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Development of E-module Based on Guided Inquiry in Chemical Bonding Topic for Class X Student Learning Materials

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Abstract. The lack of teaching materials that are able to explain the formation of chemical bonds causes students difficulties in learning. Therefore, this study focused on developing guided inquiry-based e-module of chemical bonding. This study aims to determine the feasibility and students response to guided inquiry-based e-module of chemical bonding. This study employs research and development (R&D) using ADDIE model which is limited to development stage. The due diligence was carried out by material, media and language experts. The respondents involved were 31 students of class XI MAN 2 Pontianak. The research instruments were the feasibility sheets, media, language, and response questionnaires. The results of the feasibility of e-module test is k=1 (very high validity) and student response tests k=0.85 (very interesting). Those findings indicate that the E-module is very feasible to use.
Keywords: Development, e-module, guided inquiry, chemical bonding, ADDIE.

Introduction

Technology-based learning media can increase success in the learning process. Presentation of teaching materials presented electronically can provide a better understanding visually (Delita et al., 2022). This of course, can make it easier for students to understand learning material that requires visualization, such as in chemistry subjects. Chemistry is a subject that is considered quite difficult to understand for students. This is because the chemical materials are rarely delivered through demonstration metods. Teachers use more discussions in, resulting in students being bored and having difficulty understanding chemical concepts. The lack of direct experience in observing a chemical reaction also makes chemical material seem very difficult know because it is abstract (Sunyono et al., 2009). In order to understand chemical concepts, students must be able to combine conceptual knowledge with visuo-spatial skills to create, maintain and manipulate abstract visual images. These skills are essential for students to be able to distinguish mental images from real images through physical molecular models or representations on computer screens (Kuit & Osman, 2021).

The material on chemical bonds begins by discussing the concept of electron mconfiguration, determination of valence electrons, elemental stability and a description of the lewis structure. Suppose basic knowledge such as chemical bonds cannot be understood. In that case, other materials such as reaction rates, acid-base,

electrochemistry, chemical equilibrium and solution chemistry will be difficult to learn (Shelawaty et al., 2016).

Based on the results of an interview with a chemistry teacher at MAN 2 Pontianak, it was found that chemical bonding is one of the subjects that students find difficult because it has abstract concepts related to studying the bond formation of an element. The interest of students currently learning chemical bonding causes the ability of most students to be still lacking in understanding the material. This causes the acquisition of an incomplete average of repeat values on chemical bonding materials. It was also found that the method used by the teacher was lecture because students needed guidance to be able to analyze and reason related to the formation of chemical bonds. However, this method is still unable to facilitate students optimally in reasoning and imagining the process of forming chemical bonds. The results of these interviews, found that teachers also conduct online learning via whatsApp and have provided teaching material sources from the internet. However, the teaching materials provided are still unable to overcome students common understanding of the material. Students still find it difficult to understand the teaching materials given because in these teaching materials there is still no explanation that can describe the process of chemical bonding that students can be understand. Although there are several teaching materials or media that can provide visualization of the process forming chemical bonds, these teaching materials still cannot explain in detail so that students are still confused.

Teaching materials are one way to increase students activeness and understanding of the subject matter. One of the teaching materials that can be used as a learning resource is a module. Modules are teaching materials that are able to present systematically and completely so that they can be used for learning for students with or without teachers who teach directly. Modules can also help students to learn independently by doing it anywhere either at school or at home according to their respective learning speeds (Irfandi et al., 2018). Module teaching materials can also be combined into interactive multimedia in the form of e-module. E-module are module teaching materials made in electronic form so that they can increase students interest and motivation to learn (Siregar & Harahap, 2020). In its use, e-module can increase learning enthusiasm to be more interesting and varied as evidenced by an increase in the frequency of questions and arguments from students as well as the ability to complete tasks correctly and on time (Delita et al., 2022). Digital modules are also proven to have a positive effect in improving the social competence of teachers to improve the quality of education (Rahayu et al., 2022).

One learning model that can be used to improve students thinking skills is inquiry. Inquiry is based on a key premise by looking at the habits of students who tend to get better when doing active learning. Inquiry involves the process of analyzing data, models, or examples and when discussing ideas to work together in groups. So that students are able to understand concepts, solve problems when discussing and interacting with teachers. The teacher in this case is considered a facilitator and not an informant (Syukra & Andromeda, 2019). This shows that when students are trained to make observations, make predictions and provide conclusions, students can open their minds to determine the relationship between events, objects or conditions they encounter during the learning process and relate them to real life. In chemistry learning, inquiry can increase high school students efficacy beliefs in problem solving (Nzomo et al., 2023). There are several inquiry-based learning models, one of which is the guided inquiry-based learning model. Guided inquiry-based learning is a student-centered learning model so that it is active in learning. However, the teacher also plays a role so that students can still be controlled properly (Kristin et al., 2015). The stages in the

guided inquiry syntax are identifying problems, formulating, making hypotheses, collecting data, analyzing, and concluding (Purwaningtyas et al., 2016). In the guided inquiry stage, question-writing activities can enhance the quality of science learning by significantly improving understanding and application of lessons and developing critical thinking skills (Ramirez, 2021).

The 2013 curriculum learning process requires teaching materials that can involve students actively to think critically in the learning process. The Minister of Education and Culture of the Republic of Indonesia issued Number 4 of 2021 concerning the implementation of face-to-face learning for the 2021/2022 academic year to carry out the learning process with a hybrid or blended learning pattern in limited face-to-face learning. The circular also contains the process of implementing limited face-to-face learning using adaptive and interactive technology. According to the circular, learning currently needs adjustments and adaptations in the education sector, especially in the use of technology. Teaching materials that can interpret chemical structures in a complex manner are needed in today's education in order to save learning time and can provide effective learning (Díaz-sainz et al., 2021). This study aims to determine the validity level of the developed guided inquiry-based e-module and to determine the response of MAN 2 Pontianak students to the e-module. The e-module is equipped with pictures, videos and simulations that can be tried by students in choosing bonds in the compounds shown. The existence of pictures, videos and simulations is intended as a game or method that can provide theoretical knowledge in an interesting learning atmosphere to prove the answers given (Pölloth et al., 2020).

Methods

The form of research used in this study refers to research and development (R&D) using the ADDIE model by Branch (2009) with stages analyze, design, development, evaluation, implementation. Research and development according to Sugiyono (2016) is a method in research that aims to make products and prove their effectiveness as a means of evaluation. In this study, the ADDIE stages were limited to 3 stages, namely analyze, design, and development because the purpose of this research is only limited to developing and producing a learning media that is valid to be implemented based on the validator's assessment (Setiawan et al., 2021; Yuniari & Juliari, 2020). In this study, learning media were developed in the form of E-module based on guided inquiry on chemical bonding material. E-module are created using microsoft power point and flip PDF corporate software.

