of chemical bonding for Grade XI students at SMAN 2 Sekadau.

The interactive multimedia designed by the researcher offers several advantages compared to commonly used multimedia. One of its main strengths lies in its variety of features, which include learning materials, learning objectives, user instructions, usage flow, developer information, pre-test, educational games, and ice-breaking activities. Students can directly select the section they wish to study through interactive buttons. In the pre-test section, interactive buttons are also provided to give immediate feedback. Interestingly, the multimedia begins with an ice-breaking activity to create a pleasant learning atmosphere. In addition, the inclusion of educational games makes the learning process more engaging, interactive, and less monotonous. This aligns with the findings of (Rahmawati, F., & Sari, 2022), which showed that game elements can increase students' cognitive engagement in chemistry learning.The interactive multimedia developed in this study is designed to be interactive and participatory, aiming to create an active, enjoyable, and meaningful learning experience. The combination of interactive navigation, ice-breaking activities, and educational games is expected to enhance students' emotional engagement, cognitive involvement, and learning motivation throughout the chemistry learning process.

METHOD

This research is classified as Research and Development (R&D). The purpose of this study is to produce a product that can be used in educational and instructional activities, specifically designed to address identified needs or problems found in the field. The R&D model used consists of five phases: analysis, design, development, implementation, and evaluation.

However, this study was only conducted up to the development phase. (a modification of Branch, 2009).

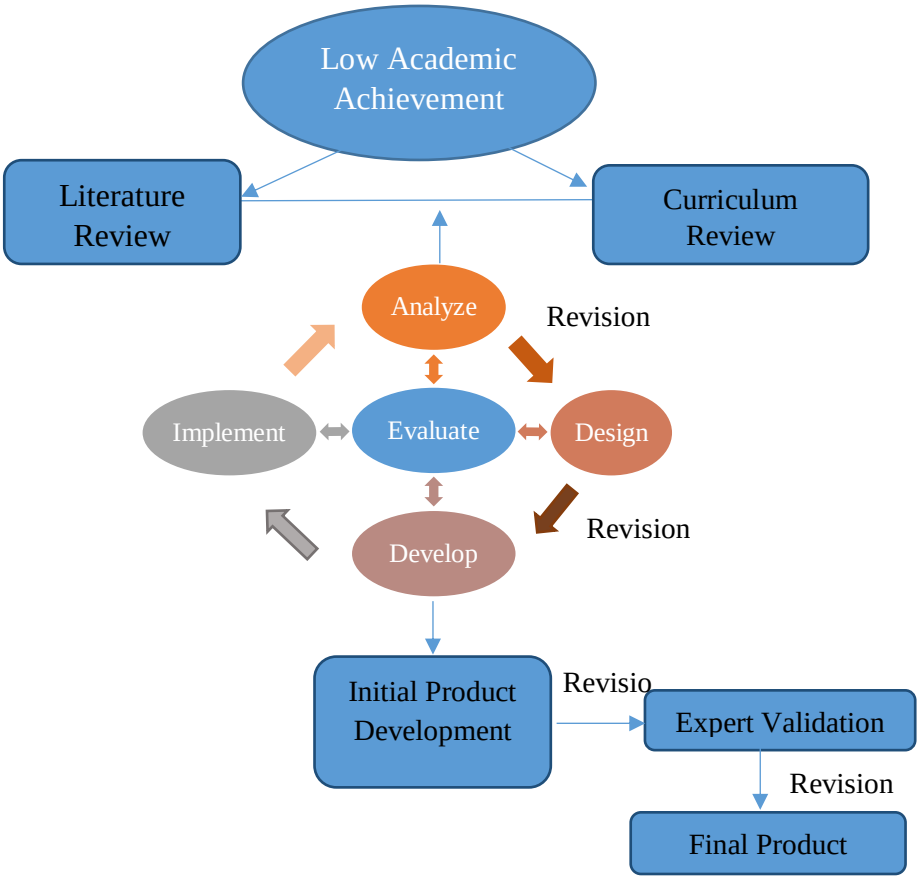


Figure 1. Steps of ADDIE Development Model Modified from Branch, (2009)

The result of this research is an Interactive Multimedia product developed for the topic of chemical bonding. The product was tested on two chemistry teachers, nine Grade XI students of SMAN 2 Sekadau for a small-scale trial, and thirty Grade XI students of SMAN 2 Sekadau for a large-scale trial. The validators in this study consisted of two media experts, two material and language experts, and two assessment experts. The object of this research is the interactive multimedia developed for chemical bonding material.

The first stage involved problem and needs analysis through semi-structured interviews with chemistry teachers at SMAN 2 Sekadau to identify learning issues and relevant media requirements. The interviews were conducted directly using open-ended question guidelines to obtain information regarding the use of learning media in the classroom, students' difficulties in understanding chemical bonding concepts, and teachers' expectations of an ideal learning medium.The interview data were analyzed using a descriptive qualitative technique with a thematic approach, by grouping respondents' answers based on emerging themes. The analysis revealed that the use of technology-based learning media is still very limited. The media commonly used by teachers are one-way and monotonous, thus failing to attract students' attention or encourage active participation in the learning process. These findings serve as the foundation for the development of interactive multimedia that is more engaging, participatory, and aligned with the needs of chemistry learning at SMAN 2 Sekadau.

The second stage is the design phase, during which the researcher created a storyboard as an initial framework for the layout and flow of the interactive multimedia. The storyboard was developed by taking into consideration the results of the needs analysis as well as input from chemistry teachers. Students were also involved on a limited basis to provide initial feedback

on the visual design and interactive features they found engaging.The development of the interactive multimedia was carried out using Canva for graphic design and CapCut for creating instructional videos. This research was limited to the development stage because its main focus was to produce an interactive multimedia product that is valid and feasible for use, based on expert evaluations and initial responses from teachers and students.

