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Development of Digital Interactive Modules for Teaching Chemical Bonding of Grade XI Senior High School Students

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Abstract
This study aims to determine the feasibility of an interactive electronic module on chemical bonding for 11th-grade high school students, as well as to describe student responses to its use. The study is a type of Research and Development (R&D) using the 4D development model (Define, Design, Develop, and Disseminate), though it is limited to the Develop stage. Data collection instruments included feasibility assessment sheets and student response questionnaires. The module's feasibility was assessed by three experts based on language, content, and media aspects. The results showed an average feasibility percentage of 95.51%, categorized as *highly feasible*. The response test was conducted on a limited basis with 30 students from grade XI at SMA N 1 Sungai Raya, yielding an average response percentage of 87.25%, categorized as *very good*. Based on these results, the interactive electronic module was deemed feasible and received positive responses from students, making it a potential alternative for engaging and interactive learning in chemical bonding.

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INTRODUCTION

The rapid advancement of science and technology in this digital age has profoundly influenced the education sector, especially in the innovation of instructional media. Various technology-based tools and applications such as computers, smartphones, websites, digital books, and internet-based resources are increasingly utilized to enhance the efficiency of learning activities (Ratminingsih *et al.*, 2020). The government, through Government Regulation No. 57 of 2021 on National Education Standards, Article 10, Paragraph 1, emphasizes that the learning process must be conducted in an interactive, inspiring, enjoyable, challenging, and motivating manner, encouraging students to actively participate and providing sufficient space for initiative, creativity, and independence in accordance with their talents, interests, and development.

The shift in the learning paradigm from teacher-centred to student-centred requires learning that can accommodate student activity in the learning process. Student-centred learning will be more meaningful if it is complemented with relevant and contextual teaching resources. However, in practice, especially in high school chemistry learning, various obstacles are still encountered, such as limited teaching materials that meet the needs of students and the low effectiveness of the media used in the learning process.

Effective teaching materials should be able to help students understand abstract concepts, such as chemical bonding. This material requires students to understand concepts that cannot be observed directly, such as atomic structure, electron configuration, ionic and covalent bonds, and Lewis structures. Based on interviews with teachers at SMAN 1 Sungai Raya, it

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was found that students had difficulty understanding these concepts. This is reinforced by the results of observations and interviews with students, which show that more than 50% of students have not achieved the Minimum Competency Criteria (KKM) in chemical bonding, particularly in understanding the octet and duplet rules, as well as distinguishing between types of bonds.

Previous studies have also shown low levels of student understanding of chemical bonding concepts. The results of Safitri *et al*. (2018) indicate that the percentage of student understanding of concepts such as Lewis structures, ionic bonds, covalent bonds, and metals is still relatively low, ranging from 34 to 47%. This condition indicates the need for learning strategies and media that can provide concrete visualization and interactivity so that abstract concepts can be more easily understood by students. The selection of teaching materials used can influence students' mastery and understanding of chemistry (Raharjo *et al*., 2017). Various efforts have been made to address this issue, one of which is through the development of technology-based teaching materials such as interactive electronic modules. Hilwanisa *et al*. (2025) state that e-modules are flexible, can be used anytime, and use simple language, thereby helping students absorb the information presented within them more smoothly.

Interactive electronic modules are digital-based teaching resources equipped with images, audio, animations, and exercises that enable two-way interaction between students and learning media (Kristanto, 2008). Several previous studies have proven the effectiveness of this media in improving student learning outcomes. The study by Asda & Andromeda (2021) showed that the use of interactive electronic modules resulted in a higher N-gain compared to classes that did not use such media. Additionally, the findings of Herawati & Muhtadi (2018) indicated a significant difference between pre-test and post-test scores after using interactive electronic modules, with a significance level of $0.000 < 0.05$.

Based on the above research findings, this study offers scientific innovation in the form of the development of interactive electronic modules on chemical bonding for grade XI, based on an analysis of the needs of students and teachers at SMAN 1 Sungai Raya. Another innovation lies in the visual design and interactivity of the modules, which are tailored to the characteristics of students and the learning outcomes of the current curriculum. Based on the research by Zakaria *et al*. (2024), field testing of the interactive multimedia-based E-module on geometric isomerism topic yielded an average score of 88.16%, categorized as very good. Based on this, the primary focus of this study is to develop an interactive electronic module that aligns with students' needs in chemistry bonding. This study aims to examine: (1) the feasibility of interactive electronic modules on chemical bonding for 11th grade high school students as a learning resource and (2) student responses to the use of interactive electronic modules in the learning process. It is hoped that the results of this study can provide an alternative teaching resources that is interesting, interactive, and supports the achievement of chemistry learning competencies in high schools.

METHOD

This study uses the research and development (R&D) method, employing the 4-D Model. This model consists of four stages: Define, Design, Develop, and Disseminate. The four stages of the 4D model are detailed in Figure 1. However, this research was only conducted up to the Develop stage due to limitations in time, manpower, and costs.