The developed product is then subjected to a validation test to determine the feasibility of the product which is carried out by six experts namely, two material experts, two media experts, and two linguists. The data collection technique used was indirect communication using instruments in the form of feasibility questionnaires and student responses. Scores in the questionnaire used a likert scale consisting of a score of 4 (strongly agree), 3 (agree), 2 (disagree), 1 (strongly disagree). The assessment items in the instrument are also adjusted to the eligibility standards of teaching materials according to the national education standards agency (BNSP). The E-module validation test instrument is equipped with an assessment rubric so that experts can provide relevant scores. The student response questionnaire instrument does not have an assessment rubric. Data obtained from the assessment results were analyzed using qualitative and quantitative analysis techniques. The validation test results are calculated

using the gregory matrix in table 1 and calculated using equation (1). The gregory matrix is used for calculation in determining content validity which is sourced from 2 experts using cross-tabulation calculations between score 1-2 with irrelevant criteria and score 3-4 with very relevant criteria.

Table 1. Cross Tabulation of Gregory Matrix.

		Expert 1	
		Irrelevant (Score 1-2)	Relevant (Score 3-4)
Expert 2	Irrelevant (Score 1-2)	(A) 0 item	(B) 0 item
	Relevant (Score 3-4)	(C) 0 item	(D) 0 item

(Sari, 2019)

$$\text{Content Validity} = \frac{D}{(A+B+C+D)} \qquad (1)$$

Information:

A = Both Experts Disagree

B = Expert 1 Agree, Expert 2 Disagree

C = Expert 1 Disagree, Expert 2 Agree

D = Both Experts Agree

From the results of content validity, the feasibility of the E-module is concluded based on the validation criteria in Table 2.

Table 2. Criteria for Calculation Validity of Gregory Matrix Tabulation.

Coefficient	Validity
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

(Sari, 2019)

The student response test was carried out after the E-module validation test by experts. The sample used was students of class XI MIPA MAN 2 Pontianak. The sampling technique was carried out by means of random sampling. There were 15 students in class XI MIPA 1 and 16 people in class XI MIPA 2. The instrument used was a response questionnaire with scoring using a Likert scale consisting of a score of 4 (strongly agree), 3 (agree), 2 (disagree), 1 (strongly disagree). The response test was carried out once, namely a field test (widespread) with 31 respondents. Data from the response test assessment results will be analyzed using a frequency descriptive table and calculated using equation (2) (Damayanti et al., 2013).

$$\bar{X} = \frac{\Sigma x}{N} \qquad (2)$$

Information:

$\bar{X}$: Rating average score

∑x : Total score obtained

N : Data count

The results of the average score that has been obtained are then used to find the response index with the formula in equation (3) as follows:

$$\text{Response index} = \frac{Average\ of\ all\ aspects}{The\ highest\ rating\ scale} \qquad (3)$$

The results obtained are then interpreted into the response test validity criteria contained in Table 3.

Table 3. Criteria for Response Test Results

Index	Information
0.00–0.49	Very bad/unattractive
0.50–0.59	Not good/less interesting
0.60–0.79	Good/interesting
0.80–1.00	Very good/very interesting

(Rosalina, 2017)

Results and Discussion

Analyze Stage

At this stage, a needs analysis is carried out which is used in schools to identify problems, information related and determine the products to be developed (Bungawati & Rahmadani, 2023). Analysis was carried out through interviews with one of the chemistry teachers at MAN 2 Pontianak. Based on the results of the interviews, it was found that chemical bonding is one of the subjects considered difficult by students, because it has

an abstract concept of bond formation in a compound. The lack of interest of students in learning chemical bonding causes the ability of most students to still be low in understanding the material. It was also found that teachers had also used teaching materials in the form of textbooks. However, the teaching materials provided are still general in nature and do not describe the process of chemical bonding, so that students find it difficult to understand the material. In the interview, the teacher also stated that the need for a module that can be developed electronically so that it can be accessed on a cellphone can be used as an alternative in solving existing problems. The use of android is considered capable of having a positive influence on students and teachers in a learning system that can be done anywhere and anytime (Al Rasyid & Partana, 2021). Based on the results of the interviews, the teacher also believes that in chemical bonding material, students also still need teachers who take an active role in learning so that students can be well controlled. The guided inquiry learning model can be applied to train students thinking skills without losing the facilitator which in this case is the teacher (Syukra & Andromeda, 2019). As a result of students lack of understanding of chemical bonding material, it is necessary to develop guided inquiry-based e-module.

Design Stage

At this stage a product is designed that is developed based on the problems found in the analyze stage. This stage is used to ensure the quality of the product developed by compiling learning objectives based on basic competencies, collecting references related to the material, and limiting the reference material (Bungawati & Rahmadani, 2023). The design process includes determining the learning model to be used, compiling the e-module framework in the storyboard shown in Table 4, creating assessment instruments, and preparing software that supports e-module creation. Storyboards are a framework for media that will be developed including several components such as layout, display, and use of media (Al Rasyid & Partana, 2021). The researcher chose chemical bond material based on the problems found during the interview. The initial design of the e-module will be prepared in microsoft powerpoint and PDF formats, which will then be converted into a flipbook format using the flip PDF corporation application. The use of the flip PDF corporation application was chosen in e-module development because it is easy to use and can be used offline. The flip PDF application is a software application that can support the creation of e-module because it is equipped with multimedia features such as images, video, audio and animation (Masruroh & Agustina, 2021). Flipbook has exe format and html link that can be opened through windows and smartphones by combining videos that students can play and and learning processes that can stimulate students to solve problems (Munzil et al., 2022). The end result of this application is also easier to operate via PC or android which many students have.