In the third stage, development is carried out, where the researcher realizes the initial design into a tangible interactive multimedia product. This process includes the preparation of various main features, such as learning materials, learning objectives, user instructions, pre-test, ice breaking, developer information, usage flow, and educational games equipped with direct feedback. In addition, expert validation instruments and response questionnaires for teachers and students are developed to assess the feasibility and attractiveness of the designed interactive multimedia.The validation process is conducted by two instrument experts, two media and language experts, and two assessment experts. The validation results are then used to review and revise the product to ensure that the interactive multimedia meets the established validation criteria. Instrument validation is carried out to assess the validity of the media validation sheet, material and language validation sheet, assessment validation sheet, as well as teacher and student response questionnaires. The validation is conducted by two validators. The measurement scale used for validation refers to Gregory's validation test (2015). The contingency table used to calculate Gregory's Index is presented in Table 1.

Table 1. Contingency Table for Calculating the Gregory Index

2×2 Cross Tabulation		**Expert Validator 1**	
		Less Feasible Score 1-2	**Highly Feasible Score 3-4**
Expert Validaor 2	Less Feasible Score 1-2	A	B
	Highly Feasible Score 3-4	C	D

Source: Gregory (2015)

The data obtained from the validators' assessments were then calculated in percentage using the following formula:

$$\text{Validation Coefficient} = \frac{\text{D}}{(\text{A} + \text{B} + \text{C} + \text{D}}$$

This formula is used to determine the feasibility level of the product based on the frequency of the highest scores given by the validators. The calculation method refers to the product validity analysis approach used by Gregory (2015), in which the resulting percentage is then interpreted into feasibility categories such as very high, high, moderate, low, and very low.

After obtaining the percentage results, the criteria for the instrument's validity can be determined as shown in Table 2**.**

Table 2. Index of Agreement for Content Validity Coefficient

Range (%)	**Category**
0,81- 1,00	Very High Validity
0,61-0,80	High Validity
0,41-0,60	Moderate Validity
0,21-0,40	Low Validity
0,00-0,20	Very Low Validity

Source: Gregory,(2015)

Furthermore, media validation was carried out using a validation sheet consisting of six aspects: media design, layout, design attractiveness, video quality, educational games, and ice-breaking activities. The material and language validation used a validation sheet covering four aspects: appearance, content, material accuracy, linguistic appropriateness, and communicativeness. Assessment validation used a validation sheet including three aspects: test blueprint, question items, and answer keys. After the validation process by the experts, a response test was conducted involving 2 chemistry teachers, 9 eleventh-grade students of SMAN 2 Sekadau (small-scale), and 30 eleventh-grade students of SMAN 2 Sekadau (large-scale).

The evaluation of the media validation sheet, material and language validation sheet, assessment validation sheet, and student and teacher response questionnaires referred to a Likert scale adapted from Sugiyono (2018**),** with a score range from 1 to 4, where:4 =Strongly Agree,3 = Agree,2 = Disagree,1 = Strongly Disagree. Comments and suggestions from validators and respondents were used as evaluation input to refine the developed product. Meanwhile, numerical data from validators and respondents were analyzed using a formula adapted from Akbar (2013) as follows:

$$\text{V- pg}= \frac{TSe}{TSh}\text{X } 100\%$$

After obtaining the percentage results, the product validity criteria can be determined as shown in Table 3**.**

Table 3. Product Validity Percentage Criteria

Achievement Criteria (%)	Qualification	Description
01,00 – 50,00	Invalid	Not suitable for use
50,01 – 70,00	Less Valid	Not recommended for use as major revisions are required
70,01 – 85,00	Fairly Valid	Can be used with minor revisions
85,01 - 100	Highly Valid	Can be used without revision

Source: (Akbar, 2013)

Meanwhile, the percentage results obtained from student and teacher respondents can be interpreted based on the validity criteria presented in Table 4**.**

Table 4. Media Feasibility Assessment Criteria

Percentage (%)	Category
01,00-50,00	Invalid
50,01-70,00	Less Valid
70,01-85,00	Fairly Valid
85,01-100	Highly Valid

Source: (Akbar, 2013)

RESULTS AND DISCUSSION

The result of this research is an Interactive Multimedia on Chemical Bonding presented in the form of a web link designed to enhance conceptual understanding. The objectives are to determine the validation level of the interactive multimedia on chemical bonding and to assess the responses of students and teachers toward the developed interactive multimedia. The steps carried out in this research include: first, analysis; second, design; and third, development. The outcomes of this process are described as follows:

Analysis Phase

The first step is the analysis stage**.** This stage serves as the initial process to identify various problems and gaps that occur in the learning process (Hidayat, 2021). The analysis stage

focuses on needs analysis in the field, particularly regarding the use of learning media in chemistry classes at school, the difficulties faced by students in understanding chemical bonding material, and the types of learning media needed by students to address these gaps.

The needs analysis was carried out through observations at SMAN 2 Sekadau, direct interviews with chemistry teachers, and a review of relevant literature related to the research problem. The results of the direct interviews with chemistry teachers at SMAN 2 Sekadau showed that most students have difficulty understanding the concepts of chemical bonding, including challenges in determining ionic bonds, covalent bonds, and metallic bonds, which subsequently affects their ability to determine ion formation. This is due to students' limited understanding of chemical bonding concepts. Students also struggle to visualize the microscopic aspects of chemical bonding. Their chemical representation skills are another factor that contributes to the difficulty in understanding chemical bonding. Most students fail to connect the symbolic, macroscopic, and microscopic aspects (Rasmawan, 2020).

Design Phase

The second step is the design stage. The product is designed through the development of a storyboard and the creation of research instruments, including validation sheets and questionnaires for student and teacher responses, which were first validated by two expert validators. The interactive multimedia was developed using Canva Pro and CapCut Pro. Canva was chosen because it has a user-friendly interface and supports visually appealing and consistent designs for learning (Prastowo, 2020). Meanwhile, CapCut Pro was used to edit instructional videos because it offers a variety of features and is easy to use, thereby enhancing the attractiveness and interactivity of the media media (Wahyuni, F., & Saputra, 2022).

The purpose of instrument validation is to ensure the reliability and validity of the instruments used to assess the feasibility of media, content, language, and assessment components. The validation process was carried out by two experts in instructional media and chemistry content, followed by a student and teacher response test to evaluate the clarity, attractiveness, and ease of use of the developed interactive multimedia. This approach aligns with the Research and Development (R&D) model proposed by (Sugiyono, 2019) and was also applied by (Astuti, et. al, 2021) in the development of Android-based interactive media.