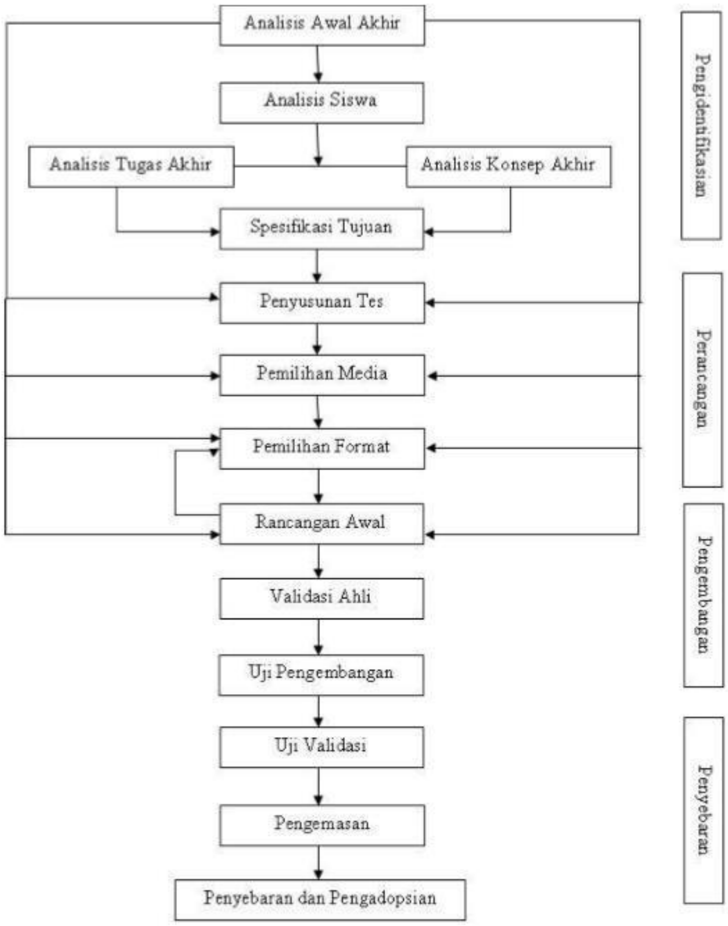


Figure 1. 4D Development Model (source: Ferdianto & Setiyani, 2018)

Define

This stage involves front-end analysis, learner analysis, task analysis, concept analysis, and formulation of learning objectives. Front-end analysis is conducted to identify learning problems, such as students' difficulties in understanding chemical bonding. Learner analysis is aimed at understanding the characteristics, abilities, and intellectual development of students. Task analysis is used to identify the key skills that students must possess to achieve learning objectives. Concept analysis is used to determine the relevant subject matter. The results of these analyses are used to formulate learning objectives that will be achieved through the development of interactive electronic modules. This stage aims to determine the initial requirements for developing the product (Pranata *et al*., 2021).

Design

At this stage, module design is carried out based on the results of the Define stage, which includes: (1) developing test instruments and feasibility questionnaires to measure aspects of content, language, and media; (2) selecting media by considering the characteristics of students who are accustomed to using digital technology and content that requires interactive visualization, so HTML-based flipbook media developed using the Heyzine application was selected. This application is free to use and supports video playback; (3) selecting a module presentation format that aligns with learning objectives, particularly in enhancing understanding of chemical bonding concepts. An interactive format enables integration between text, visuals, animations, and practice questions, thereby increasing learner engagement; and (4) creating an initial design in the form of a storyboard as a reference for module development.

Develop

The development stage of the interactive electronic module began with an expert appraisal process, in which three experts assessed the module, taking into account aspects of language, content, and media. This assessment aimed to obtain constructive feedback for product improvement. After revisions are made, the next stage is development testing, which involves a limited trial with 30 eleventh-grade students from SMA Negeri 1 Sungai Raya. This trial aims to describe students' responses to the developed interactive electronic module. The selection of 30 students refers to Arikunto's (2010) opinion that in limited trials, the minimum recommended sample size is 30 people. The validation results were analyzed quantitatively and qualitatively. Quantitative data was obtained from the validation scores and student response questionnaires. In addition to validation, product revisions and response tests were also conducted to assess user feedback on the module. The results of this stage were used as the basis for formative product improvements before broader implementation. Validation results were then analyzed by calculating the assessment scores for each statement, followed by determining the percentage of scores obtained using the following formula:

$$\boldsymbol{P} = \frac{\sum \boldsymbol{X}}{\sum \boldsymbol{Xi}} \times \mathbf{100}\ \%$$

(Riduwan, 2012)

Description:

P = Percentage of the obtained score
∑X = Total obtained score for each item
∑ Xi = Total ideal score (maximum possible score)

Next, the average percentage of the module's feasibility is calculated using the formula:

$$\mathbf{P\ total} = \frac{\sum \mathbf{P}}{\mathbf{n}}$$

(Riduwan, 2012)

Description:

P total = Average feasibility percentage
∑P = Total percentage of obtained scores
n = Total highest possible score

The final results were compared with the feasibility criteria to determine the level of feasibility of interactive electronic modules based on the percentage interval categories in Table 1.