Table 4. E-module Storyboard Components

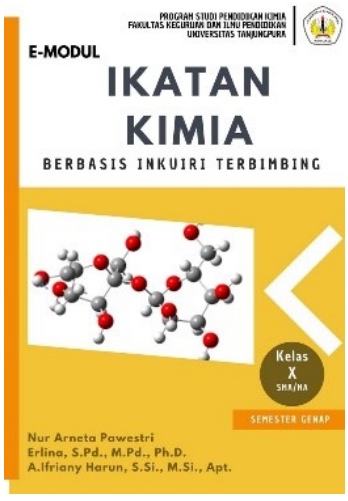
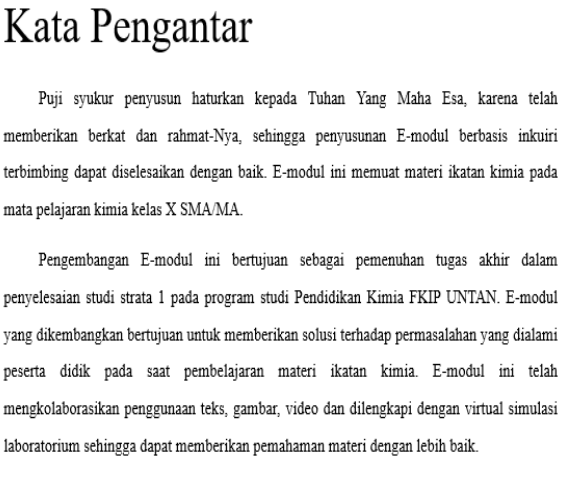
Section	Components
Front cover	The origin of the author's institution, the symbol of the institution, the title, the name of the author and supervisor, the intended user, the image relevant to the material.
E-module Identity	Name of author, supervisor, material validator, language, media, instrument.
Preface	Foreword for the preparation of e-module.
List of Contents	Instructions for e-module contents page.
Introduction	Module identity, core competencies, basic competencies,

	brief descriptions of materials, instructions for use, learning indicators, concept maps.
Identification of Problems	Presented an introduction related to the problem so that students are able to identify existing problems.
Formulate Problems	A question column is presented and students are asked to formulate problems related to the problems that have been presented.
Developing Hypotheses	A question column is presented and students are asked to compile a hypothesis based on the problem formulation that has been presented.
Collecting Data	Presented material and additional info from the material that has been explained.
Analyzing Data	Presented videos, pictures, and simulations of the formation of chemical bonds.
Formulating Conclusions	Presented questions to make conclusions related to the formulation of the problem.
Glossary	Explanation of chemical terms contained in the e-module.
Bibliography	Reference sources used in making E-module.

Development Stage

At this stage, the product that has been designed is further developed. Applying the draft that has been made to become a media according to the needs and characteristics of students that can help improve understanding and knowledge of learning (Bungawati & Rahmadani, 2023). The product being developed is a chemical bonding e-module which was compiled using the guided inquiry learning model. The several components in the e-module are described in Table 5.

Table 5. E-module Components

Front cover	Preface
	
E-module Identity	List of Contents

Identitas E-Modul

E-Modul Ikatan Kimia
Berbasis Inkuiri Terbimbing

Penulis	: Nur Arneta Pawestri
Desain Isi	: Nur Arneta Pawestri
Desain Sampul	: Nur Arneta Pawestri
Pembimbing 1	: Erlina, S.Pd., M.Pd., Ph.D.
Pembimbing 2	: A. Ifriany Harun, S.Si., M.Si., Apt.
Ahli Materi	: 1. Risya Sasri, S.Si., M.Sc.
	2. Raudhatul Fadhilah, S.Pd., M.Si.
Ahli Bahasa	: 1. Drs. Nanang Heryana, M.Pd.
	2. Mai Yuliastri Simarmata, M.Pd.
Ahli Media	: 1. Hamdil Mukhlisin, M.Pd., M.Si.
	2. Ridho Brilliantoro, M.Si.

Daftar Isi

Introduction
Pendahuluan

A. Identitas Modul

Mata Pelajaran	: Kimia
Kelas / Semester	: X / Genap
Materi	: Ikatan Kimia

B. Kompetensi Inti

K.I 3 Memahami, menerapkan, menganalisis pengetahuan faktual, konseptual, prosedural berdasarkan rasa ingintahunya tentang ilmu pengetahuan, teknologi, seni, budaya, dan humaniora dengan wawasan kemanusiaan, kebangsaan, kenegaraan, dan peradaban terkait penyebab fenomena dan kejadian, serta menerapkan pengetahuan prosedural pada bidang kajian yang spesifik sesuai dengan bakat dan minatnya untuk memecahkan masalah.

C. Kompetensi Dasar

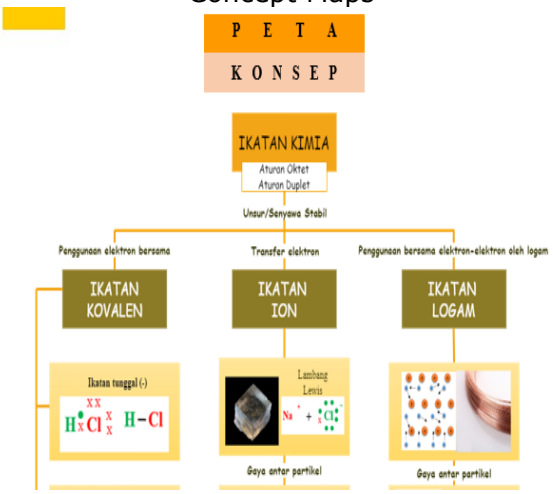
K.D 3.5 Membandingkan proses pembentukan ikatan ion, ikatan kovalen, ikatan kovalen koordinasi, dan ikatan logam serta kaitannya dengan sifat zat.

D. Deskripsi Singkat Materi

Alam semesta memiliki banyak kandungan unsur-unsur kimia. Unsur-unsur tersebut dikelompokkan berdasarkan kenaikan massa atom dan kemiripan sifat. Pengelompokkan unsur-unsur tersebut disusun kedalam tabel periodik unsur. Pada tabel periodik, kita dapat mengetahui unsur-unsur yang tersedia di alam mulai dari yang melimpah hingga sulit ditemukan keberadaannya. Unsur-unsur tersebut juga dikelompokkan menjadi unsur logam, unsur non-logam, unsur semi logam, dan gas mulia.

Namun, unsur-unsur yang terdapat di alam tidak selalu berada sebagai atom tunggal, melainkan cenderung bergabung dengan atom atau unsur sejenis berbeda lainnya. Beberapa unsur logam dan non-logam dapat dimanfaatkan di dalam kehidupan sehari-hari dalam bentuk unsur maupun senyawa. Senyawa kimia tersusun atas molekul atau atom. Atom-atom tersebut akan saling bergabung membentuk suatu ikatan kimia yang bertujuan untuk mencapai kestabilan. Ikatan kimia terbagi menjadi beberapa ikatan.

Concept Maps



Identification of Problems
Introduction

A. PENGANTAR

Senyawa terbentuk ketika dua atau lebih unsur bergabung secara kimia. Dalam bab ini kita akan melihat salah satu cara di mana unsur dapat bergabung secara kimia yaitu dengan transfer elektron untuk membentuk senyawa ionik.