Development Phase

The third step is the development phase, which begins with the creation of the product based on the storyboard design, serving as a prototype for validation. At this stage, the storyboard design is realized into a developed product, which is then validated to determine the validity of the interactive multimedia on chemical bonding material. The developed interactive multimedia product can be accessed through the following link:

https://ikatankimia1.my.canva.site/ikatan-kimia

Figure 2. Home screen of the interactive multimedia

The validation sheet serves not only as an evaluation tool but also as a reference to improve the quality and acceptability of the developed product or instrument (Arikunto, 2010). Ensuring the relevance and alignment of the instrument with the elements being measured is the primary objective of instrument validation in this research (Ernawati, I., & Sukardiyono, 2017). The

results of the instrument validation were analyzed using Gregory's formula. The calculation results showed that all instruments used namely, the media feasibility assessment sheet, material and language feasibility sheet, assessment feasibility sheet, and student and teacher response questionnaires obtained a content validity coefficient of 1. According to Menurut (Retnawati, 2016), if the content validity coefficient of an instrument exceeds 0.8, the instrument is considered to have high validity. Therefore, it can be concluded that the developed instruments are suitable for use.

However, several suggestions were provided in the media, material, and language validation sheets, including improving the design to be more appealing and user-friendly, as well as refining sentence structure to ensure clarity and effectiveness in some items. The revisions made based on the validators' suggestions are presented in Tables 5 and 6.

Table 5. Improvements in Interactive Multimedia Based on Comments and Suggestions from Material & Language Experts

Before Revision	After Revision
	
The initial menu display still appeared simple, with colors that were too soft and buttons that were not proportionally placed. Some visual elements, such as icons and text, appeared less prominent**.**	The background color was enhanced with a more balanced contrast, menu icons were enlarged, and the button layout was adjusted to make it easier for users to understand**.**
	
The main menu design displayed navigation buttons without connecting lines between levels, making the game flow less clear**.**	A snake-shaped connecting path was added between levels so that users can understand the game sequence and track their learning progress**.**
	
The text on "Initial Competency" was removed because the title did not match the questions provided.	The page title was clarified so that students can easily understand that this section is the pre-test stage before the main game**.**
	
The first text labeled "questions" was removed to align with the previous page**.**	The text was changed to "Pre-Test Questions" to match the **previous** page**.**
	

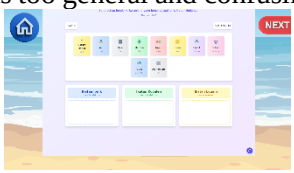
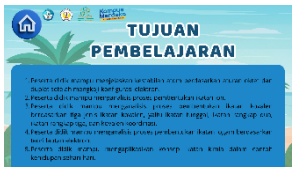
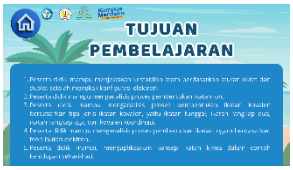
Before Revision	After Revision
In the definition of chemical bonding, only a general explanation of chemical bonds was provided, as the learning objective includes the octet and duplet rules.	The definition section was expanded to include the octet and duplet rules to align with the learning objectives.
	
In the chemical bond branch display, the description for ionic bonds was revised to "occurs between metals and non-metals, involving electron transfer" because the previous wording was too general and confusing for users.	The display was changed to "occurs between cations and anions, involving electron transfer" because this wording is more scientifically specific, improves conceptual clarity, and uses more concise and accurate language.
	
The game display was revised because several questions were inconsistent with the presented material.	The game display was replaced with a more complete feature, including score checks and material explanations, making it easier for students to understand the content.

Table 6. Improvements in Interactive Multimedia Based on Comments and Suggestions from Media Experts

Before Revision	After Revision
	
The media usage flow display was written in full text, making users reluctant to read.	The media usage flow was replaced with a video, making it easier for users to understand the navigation and sequence of the media.
	
The initial learning objectives display used black text, which did not contrast well with the background color.	The learning objectives display was changed to white text, making it easier to read and more compatible with the background.

The material and language validation was carried out by two experts in the respective fields. This validation covered five aspects: presentation, content, material accuracy, adherence to linguistic rules, and communicativeness. After the calculations were completed, the average validation score for material and language across these five aspects was 96.25%, categorized as *very valid*. The average results of the material validation are presented in Figure 3.

Based on Figure 3, the display aspect received a validity percentage of 93.75%, which falls into the very valid category. This indicates that the visual design of the interactive multimedia

was developed with careful consideration of color balance, text layout, and proportional placement of images. The validators assessed that the visual design is attractive, harmonious, and capable of enhancing students' learning motivation. These findings align with (Prastowo, 2020), who stated that an appealing visual display can increase students' interest in the material and support the internalization of concepts.