Table 1. Percentage of Feasibility Levels for Interactive Electronic Modules

Interval (100%)	Criteria
0-20	Very Unsuitable
20-40	Unsuitable
40-60	Sufficiently Suitable
60-80	Suitable
80-100	Very Suitable

(Riduwan, 2012).

At this stage, a response test was also conducted to measure the students' response to the interactive electronic module that had been developed. The questionnaire used a 4 point Likert scale to assess each statement, including SS (Strongly Agree), S (Agree), TS (Disagree), and STS (Strongly Disagree). The scoring system using the Likert scale for each statement can be seen in Table 2.

Table 2. Likert Scale Scores on the Validation Questionnaire and Response Questionnaire

Assessment	Positive Statements	Negative Statements
SS	4	1
S	3	2
TS	2	3
STS	1	4

(Hasanah *et al*., 2021)

To calculate the percentage of the total value per item, the following formula is used:

$$\boldsymbol{P} = \frac{\sum \boldsymbol{X}}{\sum \boldsymbol{Xi}} \times \mathbf{100}\,\%$$

(Riduwan, 2012)

Description:

P = Percentage of the obtained score
∑X = Total obtained score for each item
∑ Xi = Total ideal score (maximum possible score)

After obtaining the percentage of scores, the total average response percentage is then measured using the following formula:

$$\mathbf{P\ total} = \frac{\sum \mathbf{P}}{\mathbf{n}}$$

(Riduwan, 2012)

Description:

P total = Average feasibility percentage
∑P = Total percentage of obtained scores
n = Total highest possible score

Then, the scores obtained were interpreted using the Likert scale in accordance with the criteria listed in Table 3.

Table 3. Eligibility Criteria for Interactive Electronic Modules

Interval	Criteria
0% - 20%	Very Poor
20% - 40%	Poor
40% - 60%	Fair
60% - 80%	Good
80% - 100%	Very Good

(Yeni *et al*., 2021)

Meanwhile, the qualitative data consisted of suggestions from validators, which were used as a basis for revising the product.

RESULTS AND DISCUSSION

Findings from this study indicate that the development of an interactive electronic module on chemical bonding material for Grade XI is feasible and well received. The development of this interactive electronic module has gone through a series of stages in the 4D model which is limited to the develop stage, namely feasibility testing and knowing the response of students. The results at the interactive electronic module development stage are described as follows:

Define

Front End Analysis

This analysis is conducted to find and identify learning problems that occur in class XI on chemical bonding material. The techniques used were interviews and observations of teachers and students. The results of the analysis showed several main problems, namely: 1) Learners have difficulty in understanding the concept of chemical bonds because of its abstract nature, 2) Teachers have not fully utilised technology in presenting abstract material such as chemical bonds and 3) Learning resources lack animations that can help students understand the types of chemical bonds. These problems are the background for the need to develop interactive electronic modules.

Learner Analysis

This analysis aims to determine the characteristics of class XI students when learning chemistry, especially in chemical bonding material. Based on the results of observations at SMA Negeri 1 Sungai Raya, data obtained from less than 50% of students who completed or obtained scores below the minimum completeness criteria (KKM) of 75 in the assessment of chemical bonding material in that class. This shows the need for the development of learning resources that can help improve students' understanding.

Task Analysis

This analysis aims to identify and define the learning tasks that students are expected to perform in mastering the concept of chemical bonding. Through curriculum analysis, researchers determined several learning outcomes targeted to be covered in the interactive electronic module. These learning outcomes include students' ability to understand the octet and duplet rules related to elemental stability, the process of forming ionic compounds, the formation of various covalent bonds (single, double, and triple), coordination covalent bonds, and the physical properties of covalent compounds. In addition, interactive content-based evaluation questions are also designed to strengthen students' conceptual understanding.

Concept Analysis

Concept analysis was conducted to identify the main concepts in chemical bonding. Researchers compiled a concept map as a basis for developing module content. The concept map contains interrelationships between sub-topic such as electron configuration, elemental stability, types of chemical bonds, Lewis structure, and polarity of compounds. This concept mapping aims to ensure that the learning flow in the module is systematic, logical, and makes it easier for students to understand the relationship between concepts. The concept map is shown in Figure 2.

Formulation of Learning Objectives

Based on the results of task analysis and concept analysis, learning outcomes are formulated. Learning outcomes are used to determine learning objectives. Learning objectives are things that are expected to be understood and mastered by students in the learning process (Dennys & Sunaryo, 2018). The learning outcomes that have been formulated can be seen in Table 4.