Sumber: googleimage.com dengan modifikasi

Gambar 1.1. Pembentukan Garam Dapur

Tahukah Kamu?

Garam sering kali kita gunakan dalam kehidupan sehari-hari. Namun, tahukah kamu bahwa unsur pembentuk dari garam dapur merupakan unsur-unsur yang berbahaya dan beracun. Garam dapur terdiri atas unsur natrium dan klor. Pada kenyataannya, logam natrium merupakan logam yang sangat reaktif dan mudah meledak, sedangkan gas klorin merupakan gas yang beracun. Apa pendapatmu mengenai hal tersebut? Buatlah rumusan masalah dan hipotesis awal terkait peristiwa tersebut. Untuk dapat menemukan jawaban yang tepat, simaklah penjelasan dibawah ini!

Formulate Problems and
Developing Hypotheses

Tahukah Kamu?

Air merupakan senyawa yang memiliki ikatan kovalen. Namun, garam yang larut dalam air laut merupakan senyawa ionik. Apa pendapatmu mengenai hal tersebut? Buatlah rumusan masalah dan hipotesis awal terkait fenomena tersebut. Untuk dapat menemukan jawaban yang tepat, simaklah penjelasan dibawah ini!

Rumusan Masalah: _____

Hipotesis Awal: _____

Collecting data
Materials, Chemical Info

Info Kimia

Pada kenyataannya kamu tidak mereaksikan natrium dengan atom klorin, namun dengan molekul klorin, Cl_2

Karena elektron memiliki muatan negatif, maka atom yang menerima elektron menjadi bermuatan negatif, dan atom yang kehilangan elektron, menjadi bermuatan positif.

- Atom Na (Z = 11) memiliki konfigurasi elektron (2.8.1). Gas mulia yang memiliki konfigurasi elektron terdekat adalah Ne (2.8). Sehingga, atom Na akan melepas 1 elektron membentuk atom Na bermuatan 1+, yang disebut **ion** Na^+.

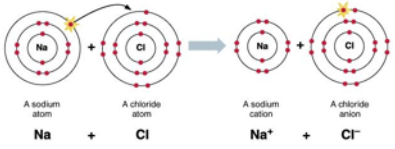
$$Na\ (2.8.1) \longrightarrow Na^+\ (2.8) + e^-$$

- Atom Cl (Z = 17) memiliki konfigurasi elektron (2.8.7). Gas mulia yang memiliki konfigurasi elektron terdekat adalah Ar (2.8.8). Sehingga, atom Cl akan menerima 1 elektron membentuk atom Cl bermuatan 1-, yang disebut **ion** Cl^-.

$$Cl\ (2.8.7) + e^- \longrightarrow Cl^-\ (2.8.8)$$

Info Kimia

Gaya tarik-menarik elektrostatik berarti bahwa partikel bermuatan positif menarik partikel bermuatan negatif.



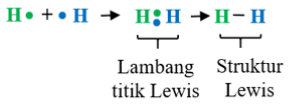
Info Kimia

Setiap atom dalam ikatan kovalen memberikan satu elektron ke pasangan elektron bersama. Namun, hal tersebut tidak harus terjadi. Kedua elektron juga dapat berasal dari atom yang sama.

Beberapa contoh penulisan struktur Lewis diberikan berikut ini.

- *Molekul* H_2

Molekul H_2 terdiri 2 atom H. Atom H (Z = 1) memiliki konfigurasi elektron (1). Atom H memerlukan 1 elektron tambahan untuk mencapai He (2). Aturan duplet dapat dipenuhi apabila 1 atom H bergabung dengan 1 atom H lain membentuk 1 ikatan kovalen H – H.



Gambar 2.5. Struktur Lewis molekul H_2

- Molekul CH_4

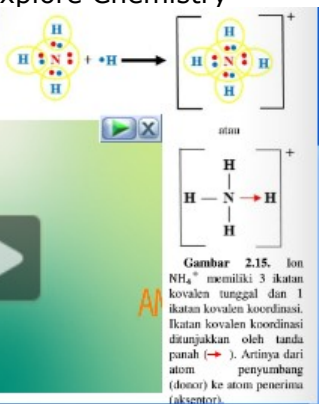
Molekul CH_4 terdiri dari 1 atom C dan 4 atom H.

➢ Atom C (Z = 6) dengan konfigurasi elektron (2.4) memerlukan 4 elektron tambahan untuk mencapai konfigurasi elektron 4 elektron tambahan untuk mencapai konfigurasi elektron Ne (2.8). (Aturan Oktet)

Analyzing Data
Video, Explore Chemistry

Jelajah Kimia

Agar kamu lebih memahami pembentukan ikatan kovalen pada NH_3, yuk amati video dibawah ini.



Gambar 2.15. Ion NH_4^+ memiliki 3 ikatan kovalen tunggal dan 1 ikatan kovalen koordinasi. Ikatan kovalen koordinasi ditunjukkan oleh tanda panah (→). Artinya dari atom penyumbang (donor) ke atom penerima (aksentor).

I. Kimia Otak Atik

Untuk dapat mengetahui lebih lanjut bagaimana suatu atom mecapai kestabilan melalui pembentukan ikatan kimia, kamu bisa klik link https://teachchemistry.org/classroom-resources/ionic-covalent-bonding-simulation untuk mencoba secara langsung beberapa atom yang dapat kamu pasangkan dengan atom lainnya agar dapat membentuk suatu senyawa. Kamu bisa mengikuti langkah-langkah berikut:

1. Pilihlah 2 atom pada tabel periodik yang dapat membentuk suatu senyawa.

Seperti senyawa: Na_3N, Na_2O, NaF, Na_2S, NaCl, Mg_3N_2, MgO, MgF_2, MgS, $CaCl_2$

2. Tentukan ikatan kimia yang akan terjadi pada senyawa yang telah kamu pilih.
3. Berdasarkan pengetahuanmu, tentukan elektron yang dibutuhkan dari setiap atom pada senyawa yang telah dipilih untuk mencapai kestabilan.
4. Selanjutnya klik *"Submit Answer"* untuk melihat bagaimana terjadinya penggunaan elektron untuk mecapai kestabilan.

Formulating Conclusions
Self Test

H. Uji Diri 2

1. Atom-atom non-logam cenderung saling berikatan dengan ikatan kovalen membentuk molekul.

a. Apa itu ikatan kovalen?_____

b. Mengapa ikatan kovalen cenderung terbentuk antara dua atom non-logam?