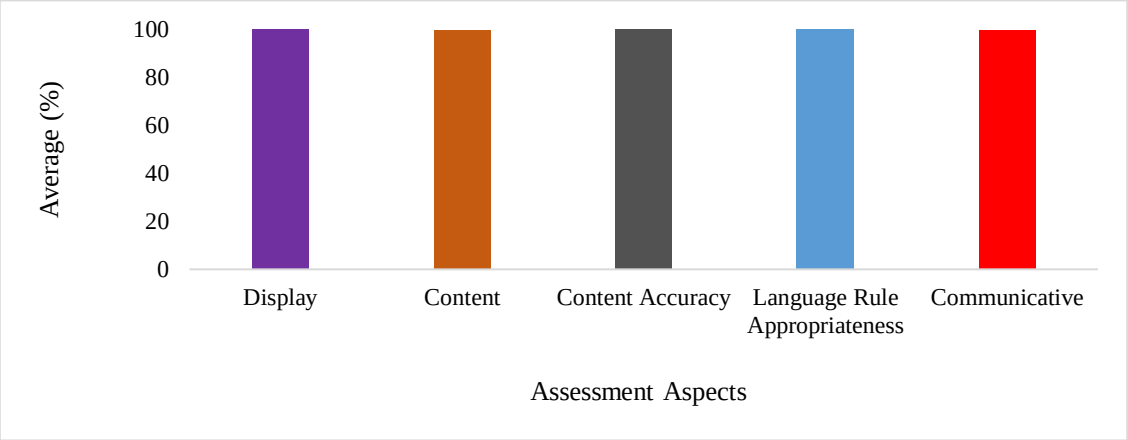


Figure 3. Percentage of feasibility test assessment for Content and Language

In addition, (Sari, D. P., & Rahmawati, 2021) also found that media designs that integrate harmonious colors and interactive layouts contribute to improved focus and learning motivation.The content aspect achieved a validity percentage of 100.00%, which is categorized as very valid. This means that all indicators within the content aspect were rated as excellent by the validators. The development of interactive multimedia must align with the learning material and students' characteristics to effectively achieve learning objectives and meet diverse learning needs. This finding is supported by (Mayer, 2021), who emphasized that the alignment between content, context, and learner characteristics is a key factor in successful multimedia learning.The material accuracy aspect obtained a percentage of 87.50%, which is also categorized as very valid. This score indicates that the material was presented with scientific accuracy. Each concept was delivered accurately and in accordance with established theories, although a few minor suggestions were made by the validators to clarify certain terms for better student understanding. High content accuracy supports the role of interactive multimedia as a reliable learning resource (Clark, R. C., & Mayer, 2016).

The aspect of conformity to linguistic rules obtained a validity percentage of 100.00%, which falls into the very valid category. This indicates that the language used in the media adheres to proper and correct Indonesian language standards. The sentences are clear, the spelling follows PUEBI (General Guidelines for Indonesian Spelling), and chemical terms are used consistently. The selection of font type in the developed audiovisual media is crucial, as font clarity helps deliver the instructional content effectively (Handayani., et al 2018).The communicative aspect also received a percentage of 100.00%, categorized as very valid. This result shows that the interactive multimedia is capable of conveying messages effectively and interactively to users. The communication between text, images, and visual elements is well-balanced, allowing information to be easily understood.

The validation percentages for the content aspect (100.00%), the linguistic accuracy aspect (100.00%), and the communicative aspect (100.00%) indicate an interesting variation that is worth analyzing. The high percentage in the content aspect is due to the material presented being aligned with the learning objectives, scientifically accurate, and relevant to real-life contexts, all of which met the validators' expectations. This is likely supported by the linguistic accuracy and communicative aspects, which consist of several indicators, all of which were rated highly by the validators.Conversely, although the display aspect (93.75%) and the

material accuracy aspect (87.50%) are also categorized as *very valid*, their percentages are slightly lower. This is because the display aspect consists of only two items and the material accuracy aspect contains only one evaluation item in the validation sheet. As a result, any suboptimal rating in these aspects has a greater impact on the overall percentage compared to aspects with a larger number of indicators.

Conversely, although the display aspect (93.75%) and the material accuracy aspect (87.50%) are also categorized as very valid, their percentages are slightly lower. This is due to the fact that the display aspect consists of only two items, and the material accuracy aspect includes only one evaluation item in the validation sheet. As a result, any suboptimal rating has a greater impact on the overall percentage compared to aspects that contain a larger number of indicators.

Therefore, this difference does not imply that the display and material accuracy are lacking in detail, but rather highlights the limitation in the number of evaluation items within these aspects. Consequently, it is recommended that future development include a greater number of indicators within the content detail aspects to enable a more comprehensive and proportional validity analysis.

Furthermore, the media validation test was conducted by two media experts. This validation covered six aspects: media design, layout, design appeal, video quality, educational games, and ice-breaking features. After the calculations were completed, the average media validation score for these aspects was 88.33%, which falls into the very valid category. The average validation results are presented in Figure 4.

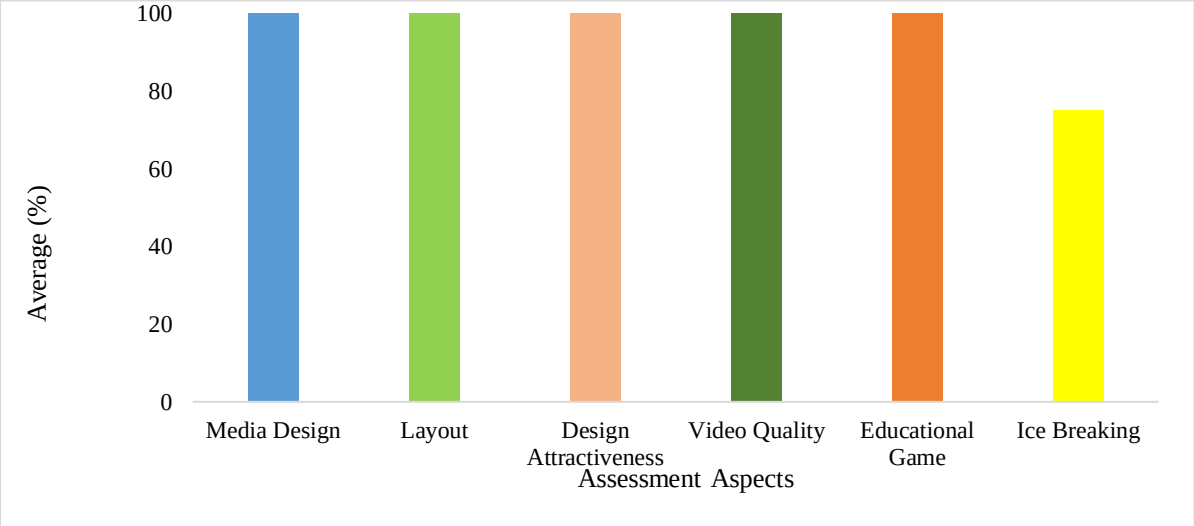


Figure 4. Percentage of Media Feasibility Assessment Ratings

Based on Figure 4, the media design aspect obtained a validity percentage of 91.67%, which falls into the very valid category. This indicates that the visual appearance is attractive, consistent, and aligned with the learning concept, thereby enhancing students' learning interest (Hulu DM., et. al 2022). The layout aspect achieved a validity percentage of 87.50%, also within the very valid category. This shows that the arrangement of menus and navigation buttons is well-organized, making it easier for users to explore the available features. An organized layout not only improves visual comfort but also plays an important role in facilitating user interaction with the learning media (Mayer, 2014). The design appeal aspect obtained a validity percentage of 87.50%, which is categorized as very valid. This demonstrates a harmonious combination of colors, icons, and illustrations, creating an aesthetic and non-monotonous display that successfully attracts users' attention (Mayer, 2014).