Table 4. Scope of Content and Learning Outcomes on Chemical Bonding

Material Scope	Learning Outcome
- The Role of Electrons in the Formation of Chemical Bonds - Ion Bond - Covalent Bond	Learners are able to: o Understanding the octet and duplet rules in elemental stability o Understanding the formation of ionic compounds and the physical properties of ionic compounds

Material Scope	Learning Outcome
	○ Understanding the formation of covalent bonds and the physical properties of covalent compounds

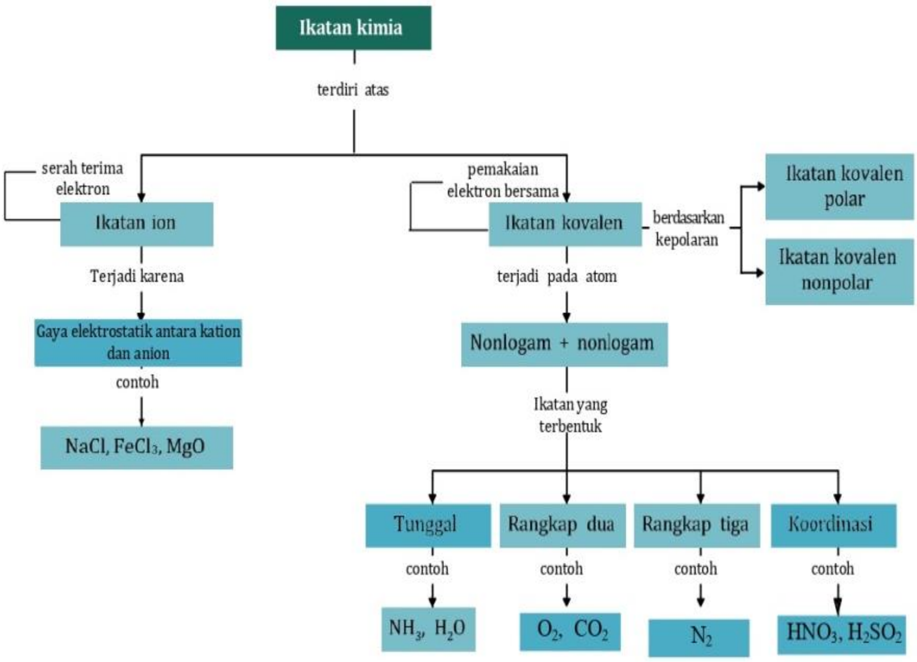


Figure 2. Concept Map of Chemical Bonding in the Interactive Electronic Module

Design

Standardised Test Development

At this stage, the test developed is an instrument to assess the feasibility of interactive electronic modules consisting of language, material, and media feasibility. The instrument was developed based on the results of the formulation of learning objectives indicators that were adjusted to the feasibility standards of teaching resources according to the National Education Standards Agency (BSNP). In addition, to determine the readability test of the interactive electronic module developed, the researcher also developed an instrument in the form of a student response questionnaire to the interactive electronic module.

Media Selection

The learning media chosen in this study is a flipbook-based interactive electronic module. This media was chosen because it is able to integrate visual, audio, and interactivity elements that are suitable for conveying abstract chemistry material. The selection of this type of media also considers the characteristics of students who are familiar with digital technology and tend to be more interested in visual and interactive presentations.

Format Selection

The presentation format of the module was developed in HTML (Hypertext Markup Language) using the Heyzine application as an interactive flipbook platform. This format allows the module to be accessed online through various devices, both laptops and gadgets. The module is designed with a systematic content structure, including introduction, delivery of subject matter, visual illustrations, learning videos, practice questions, and Quizizz-based evaluation. This format is expected to increase students' engagement and understanding of chemical concepts. The presentation format of the developed interactive electronic module can be seen in table 5.

Table 5. Format of the Electronic Module Content

Section of the Electronic Module	Electronic Module Content
Introduction	Cover Page
	Foreword
	Concept Map
	Table of Contents
	User Guide
	Introduction
	Learning Outcomes
Main Content	Scope of Material
	Practice Questions
	Material Evaluation Questions
	Summary
Closing	Glossary
	References
	Author Profile

Preliminary Design

Researchers compiled a storyboard as a reference in developing the module. The content module were obtained from relevant sources such as textbooks, scientific journals, and online references. The module also included images, video links, and question links to help students understand the concept of chemical bonding thoroughly. In addition to the storyboard, the researcher also compiled a module feasibility test instrument covering aspects of language, material, and media/graphics. This instrument was prepared based on the feasibility standards of teaching resources from the National Education Standards Agency (BSNP). In addition, a response questionnaire was also prepared for students to obtain responses to the feasibility and usefulness of the module in learning. The storyboard of the interactive electronic module is arranged as in Table 6..

Table 6. Interactive Electronic Module Storyboard

Section	Components
Front Cover	The cover page consists of the title of the material, author, college of origin, and target class.
Foreword	This section contains the author's gratitude for the completion of the preparation and development of the module as well as the purpose of developing this module and a brief description of the contents of the module.
Concept Map	This page presents a structured visual overview of the key concepts and their interrelationships in the material.
Table of Contents	This page contains a complete list of topics and subtopics covered in the chemical bond electronic module along with their page numbers, to facilitate navigation for the reader.
Instructions for Use	This page provides a step-by-step guide on how to use and utilise this chemical bonding e-module effectively.
Introduction	This page introduces the reader to the main topic, provides background material and contains a brief description of chemical bonding material.
Learning Outcomes	Contains a specific description of the knowledge and skills that are expected to be mastered by students after studying chemical bonding material.
Material	This chapter presents in-depth explanations of concepts, theories, examples and illustrations relevant to chemical bonding material and includes videos to add visualisation of the chemical bond formation

Section	Components
	process in each type of chemical bond.
Summary	This contains a summary of the key points of the material covered, helping students to tie in and understand the essence of the learning.
Material Evaluation Questions	This section contains questions that aim to measure the level of student mastery of the overall material that has been learned. The form of questions is multiple choice and can be accessed through the link provided.
Glossary	This page lists important terms used in the chemical bonding material along with their definitions, helping students understand specialised terminology.
Author Profile	This section lists the reference sources used in the preparation of chemical bonding and provides further information for readers who are interested in exploring related topics.