_____

2. Air (H_2O) merupakan senyawa yang memiliki ikatan kovalen. Sedangkan NaCl dalam bentuk pada merupakan senyawa yang memiliki ikatan ion.

a. Bagaimana ikatan kimia yang terjadi pada air laut yang mengandung garam? Berikanlah penjelasan dan kesimpulan terkait hal tersebut.

Glossary

GLOSARIUM

Anion: Ion yang bermuatan negatif.

Atom: Materi tersusun dari partikel-partikel terkecil.

Aturan oktet: Atom-atom cenderung memiliki 8 elektron pada kulit terluarnya seperti konfigurasi elektron gas mulia terdekat.

Aturan duplet: Atom-atom dengan nomor atom kecil cenderung memiliki 2 elektron pada kulit terluarnya seperti konfigurasi elektron gs mulia He.

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Back Cover

The software used in the manufacturing process is power point and flip PDF corporate edition. The e-module is made with A4 paper size and the chau philomene font type, and the spartan league on the cover and times new roman on the contents. The number of pages in the e-module is 56 pages including the front cover to the back cover. The e-module is structured based on the guided inquiry syntax, namely identifying problems, formulating problems, compiling hypotheses, collecting data, analyzing data, and conclude (Purwaningtyas, 2017). In the e-module there are also questions as an evaluation to measure student understanding.

The e-module that has been developed will be validated by experts to determine the results of the validity. Product validation is used to determine the feasibility of the product through approval or ratification of products that have met the requirements and are suitable for use (Maulidiya & Mercuriani, 2023). The validation carried out consisted of several aspects, namely material, graphics or media, and language. Through the product validation process, suggestions can be found to improve the product to make it better (Rezeki & Kamaludin, 2023). Material validation with the assessment instruments contained in Table 6. Prior to use, the instruments were validated and declared valid by 2 validators.

Table 6. Material Validation Assessment Items

No	Rating Items
1	The material contained in the module is appropriate to the KI and KD of chemistry subjects.
2	The material contained in the module is in accordance with the competency achievement indicators.
3	The material contained in the chemical bond e-module is in accordance with the concept of chemical bond according to the guided inquiry syntax.
4	The sample images of compounds contained in the e-module are in accordance with the concept of chemical bonds.
5	The examples of compounds contained in the e-module fit exactly with the concept of chemical bonding.
6	The material contained in the e-module has complete chemical bonds.
7	The material contained in the chemical bond e-module is displayed in a coherent manner.
8	The material contained in the chemical bond e-module can be understood easily.
9	The practice questions contained in the e-module are in accordance with indicators of competency achievement.
10	The answer keys to the questions in the e-module are appropriate and correct.
11	The preparation of e-module has a complete and systematic material systematics.
12	The glossary displayed in the E-module is concise and complete.
13	The material in the e-module has examples and illustrations related to the bond formation process.
14	The e-module has complete and easy-to-understand instructions for use.

In the material validation questionnaire, 14 assessment points are given to assess the validity of the material in the e-module. The material instrument is equipped with an

assessment rubric. Based on the assessment items in Table 6, the results obtained from material experts are interpreted in Figure 1.

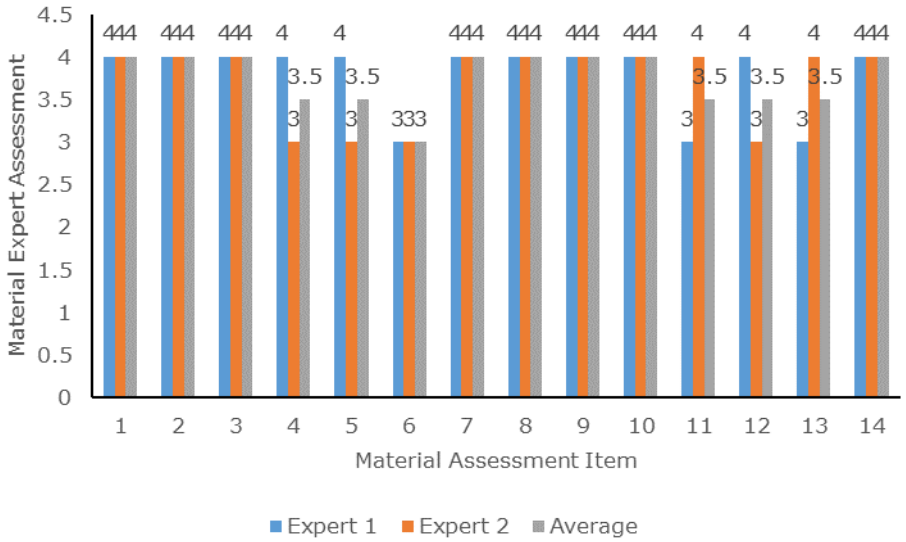


Figure 1. Results of Material Expert Assessment

Based on Figure 1 it is known that the two experts gave different scores on the existing assessment items. Expert 1 dominantly gives a score of 4 except for items 6, 11, and 13. While expert 2 also dominantly gives a score of 4 except for items 4, 5, 6, and 12. This causes different average results for several items evaluation. In the assessment items 1,2,3,7,8,9,10, and 14 obtain an average result of 4. In items 4,5,11,12,13 obtain an average result of 3.5. Point 6 obtains an average result of 3. Based on the results of the assessment, it shows that the material contained in the e-module is in line with the development of science and in accordance with the learning objectives to be achieved, has power in the learning process, good accuracy to the material and the context of student thinking (Hurrahman et al., 2022). According to Bungawati & Rahmadani (2023) this assessment shows that the product is in the appropriate category because the material presented is in accordance with the learning objectives to be achieved, the case examples presented are also related and can be found in everyday life. Thus, this can provide an overview for students to analyse and find a concept. Tests presented in the form of essays can complement the critical thinking process so that students can measure their understanding in accordance with the characteristics of the e-module (Anggraini et al., 2022). The difference in the average results of the assessment items is due to comments/suggestions on the e-module to be improved so that it becomes more perfect. Suggestions can be considered to improve the product even if it is declared that no revision is needed (Bungawati & Rahmadani, 2023). Even though there are differences in the average results for several assessment items, the categories obtained by the e-module are still included in the very relevant validity according to the gregory matrix in table 1. According to Sajidan et al. (2022), a score of 3-4 is the very relevant score range. Then media validation is carried out with the assessment instruments contained in Table 7.