The video quality achieved a validity percentage of 100.00%, which is categorized as very valid, indicating that both the visual and audio components of the video are excellent. The

instructional video is interactive, thereby enhancing students' understanding of the material presented (Kurniasih., 2023). The narrator's voice is clear, and the background music is well-aligned with the learning content (Mehrvarz dkk, 2022). The educational game obtained a validity percentage of 87.50%, which falls into the very valid category. This indicates that the game successfully integrates educational elements with entertainment, allowing students to learn while playing in an enjoyable manner (Hamari, et al., 2016).The ice breaking activity received a validity percentage of 75.00%, which is considered fairly valid. However, it requires minor improvements in terms of activity variations and timing to make it more engaging and appropriately aligned with the learning atmosphere. Well-designed ice-breaking activities can enhance students' focus, motivation, and social interaction in the learning process (Barkley, & Major, 2014).

The difference in validation percentages between the media design aspect 91.67% and the video quality aspect 100.00% indicates variation in the quality of the interactive multimedia development. The high percentage in the video quality aspect is due to the use of videos with clear resolution, synchronized audio, smoothly running material animations, and the ability to effectively explain abstract concepts of chemical bonding. All of these elements met the expectations of the validators.Meanwhile, in the media design aspect, although the layout, color combinations, and navigation were rated as very good, several suggestions for improvement were still provided by the validators. This resulted in a slightly lower percentage compared to the video quality aspect.

Conversely, although the Ice Breaking aspect received a score of 75% and is still considered fairly valid, its percentage is slightly lower compared to the other aspects. This is because the Ice Breaking aspect consists of only one evaluation item in the validation sheet. As a result, a less optimal score has a greater impact on the overall percentage compared to aspects with a larger number of indicators. However, several aspects such as design and ice breaking still require improvements to achieve a more optimal level of quality.

Subsequently, the feasibility test of the assessment was carried out by two assessment experts. This validation covered three aspects: the test blueprint, test items, and answer key. Upon completion of the calculation, the average validation score for these three aspects was 97.92%, which falls into the "very valid" category. The average validation results are presented in Figure 5.

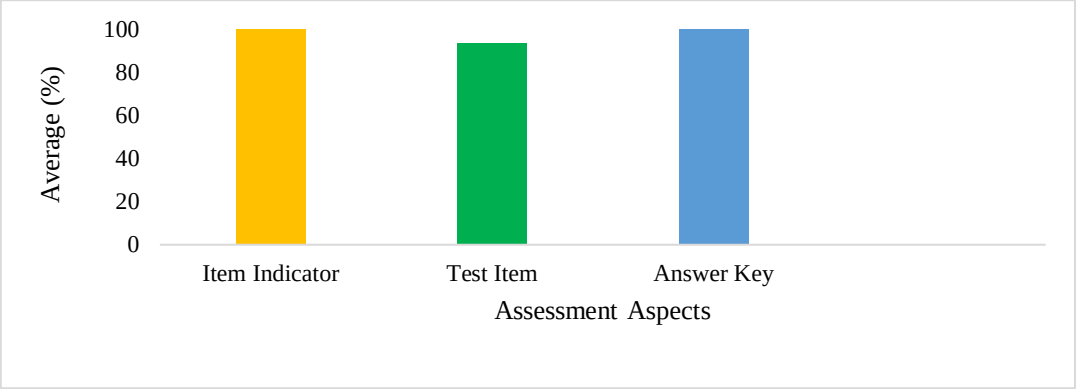


Figure 5. Percentage Ratings of Assessment Feasibility Test

Based on Figure 5, the test blueprint aspect obtained a validity percentage of 100.00%, which is categorized as very valid. This indicates that the indicators developed are aligned with the learning objectives and competency achievements. A well-constructed test blueprint plays a crucial role in ensuring content validity and alignment between learning objectives and assessment tools, which is a key indicator of assessment quality in education (McMillan,

2018)..The test item aspect received a validity percentage of 93.75%, also categorized as very valid. This shows that the wording of the questions is appropriate, the language used is easy to understand, and each item measures students' thinking skills according to the expected cognitive level. Additionally, each question item has been designed to measure cognitive abilities in accordance with Higher Order Thinking Skills (HOTS)-based learning. Well-developed test items not only assess factual knowledge but also students' abilities in analysis, synthesis, and evaluation (Brookhart, 2010). The answer key aspect achieved a validity percentage of 100.00%, which is categorized as very valid. The answer keys are consistent with the test items and the material being assessed, and they facilitate objective scoring by teachers. Overall, the assessment instrument developed has met the criteria for validity (Nitko, A. J., & Brookhart, 2014).

The validation results show that both the test blueprint and answer key aspects achieved a percentage of 100.00%, reflecting exceptionally high and consistent quality. This high score indicates that the content and answers developed align with the learning objectives, are scientifically accurate, communicative, and easy to understand. All indicators within these aspects were rated as excellent by the validators, resulting in a perfect score.

Conversely, although the test item aspect obtained a validity percentage of 93.75%, which is still categorized as very valid, the percentage is slightly lower. This is due to several test items requiring improvements in terms of clarity of wording and cognitive level alignment. Additionally, the number of assessment indicators in this aspect is limited, so a single suboptimal evaluation has a relatively significant impact on the overall percentage.

Thus, this difference does not indicate that the test items are of low quality or lacking in detail, but rather is due to differences in subjectivity among the validators. In the test item aspect, for example, the validators assigned different scores for the cognitive level-validator 1 gave a score of 3, while validator 2 gave a score of 4-resulting in a slight decrease in the overall percentage. Therefore, it is necessary in the future to establish a common understanding or conduct a discussion among validators prior to the assessment process, in order to ensure more consistent validity results.

After validation by the experts was completed, the next step in this phase was the teacher response test. The response test was conducted with two teacher respondents. This test included three aspects: appearance, content, and usability. After the calculation was completed, the average response score for these three aspects was 83.07%, which falls into the "fairly valid" category. The average response results are presented in Figure 6.