Develop

At this stage, an expert-validated interactive electronic module on chemical bonding was developed and tested on 30 eleventh-grade students of SMA Negeri 1 Sungai Raya. The results of the Interactive Electronic Module on Chemical Bonding Material developed can be seen in the following link: https://heyzine.com/flip-book/55f04bbb71.html

Expert Appraisal

The expert assessment used feasibility assessment sheets on language, material and media aspects by 3 validators. The criteria assessed were 34 consisting of 8 assessment criteria in the language aspect, 14 assessment criteria in the material aspect and 12 assessment criteria in the media aspect. Details of the results of the feasibility test on language aspects are described in table 7.

Table 7. Feasibility Test Results on Language Aspects

No	Assessment Items	Validator 1	Validator 2	total score
1	The words chosen are appropriate.	3	4	7
2	The sentences used are effective.	4	4	8
3	The terms used are standardised	4	4	8
4	Sentences are easy to understand.	4	4	8
5	The language used is appropriate for high school education level	4	4	8
6	Sentences are in accordance with Indonesian language rules	3	4	7
7	The Chemical Bonding Module adheres to proper and standard Indonesian grammar conventions.	3	4	7
8	Terminology, symbols, and icons within the Chemical Bonding e-Module are applied consistently throughout the content.	4	4	8
	Total score			61
	Average Percentage (%)			97 %
	Category			Very Suitable

Based on the data presented in Table 7, the language feasibility assessment revealed that the validators rated the language used in the interactive electronic module as highly appropriate, with a score of 97%. The sentence structures employed in the module were also found to be in accordance with the Enhanced Spelling System (EYD) of the Indonesian language, which contributes to improving students' comprehension of the chemical bonding topic. Applying proper and grammatically correct Indonesian language conventions in educational resources can significantly support students' understanding during the learning process (Yeni et al., 2021). The results related to the material feasibility assessment are presented in table 8.

Table 8. Feasibility Test Results on Material Aspects

No	Assessment Items	Validator 1	Validator 2	Total Score
1	The material contained in the module is in accordance with the learning outcomes.	4	4	8
2	The material reflects the indicators of learning objectives.	4	4	8
3	The content corresponds to the chemical bonding concepts.	4	4	8
4	Visuals and videos support the understanding of chemical bonding.	3	4	7
5	Compound examples are relevant to the concept of bonding.	4	4	8
6	The material is comprehensive and follows a logical hierarchy.	4	4	8
7	The material contained in the Chemical Bonding Electronic Module is displayed coherently.	4	4	8
8	The material is presented in a coherent and sequential manner.	4	3	7
9	The exercise questions contained in the Chemical Bonding Electronic Module are in accordance with the learning outcomes.	3	4	7
10	The answer key to the questions in the Electronic Module is appropriate and correct.	3	3	6
11	The preparation of the Electronic Module has a complete and systematic systematics.	3	4	7
12	The glossary displayed in the Electronic Module of Chemical Bonding has order and is complete.	3	3	6
13	The material in the Electronic Module has examples and illustrations related to the bond formation process.	4	4	8
14	The Electronic Module has instructions for use that are complete and easy to understand.	4	4	8
	Total score			104
	Average Percentage (%)			93 %
	Category			Very Suitable

Based on Table 8, the results of the material feasibility assessment indicated that the validator stated the content presented in the interactive electronic module is very suitable, with a percentage of 93%. These results show that the developed interactive electronic module can be used as a learning resource that presents material aligned with the learning objectives and the students' level of knowledge. The use of interactive electronic modules in the learning process has been proven to improve students' understanding of the subject matter, as this method allows students to directly engage with the learning content (Zakaria *et al*., 2024). The results of the feasibility test on the media aspect are outlined in table 9.