Table 7. Media Validation Assessment Items

No.	Rating Items
1	The standard size of the e-module used is in accordance with the ISO standard A4 paper size, namely 21 x 29.7 cm.
2	Accuracy in systematic cover (cover) and also Lay Out.
3	The layout (lay out) of each part in the e-module is proportional.
4	The appearance of the e-module is interesting.
5	The presentation of the image on the cover is precise and attractive.
6	The selection and layout of the images in the e-module is correct.
7	The instructions for using the e-module are clear and easy to understand.
8	The Chemical Bond e-module is easy to operate.
9	The buttons on the chemical bond e-module can function properly.
10	Visualization of the process of forming ionic compounds is well presented.
11	Visualization of the process of forming covalent compounds is well presented.
12	Visualization of the process of forming metal compounds is well presented.
13	Visualization on the physical properties of ionic compounds, covalent compounds, and metal compounds

In the media validation questionnaire, 13 assessment items were given to assess the validity of the media in the E-module. The media instrument is equipped with an assessment rubric. Based on the assessment items in Table 7, the assessment results obtained from media experts are interpreted in Figure 2.

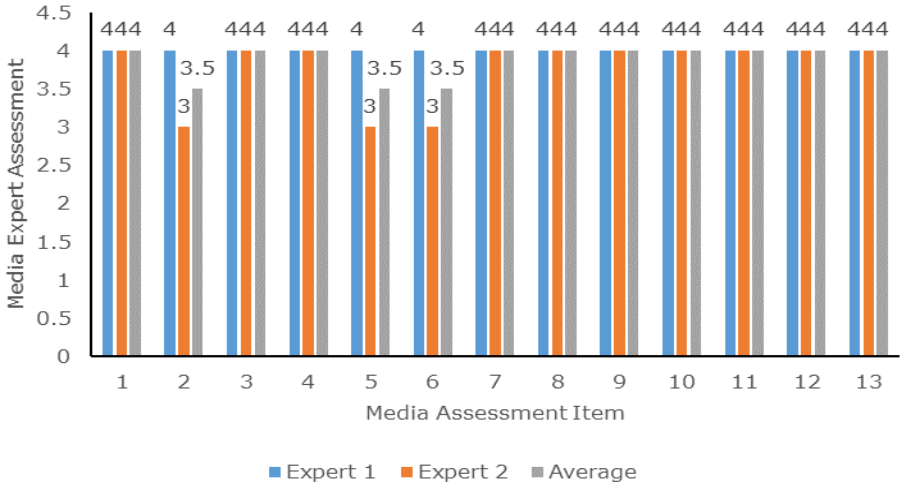


Figure 2. Results of Media Expert Assessment

Based on Figure 2 it is known that the two experts gave different scores on the existing assessment items. Expert 1 gave a score of 4 on all assessment items. Meanwhile, expert 2 also gave a dominant score of 4 except for points 5 and 6. This resulted in different average results for several assessment items. In the assessment items 1,3,4,7,8,9,10,11,12, and 13 obtain an average result of 4. In items 2,4 and 6 obtain an average result of 3.5. Based on the result, presentation of images, layout, and visualisation on the use of animations and videos can be used well by both teachers and students which can increase learning motivation (Rezeki & Kamaludin, 2023). An attractive product display equipped with a video can attract students interest. Videos used to visualise compounds can be used as alternative learning media in addition to text

material (Erniwati et al., 2014). Visualisation of chemical bonds in some compounds can improve student learning outcomes and knowledge. The usability of the product that has been developed is good because it is equipped with a controller to make it easier for users and has a clear visualisation display. Thus the aspect of good media usability can provide a satisfying user experience (Hurrahman et al., 2022). The difference in ratings on several items is due to comments/suggestions that are useful as a means of improvement for the e-module. Suggestions can be considered to improve the product even if it is declared that no revision is needed (Bungawati & Rahmadani, 2023). Even though there are differences in the average results for several assessment items, the categories obtained by the e-module are still included in the very relevant validity according to the gregory matrix in table 1. According to Dewi et al. (2022), the acquisition of a score of 3 to 4 is a very relevant score range. Next, language validation is carried out with the assessment instruments contained in Table 8.

Table 8. Language Validation Assessment Items

No.	Rating Items
1	The word chosen on the e-module is the right chemical bond.
2	The sentence used in e-modil chemical bond is already effective.
3	The terms used in the chemical bond e-module application are standard.
4	The sentences used in the chemical bond e-module are easy to understand.
5	The language used in the chemical bond e-module application is in accordance with the level of education (high school students).
6	The sentence structure used to convey messages in the chemical bond e-module refers to good and correct Indonesian grammar rules.
7	The use of terms, symbols and icons in the chemical bond e-module application is consistent.

In the language validation questionnaire, 7 assessment items are given to assess the validity of the language in the e-module. The language instrument is equipped with an assessment rubric. Based on the assessment items in Table 8, the results obtained from media experts are interpreted in Figure 3.

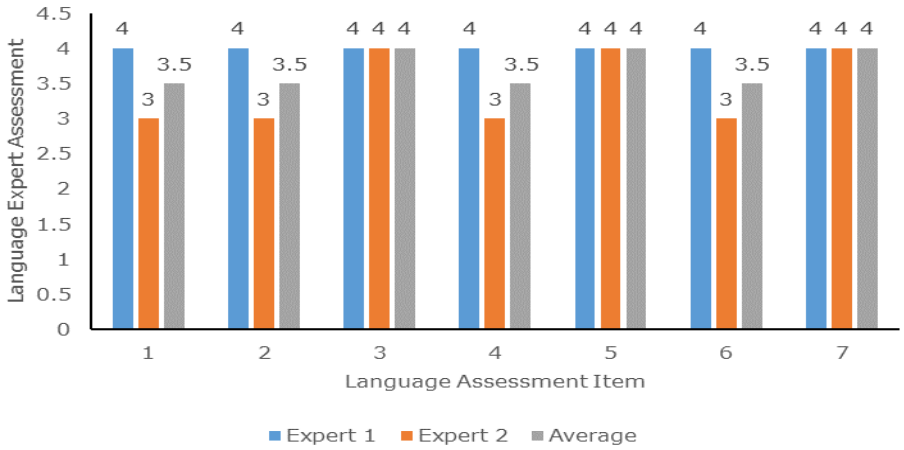


Figure 3. Results of Language Expert Assessment

Based on Figure 3 it is known that the two experts gave different scores on the existing assessment items. Expert 1 gave a score of 4 on all assessment items. Whereas expert 2 also gave a score of 3 on all assessment items except for item 3, and 7 expert 2 gave a score of 4. This causes different average results for several assessment items. In the assessment items 3.5, and 7, the average result is 4. In items 1, 2, 4, and 6, the average result is 3.5. Overall, the use of language is clear and does not give double meanings so that it can help readers to understand the purpose and meaning being learnt (Panjaitan et al., 2021). The use of terms, sentence structure, symbols in the e-module has been adjusted to the correct language rules and has written the source on each picture used (Sari & Sutihat, 2022). Differences in ratings on several items are due to comments/suggestions to improve the e-module. Suggestions can be considered to improve the product even if it is declared that no revision is needed (Bungawati & Rahmadani, 2023). Even though there are differences in the average results for several assessment items, the categories obtained by the e-module are still included in the very relevant validity according to the Gregory matrix in Table 1. Based on the findings of Erlina et al. (2022), a score of 3-4 is relevant. Furthermore, all results of the validation assessment carried out by 6 validators are analyzed using the gregory matrix so that the results obtained content validity interpreted in Figure 4.