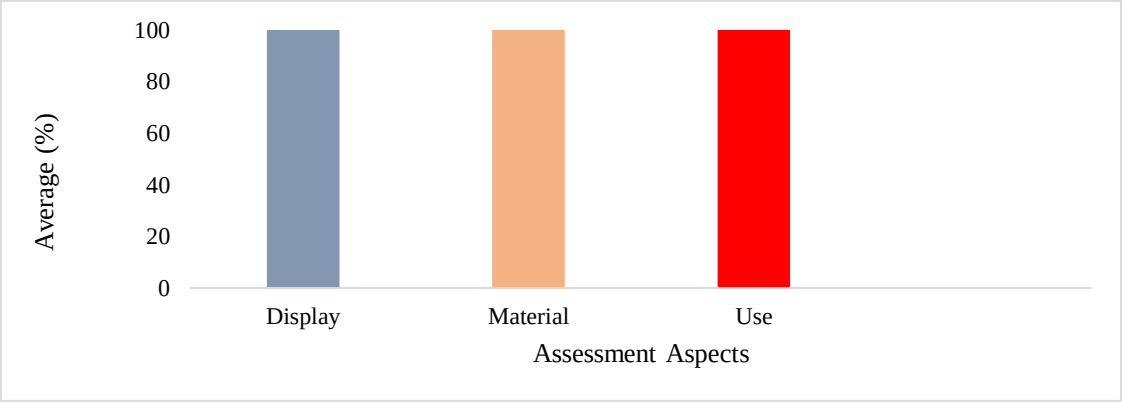


Figure 6. Percentage of Teacher Response Assessment

Based on Figure 6, the appearance aspect received a validity percentage of 82.55%, which falls into the "fairly valid" category. This indicates that the design of the interactive multimedia is visually appealing, aligns with the theme of chemistry learning, and helps create a conducive

learning atmosphere. The attractive visual display not only enhances the aesthetics of the media but also helps students stay focused on the learning material and reduces boredom during the learning process.The material aspect obtained a validity percentage of 87.50%, which is categorized as "highly valid." This means that the content presented is aligned with the learning objectives, systematically structured, scientifically accurate, and follows the development of chemical science Sastro., et. al (2023).

In classroom practice, the structured and contextual delivery of content can improve students' conceptual understanding and prevent misconceptions, especially regarding abstract concepts such as atomic structure.The usability aspect received a percentage of 79.17%, which is categorized as "fairly valid." This shows that the interactive multimedia developed is easy to use for both teachers and students. These findings are consistent with Sastro., et. al (2023), who stated that interactive learning media play an important role in increasing student engagement in the classroom. Its ease of use allows teachers to effectively integrate the media into various learning models, such as group discussions, problem-based learning, or interactive demonstrations.

The differences in validation percentages across the material aspect 87.50%, appearance 82.55%, and usability 79.17% indicate variations in quality that are important to analyze further. The material aspect received the highest score because the content aligns with learning objectives, is systematically organized, and is relevant to real-life contexts. This led validators to rate the material very positively, as it provides comprehensive understanding for students and helps prevent misconceptions.The appearance aspect obtained a score of 82.55%, which falls into the "fairly valid" category. This indicates that the visual design of the media is already attractive and consistent with the theme of chemistry learning, although several visual elements such as color consistency, layout arrangement, and navigation icons could still be improved to make it more user-friendly.Meanwhile, the usability aspect received a score of 79.17%, indicating that the media is relatively easy to use, but still presents some technical issues. These include navigation that is not fully intuitive and response delays when switching between menus, which require further refinement.

Thus, these differences do not indicate that the appearance or usability aspects are inadequate, but rather reflect limitations in the assessment indicators and the presence of several technical components that require improvement. In the future, enhancements in visual design, simplification of navigation, and the addition of more detailed evaluation indicators are strongly recommended so that the assessment results become more proportional, representative, and better support the effectiveness of multimedia in learning.

The next step in this phase was the small-scale student response test, which involved 9 students from SMAN 2 Sekadau. After the calculation, the average response score was 90.69%, which falls into the "highly valid" category. The average validation results are presented in Figure 7.

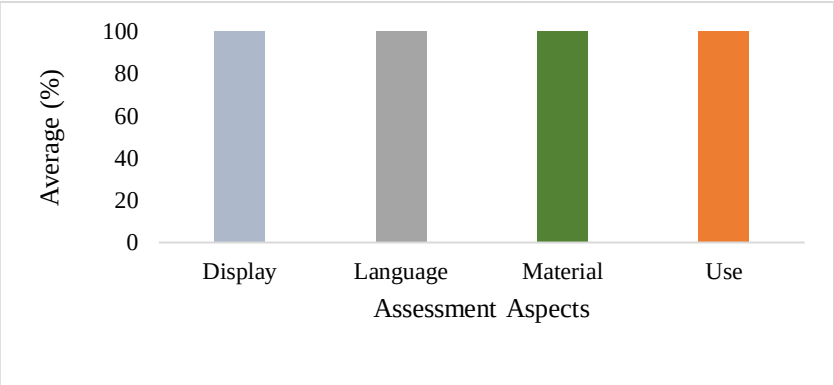


Figure 7. Percentage of Small-Scale Student Response Assessment

Based on Figure 7, the appearance aspect received a validity percentage of 94.44%, which falls into the "highly valid" category. This indicates that the developed interactive multimedia has excellent visual quality, with harmonious color combinations, well-organized element layout, and consistent design. The attractive appearance not only serves an aesthetic purpose but also helps focus students' attention and supports concept comprehension. According to Mayer, (2017), a well-designed visual can strengthen students' cognitive processes through the systematic integration of text, images, and animations.

The language aspect received a validity percentage of 86.11%, which is categorized as "highly valid." The language used is clear, communicative, and appropriate for the cognitive development level of the students. The sentence structure is straightforward, free from ambiguity, and complies with the rules of the Indonesian language. Proper use of language is crucial for minimizing students' cognitive load, as explained by Sweller, & Kalyuga, (2011),, allowing students to focus more on understanding the concepts rather than interpreting the language.