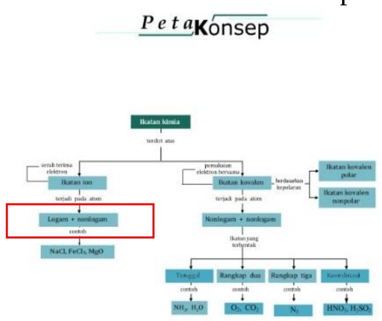
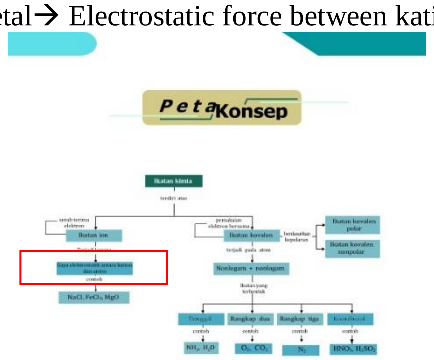
According to Table 9, the validator assessed that the media and graphic aspects of the interactive electronic module were highly appropriate, receiving a score of 97%. These findings indicate that the developed module aligns with established standards, including the A4 size format (210 x 297 mm). The layout and color schemes used in both the cover and content reflect visual consistency and coherence. As a result, the module's design is visually appealing and has the potential to increase students' interest in learning chemical bonding concepts. This highlights that visual elements such as color coordination, font choices, and the arrangement of images, audio, and video were considered highly valid (Alwanuddin *et al*., 2022).

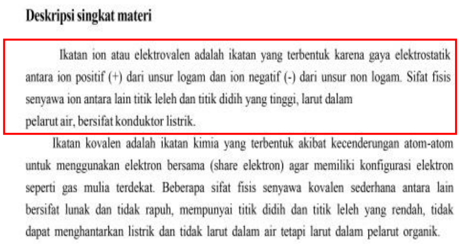
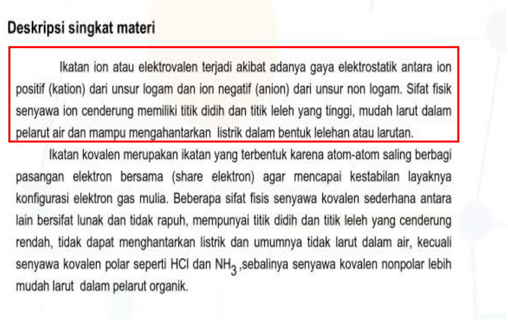
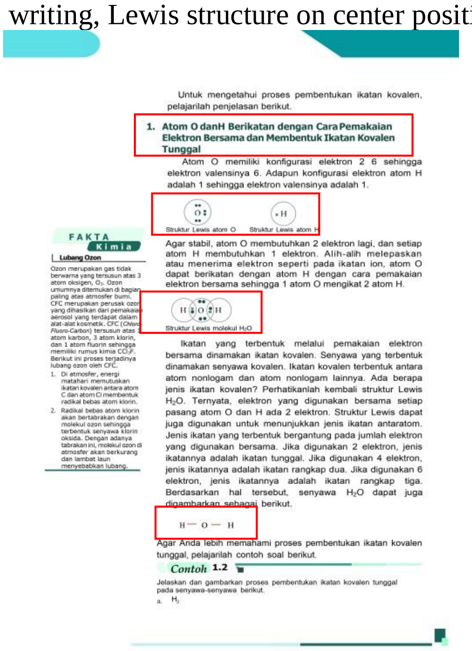
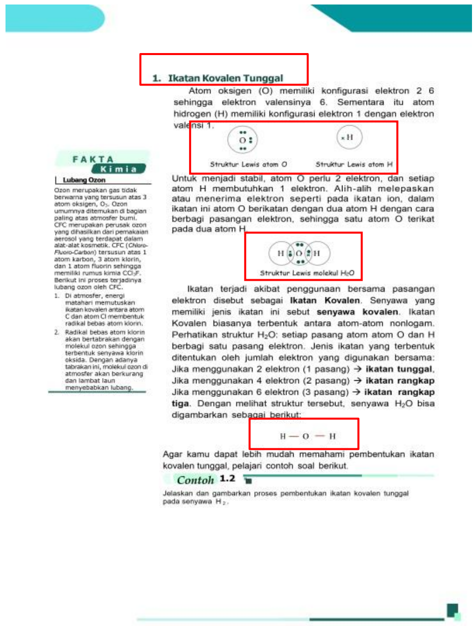
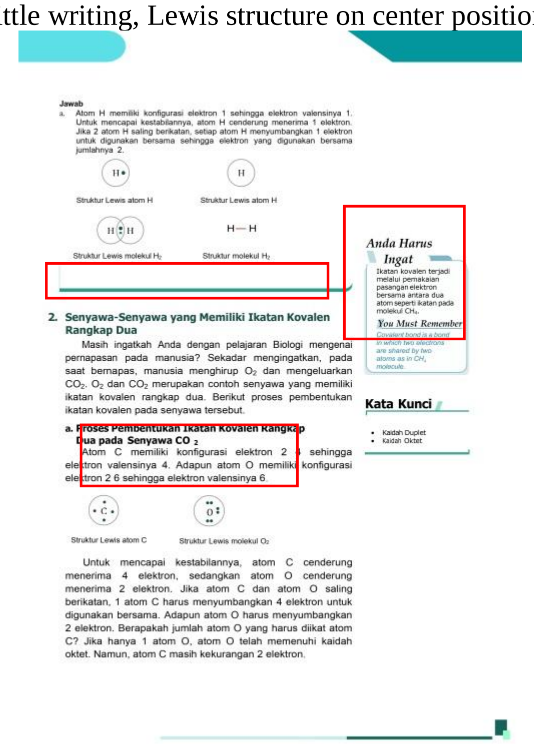
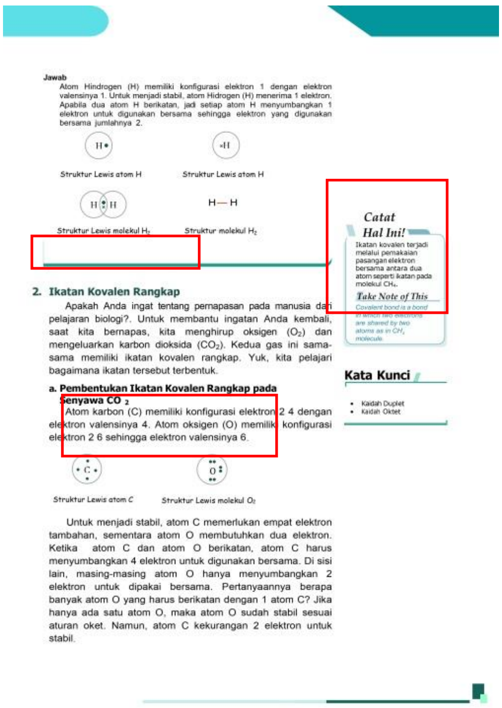
Table 9. Feasibility Test Results on Media Aspects