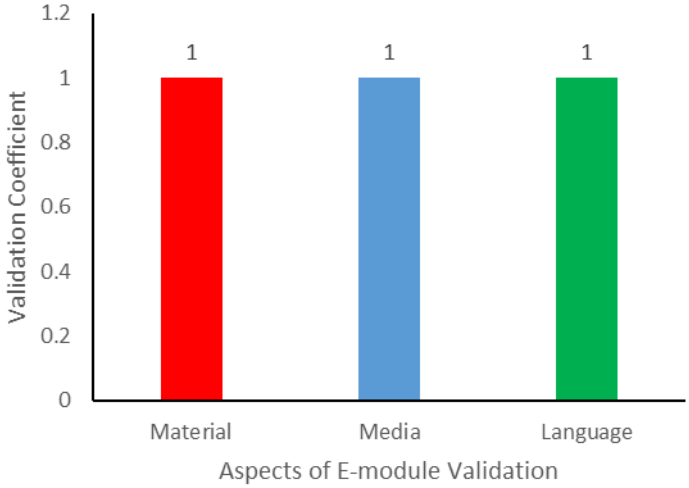


Figure 4. Results of Material, Media, and Language Validation Coefficient Scores

Based on figure 4, the e-module validation results obtained from experts obtained a coefficient value of k = 1.00 in each aspect of validation, namely material, media and language. Based on the coefficients obtained, it can be concluded that the e-module is included in the very high validity category with a note of some of the suggestions contained in table 9. Based on Erlina et al. (2022), validity score 1 is a very high category.The acquisition of the coefficient score also shows that the e-module has met the theoretical eligibility criteria in the aspects of material, media, and language. In line with research Yanti et al. (2022), these results indicate that the product has good quality in terms of content, presentation, and graphic components as indicated by the acquisition of a score of k = 1. So it can be concluded that the results are valid with internal consistency (reliable) suitable for use and has fulfilled the objective of module validation based on the Ministry of National Education (2008). The obtained score shows that the e-module has very valid criteria and can be implemented without any improvements (Atmaja et al., 2021). However, the recommendations given by the experts are still

considered and used as a consideration for improving the e-module so that it is better and complements existing deficiencies. The validation results obtained have fulfilled several aspects that are in accordance with the level of development of students such as readability, ability to motivate, clarity, thinking flow relationships, conformity with language conventions and presentation techniques (Firdaus & Pahlevi, 2022). Obtaining an average with a very feasible category can be continued to the next stage (Fatmawati et al., 2023).

Table 9. Advice from Experts

No.	Expert	Suggestion
1	Material	The KI in the E-module has not been found, so it is better if the KI in question is written in the e-module
		There is 1 material that has not been written on the indicator, so the indicator should be added to explain the limitations of the octet rule
		In covalent bond material, there is material that is lacking, namely the type of covalent bond based on charge (polar and non-polar covalent). We recommend that you add this material
		Codes should be added to the self-test questions, for example: Self-Test 1, Self-Test 2, to make it easier for students to see the answer key
		We recommend that you add an answer column so that the guided inquiry process can be seen
2	Media	Use a maximum of 2 types of fonts on the front cover
		Increase the font size in the title on the front cover
3	Language	Correct the writing of the e-module in the preface to become e-module
		Choose one of the author's or compiler's sentences in the preface, consistent with the author's or compiler's words

There are suggestions from each material, media and language expert. The material validator gave suggestions to include KI in the introduction of the e-module, giving a code number for each evaluation. According to Hurrahman et al. (2022) that learning outcomes must be contained completely, and not confuse students. In addition, there is a suggestion to provide an answer column to show the guided inquiry process. According with Anggraini et al. (2022) that the essay answer column provided can train students critical thinking process. Media experts gave suggestions to use different fonts with a maximum of 2 fonts and increase the font size so that it can be seen clearly. According to Hurrahman et al. (2022) the use of images and text with high resolution and can be seen clearly is useful so that information can be conveyed properly. The linguist gave advice to choose consistently the use of the word compiler or author in the preface and pay attention to the consistency of the use of capital letters in the use of the word e-module. This is in accordance with Indonesian language rules that letters that mean abbreviations must use capital letters (Panjaitan et al., 2021). The suggestions obtained from the experts are then used to make improvements to the e-module. The e-module components before and after revision can be seen in Table 10.

Table 10. Results of e-module Component Improvements Based on Expert Advice

Before Repair	After Repair
The KI in the e-module has not been found, so it is better if the KI in question is written in the e-module	Added core competencies in section B which were originally basic competencies
	
Pendahuluan A. Identitas Modul Mata Pelajaran : Kimia Kelas / Semester : X / Genap Materi : Ikatan Kimia B. Kompetensi Dasar 3.5 Membandingkan proses pembentukan ikatan ion, ikatan kovalen, ikatan kovalen koordinasi, dan ikatan logam serta kaitannya dengan sifat zat. C. Deskripsi Singkat Materi	Pendahuluan A. Identitas Modul Mata Pelajaran : Kimia Kelas / Semester : X / Genap Materi : Ikatan Kimia B. <u>Kompetensi Inti</u> KI 3 Memahami, menerapkan, menganalisis pengetahuan faktual, konseptual, prosedural berdasarkan rasa ingintahunya tentang ilmu pengetahuan, teknologi, seni, budaya, dan humaniora dengan wawasan kemanusiaan, kebangsaan, kenegaraan, dan peradaban terkait penyebab fenomena dan kejadian, serta menerapkan pengetahuan prosedural pada bidang kajian yang spesifik sesuai dengan bakat dan minatnya untuk memecahkan masalah. C. Kompetensi Dasar 3.5 Membandingkan proses pembentukan ikatan ion, ikatan kovalen, ikatan kovalen koordinasi, dan ikatan logam serta kaitannya dengan sifat zat. D. Deskripsi Singkat Materi

There is 1 material that has not been written on the indicator, so the indicator should be added to explain the limitations of the octet rule.