The material aspect received a validity percentage of 88.89%, which falls into the "highly valid" category. This indicates that the content aligns with the learning objectives and is connected to real-life contexts. Linking the material to practical contexts allows students to understand that chemistry is not merely theoretical but also has practical applications in daily life. Consequently, this multimedia supports contextual learning, which can enhance students' critical thinking skills and the transfer of knowledge to real-life classroom situations.The usability aspect received a validity percentage of 93.33%, also categorized as "highly valid." The media is easy to operate for both teachers and students independently, featuring clear navigation and fully functional tools. This ease of use facilitates the integration of the media into various teaching models, such as group discussions and project-based learning.

The next step in this phase was the large-scale student response test, which involved 30 students from SMAN 2 Sekadau. After calculation, the average response score was 94.53%, which falls into the "highly valid" category. The average validation results are presented in Figure 8.

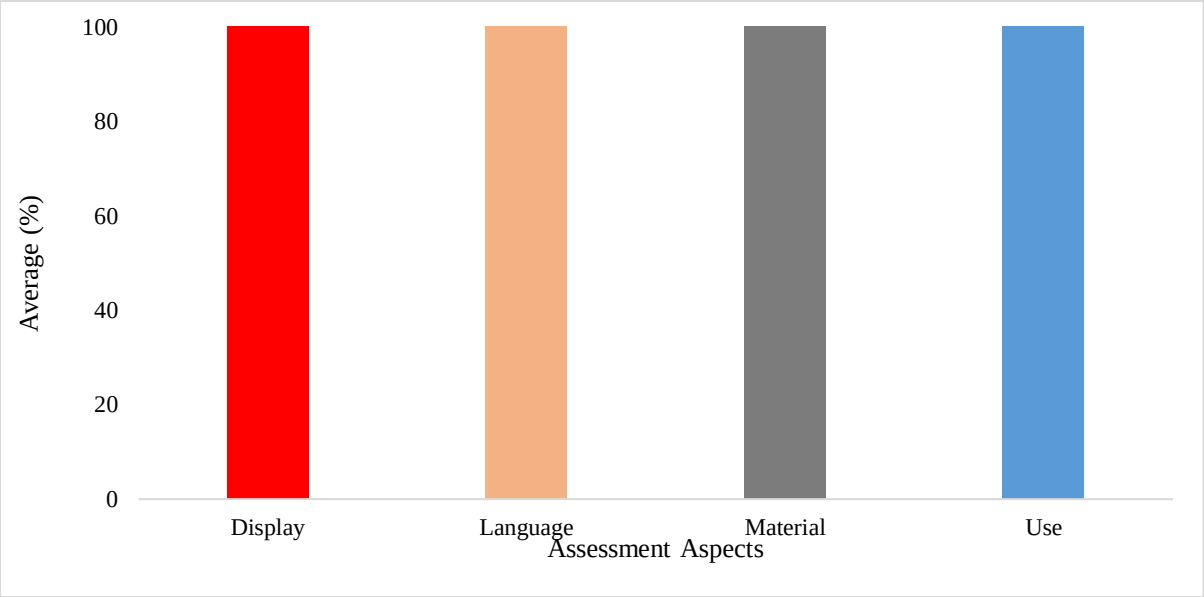


Figure 8. Percentage of Large-Scale Student Response Assessment

Based on Figure 8, the display aspect received a validity percentage of 94.79%, categorized as highly valid. This is attributed to several factors: the interactive multimedia display is visually appealing, with harmonious color combinations and well-organized element layouts. The visual design, including the systematic presentation of images, text, and animations, is clear

and not confusing, making it easier for students to understand the content.The language aspect achieved a validity percentage of 96.67%, also categorized as highly valid. This high rating is due to the clear, concise language used in the interactive multimedia, which adheres to proper Indonesian language rules. Moreover, the sentences are easily understood by students and do not create ambiguity.The material aspect obtained a validity percentage of 95.83%, falling into the highly valid category. This was achieved because the content aligns with the learning objectives and expected learning outcomes.

This finding aligns with (Lestari, R., & Wibowo, 2022), who stated that presenting contextualized material can enhance students' conceptual understanding. Additionally, according to (Suryani, N., Rahayu, T., & Prasetyo, 2021), using interactive multimedia that includes practical examples can stimulate students' learning interest and help them build connections between theory and practice.The usability aspect showed excellent results with a validity percentage of 90.83%, also categorized as highly valid. This is because the media is easy for students to operate independently without complicated guidance. In addition to operational ease, the features provided function effectively and support learning efficiently.

CANCLUSION

Based on the results of the research and development, the interactive multimedia on chemical bonding material is declared highly valid in terms of media, content & language, and assessment, and received very positive responses from both teachers and students. The novelty of this study lies in the integration of various interactive features, such as ice-breaking activities and educational games, which create an enjoyable learning environment and enhance students' emotional and cognitive engagement during the learning process. Future research is recommended to conduct comprehensive classroom implementation trials to evaluate the effectiveness of the media on student learning outcomes. Furthermore, further development can be carried out across different educational levels and school environments with limited resources, by adjusting file size, feature complexity, and access modes to ensure efficiency and ease of use.

RECOMENDATION

This study received very positive feedback from educators, indicating that the developed media is relevant and useful in supporting the learning process. Nevertheless, further development is needed to make the product more engaging, interactive, and user-friendly, thereby enhancing student engagement in the classroom. Additionally, the implementation of this media should consider the availability of devices, internet connectivity, and ease of access for educators to ensure its optimal and equitable use across various school settings.

ACKNOWLEDGEMENT

The author would like to express sincere gratitude to the Faculty of Teacher Training and Education at Tanjungpura University for the support and facilities provided throughout this research. Deep appreciation is also extended to the validators and respondents who have taken the time to provide valuable assessments and feedback. Special thanks are given to Yulius Bagara Motuhonu, a student of the Chemistry Education Study Program at FKIP UNTAN, for his assistance and cooperation in the data collection process, which enabled this research to be successfully completed.

BIBLIOGRAPHY

Akbar, S. (2013). *Instrumen Perangkat Pembelajaran.* Bandung: Remaja Rosda Karya.

Arikunto, S. (2010). *Prosedur Penelitian Suatu Pendekatan Praktik.* Jakarta: Rineka Cipta.

Astuti, R., Lestari, D., & Nurhasanah, S. (2021). Pengembangan media pembelajaran interaktif berbasis Android untuk meningkatkan motivasi belajar siswa SMA. *Jurnal Pendidikan Sains, 9(2), 112-*.