No	Assessment Items	Validator 1	Validator 2	Total Score
1	The standard size of the Electronic Module used (A4).	4	4	8
2	Systematic accuracy of the cover and also Layout.	4	4	8
3	The layout of each section in the Electronic Module is proportional.	3	4	7
4	The display on the Electronic Module is attractive.	4	3	7
5	The image used on the cover is appropriate and visually attractive.	4	4	8
6	Image placement and selection in the module are relevant.	3	4	7
7	User guidance is clear and easy to understand.	4	4	8
8	The module is easy to navigate and operate.	4	4	8
9	All interactive buttons function as intended.	4	4	8
10	The visualization of ionic bond formation is effectively presented.	4	4	8
11	Visualisation of the formation process covalent compounds is well presented.	4	4	8
12	The visualisation and quality of the inserted videos are well presented and engaging.	4	4	8
	Total score			93
	Average Percentage (%)			97 %
	Category			Very Suitable

A visually engaging module is expected to create a learning atmosphere that encourages students to participate more actively (Putra et al., 2017). The expert validation results across the three assessment aspects-language, content, and media-showed an average feasibility score of 96%. This indicates that the interactive electronic module meets the criteria for being highly feasible and is ready to be used in the learning process without requiring further revisions (Atmaja *et al*., 2021). The expert recommendations were also taken into consideration to further refine the interactive electronic module, which are presented in Table 10.

Table 10. Improvements to Electronic Module Components Based on Expert Feedback

Before revisions	**After revisions**
Ionic bond definition in concept map: metal+nonmetal→ Electrostatic force between kation and anion	
	

Before revisions	After revisions
Ionic bond definition in content description	
	
Tittle writing, Lewis structure on center position	
	
Tittle writing, Lewis structure on center position	
	

Before revisions (image 1):

Deskripsi singkat materi

Ikatan ion atau elektrovalen adalah ikatan yang terbentuk karena gaya elektrostatik antara ion positif (+) dari unsur logam dan ion negatif (-) dari unsur non logam. Sifat fisis senyawa ion antara lain titik leleh dan titik didih yang tinggi, larut dalam pelarut air, bersifat konduktor listrik.