Barkley, E. F., Cross, K. P., & Major, C. H. (2014). *Collaborative Learning Techniques: A Handbook for College Faculty (2nd ed.)*. San Francisco, CA: Jossey-Bass.

Branch, R. M. (2009). *Instructional Design-The ADDIE Approach*. New York: Springer.

Brookhart, S. M. (2010). *How to Assess Higher-Order Thinking Skills in Your Classroom* (ASCD. (ed.)).

Clark, R. C., & Mayer, R. E. (2016). *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning (4th ed.).* Wiley.

Dewi, N., Murtinugraha, R. E., & Arthur, R. (2018). Pengembangan Media Pembelajaran Interaktif Pada Mata Kuliah Teori Dan Praktik Plambing Di Program Studi S1 Pvkb Unj. *Jurnal Pendidikan Teknik Sipil*, *7(2)*, 95–104. https://doi.org/10.21009/pensil.7.2.6

Ernawati, I., & Sukardiyono, T. (2017). Uji Kelayakan Media Pembelajaran Interaktif Pada Mata Pelajaran Administrasi Server. *Elinvo (Electronics, Informatics, and Vocational Education), 2 (2)*, 204–210.

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior*, *54, 170–17*.

Handayani, Y., Sugiarti, Y., & Handayani, M. N. (2018). Pengembangan media pembelajaran audiovisual pada kompetensi pengujian bahan hasil pertanian dan perikanan secara kimiawi untuk meningkatkan hasil belajar siswa. 51–59. *Edufortech*, *3(1)*, 51–59.

Hidayat, F. (2021). Model Addie (Analysis, Design, Development, Implementation and Evaluation) Dalam Pembelajaran Pendidikan Agama Islam Addie (Analysis, Design, Development, Implementation and Evaluation) Model in Islamic Education Learning. *Jurnal Inovasi Pendidikan Agama Islam, 1 (10*, 28–37.

Hulu DM, Pasaribu K, Simamora E, Waruwu SY, B. (2022). Pengaruh Penggunaan Media Visual Terhadap Motivasi Belajar Siswa. *Jurnal Kewarganegaraan*, *6(2)*, 7.

Kurniasih, S. R., Nugraha, M. S., & Muslih, H. (2023). Pengembangan Bahan Ajar Video Interaktif berbasis Edpuzzledalam Pembelajaran Pendidikan Agama Islam. *Jurnal Pendidikan Agama Islam Al-Thariqah*, *8(2)*, 275–294.

Lestari, R., & Wibowo, S. (2022). Pengaruh penyajian materi kontekstual dalam multimedia interaktif terhadap pemahaman konsep kimia siswa SMA. *Jurnal Pendidikan Kimia Indonesia*, *6(2), 87–9*.

Lestari, N. (2020). *Media Pembelajaran Berbasis Multimedia Interaktif.* Lakeisha.

Mayer, R. E. (2014). *The Cambridge Handbook of Multimedia Learning (2nd ed.).* Cambridge University Press.

Mayer, R. E. (2017). *Multimedia Learning (3rd ed.).* Cambridge University Press.

Mayer, R. E. (2021). *Multimedia Learning (3rd ed.).* Cambridge University Press.

McMillan, J. H. (2018). *Classroom Assessment: Principles and Practice for Effective Standards-Based Instruction (7th ed.)*. Pearson.

Mehrvarz dkk. (2022). Media Pembelajaran Teknologi Digital. *Jurnal Pendidikan Anak, (Vol.8, Ed*.

Nitko, A. J., & Brookhart, S. M. (2014). *Educational Assessment of Students (7th ed.)*. Pearson.

Prastowo, A. (2020). *Panduan kreatif membuat bahan ajar inovatif*. Diva Press.

Purnamasari, L. E., Suratman, D., & Umar, S. (2015). Pengembangan Multimedia Interaktif Pembelajaran Kimia untuk Perolehan Belajar Konsep Ikatan Kimia Kelas X IPA. *Jurnal Pendidikan Dan Pembelajaran*, *4*(9), 1–14. http://jurnal.untan.ac.id/index.php/jpdpb/article/view/11299

Rahmawati, F., & Sari, D. P. (2022). Pengaruh game edukatif terhadap motivasi dan hasil belajar kimia siswa SMA. *Jurnal Inovasi Pendidikan Sains, 9(1), 45–5*.

Rahmawati, D. (2021). Efektivitas multimedia interaktif dalam meningkatkan keterlibatan belajar siswa pada pembelajaran kimia daring. *Jurnal Inovasi Pendidikan Kimia, 15(2), 102*.

Rasmawan, R. (2020). Development of multi-representation based electronic book on inter molecular forces (IMFs) concept for prospective chemistry teachers. *International Journal of Instruction, 13(4),* 747–762.

Retnawati, H. (2016). *Analisis Kuantitatif Instrumen Penelitian.* Parama publishing. www.nuhamedika.gu.ma.

Sabrina, R. (2020). Identifikasi Kesulitan Siswa Pada Materi Ikatan Kimia di SMAS Muslimat Samalanga Bireuen. *Journal GEEJ, 7(2)*.

Sari, D. P., & Rahmawati, F. (2021). Pengaruh desain tampilan media interaktif terhadap motivasi dan hasil belajar siswa SMA. *Jurnal Inovasi Teknologi Pendidikan*, *8(3), 122*-.

Sastro, W., Mora, E., Lubis, A. R., & Gusnirwanda, H. (2023). Pengembangan media pembelajaran interaktif berbasis multimedia untuk meningkatkan pemahaman konsep matematika siswa mis aisyah wil. Sumut. *Jurnal Penelitian Pendidikan Indonesia*, *1(1),* 296–302.

Sugiyono. (2019). *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D.* Alfabeta.

Suryani, N., Rahayu, T., & Prasetyo, M. (2021). Peran multimedia interaktif dalam meningkatkan minat dan pemahaman konsep sains. *Jurnal Teknologi Dan Pembelajaran*, *10(1), 33*-.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. Springer.

Wahyuni, F., & Saputra, A. (2022). Pemanfaatan aplikasi CapCut dalam pengembangan media video pembelajaran interaktif. *Jurnal Teknologi Pendidikan*, *14(1), 45*-.