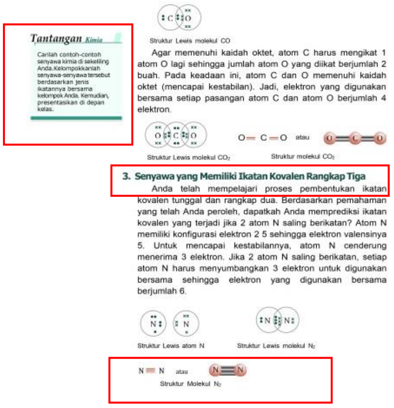
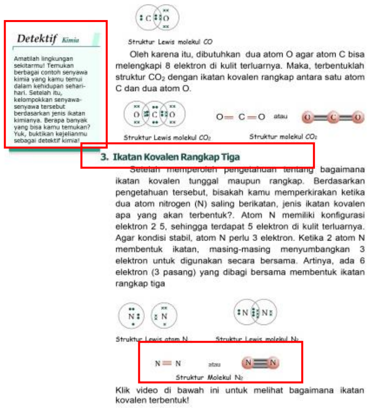
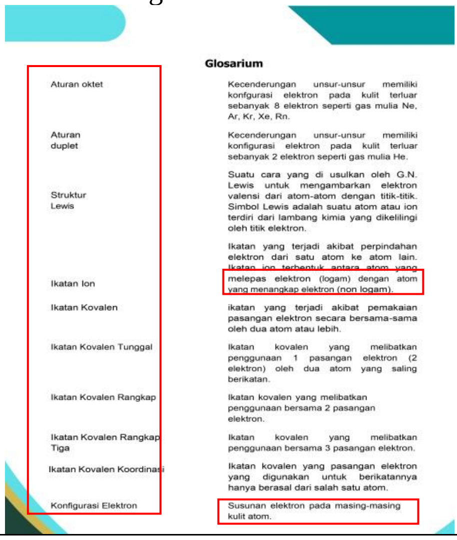
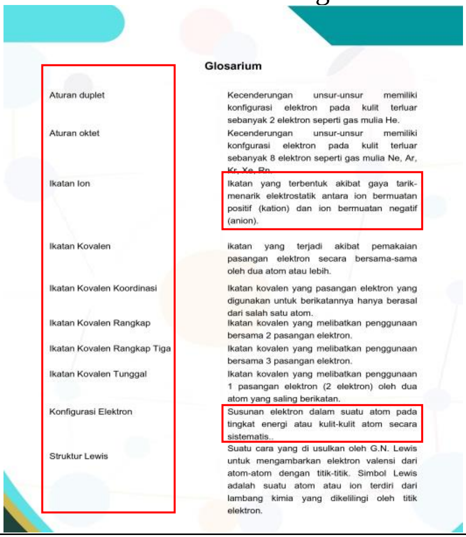
Ikatan kovalen adalah ikatan kimia yang terbentuk akibat kecenderungan atom-atom untuk menggunakan elektron bersama (share elektron) agar memiliki konfigurasi elektron seperti gas mulia terdekat. Beberapa sifat fisis senyawa kovalen sederhana antara lain bersifat lunak dan tidak rapuh, mempunyai titik didih dan titik leleh yang rendah, tidak dapat menghantarkan listrik dan tidak larut dalam air tetapi larut dalam pelarut organik.

After revisions (image 2):

Deskripsi singkat materi

Ikatan ion atau elektrovalen terjadi akibat adanya gaya elektrostatik antara ion positif (kation) dari unsur logam dan ion negatif (anion) dari unsur non logam. Sifat fisik senyawa ion cenderung memiliki titik didih dan titik leleh yang tinggi, mudah larut dalam pelarut air dan mampu mengahantarkan listrik dalam bentuk lelehan atau larutan.

Ikatan kovalen merupakan ikatan yang terbentuk karena atom-atom saling berbagi pasangan elektron bersama (share elektron) agar mencapai kestabilan layaknya konfigurasi elektron gas mulia. Beberapa sifat fisis senyawa kovalen sederhana antara lain bersifat lunak dan tidak rapuh, mempunyai titik didih dan titik leleh yang cenderung rendah, tidak dapat menghantarkan listrik dan umumnya tidak larut dalam air, kecuali senyawa kovalen polar seperti HCl dan NH_3 ,sebalinya senyawa kovalen nonpolar lebih mudah larut dalam pelarut organik.

Before revisions	After revisions
Tittle writing, Lewis structure on center position	
	
Glossarium writing alfabetic with correct definition of ionic bond and electron configuration	
	

Development Testing

This trial was conducted to describe the students' response to the electronic module display. The results of the questionnaire assessment of the response to the electronic module are described in Table 11.

Tabel 11. Results of Student Response Questionnaire Assessment

Assesment Aspect	Number of Assesment Items	Score (%)	Category
Ease	3	86	Very Good
Attractiveness	2	89	Very Good
Comprehensibility	3	89	Very Good
Usefulness	2	85	Very Good
Average Percentage		87,25	
Category		Very Good	

Based on Table 11, students responded positively to the interactive electronic module, as indicated by an average score of 87.25% in the "very good" category. The module was found to be easy to use, engaging, and helpful in assisting students in understanding the abstract concepts of chemical bonding. This finding aligns with the research by Pawestri *et al*. (2023), where an e-module based on guided inquiry on chemical bonding material received very positive student responses (k=0.85). These results indicate that electronic modules have great potential as effective teaching resources for chemical bonding. The appeal of the teaching resources can motivate prospective users to use interactive electronic modules for chemical bonding, where the content aligns with their level of understanding, thereby helping them learn the concepts of chemical bonding (Rasmawan & Erlina, 2021). With the completion of the development testing phase, the product development has reached the develop stage. This research was not continued to the dissemination stage due to limitations in time, manpower, and costs. However, the stages that have been completed have produced a product that is suitable for use.

CONCLUSION

The research results indicate that the interactive electronic module on chemical bonding for 11th-grade students was classified as highly feasible, with a feasibility score of 96%. The average score from the student response assessment was 87.25%, categorized as "very good." These findings imply that the module is suitable for practical use and can enrich current teaching resources. Even though the research only reached the development phase of the Four-D Model, the feasibility and testing outcomes demonstrate the module's potential for effective application.

RECOMMENDATIONS

Based on the results of the feasibility test and limited trial, the developed interactive electronic module is declared feasible to use as learning media. Furthermore, the interactive electronic module that has been developed can be measured for its effectiveness at the disseminate stage. However, the obstacles faced during the implementation of the research were mainly time constraints in the trial process, which caused the module to not be implemented thoroughly in the sub-topic.

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