F. Indikator Pembelajaran

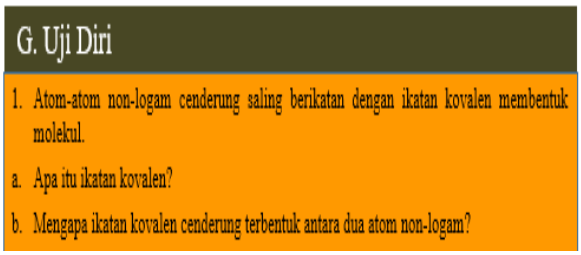
1. Menjelaskan ikatan ion.
2. Menjelaskan ikatan kovalen.
3. Menjelaskan ikatan kovalen koordinasi.
4. Menjelaskan ikatan logam.
5. Menjelaskan pengecualian aturan oktet.
6. Membedakan antara ikatan ion, ikatan kovalen, ikatan kovalen koordinasi, serta ikatan logam.
7. Menuliskan lambang Lewis untuk menggambarkan pembentukan ikatan.
8. Mengevaluasi struktur Lewis pada ikatan kovalen koordinasi.
9. Membedakan sifat fisis senyawa ion, senyawa kovalen, dan logam.

Added 10th indicator

F. Indikator Pembelajaran

1. Menjelaskan ikatan ion.
2. Menjelaskan ikatan kovalen.
3. Menjelaskan ikatan kovalen koordinasi.
4. Menjelaskan ikatan logam.
5. Menjelaskan pengecualian aturan oktet.
6. Membedakan antara ikatan ion, ikatan kovalen, ikatan kovalen koordinasi, serta ikatan logam.
7. Menuliskan lambang Lewis untuk menggambarkan pembentukan ikatan.
8. Mengevaluasi struktur Lewis pada ikatan kovalen koordinasi.
9. Membedakan sifat fisis senyawa ion, senyawa kovalen, dan logam.Mengaitkan sifat fisis senyawa pada kegunaannya.
10. <u>Mengaitkan sifat fisis senyawa pada kegunaannya.</u>

In covalent bond material, there is material that is lacking, namely the type of covalent bond based on charge (polar and non-polar covalent). We recommend that you add this material.



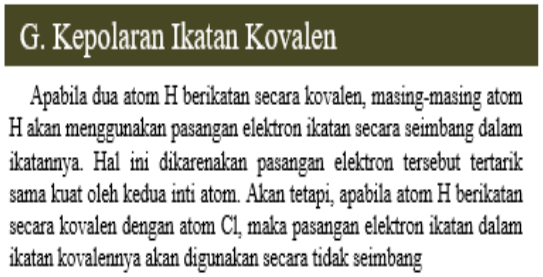
G. Uji Diri

1. Atom-atom non-logam cenderung saling berikatan dengan ikatan kovalen membentuk molekul.

a. Apa itu ikatan kovalen?

b. Mengapa ikatan kovalen cenderung terbentuk antara dua atom non-logam?

Added covalent bond polarity material to sub chapter G which was originally a self test.



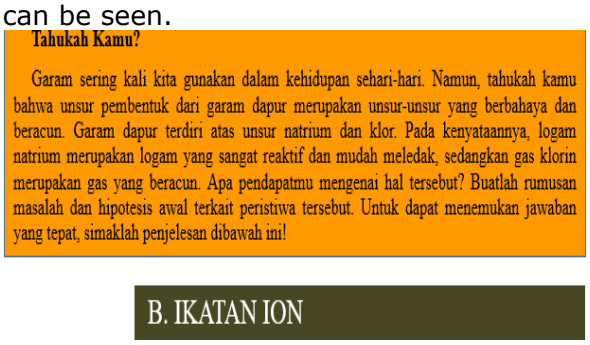
G. Kepolaran Ikatan Kovalen

Apabila dua atom H berikatan secara kovalen, masing-masing atom H akan menggunakan pasangan elektron ikatan secara seimbang dalam ikatannya. Hal ini dikarenakan pasangan elektron tersebut tertarik sama kuat oleh kedua inti atom. Akan tetapi, apabila atom H berikatan secara kovalen dengan atom Cl, maka pasangan elektron ikatan dalam ikatan kovalennya akan digunakan secara tidak seimbang

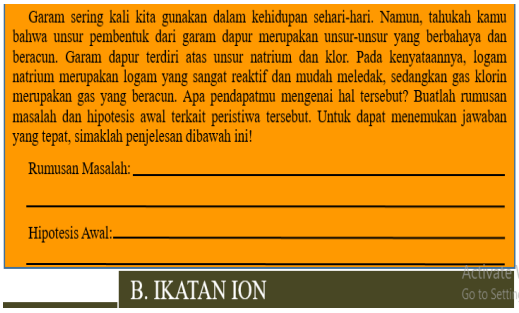
Codes should be added to the self-test questions, for example: Self-test **1**, Self-test **2**, to make it easier for students to see the answer key.

Add codes to each self-test. Such as self Test **1**, Self test **2**, Self test **3**, Self test **4**.

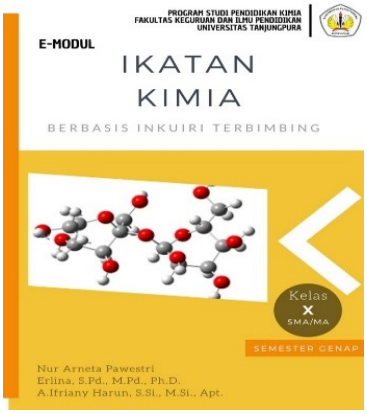
We recommend that you add an answer column so that the guided inquiry process can be seen.

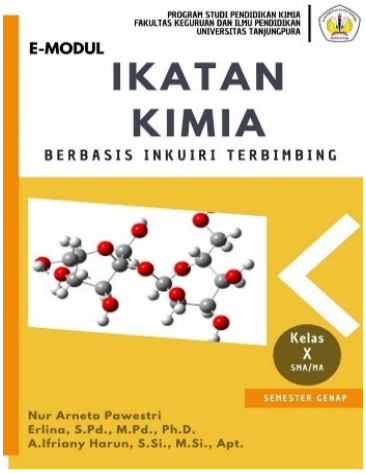


Added answer columns to problem formulation, hypothesis, and test.

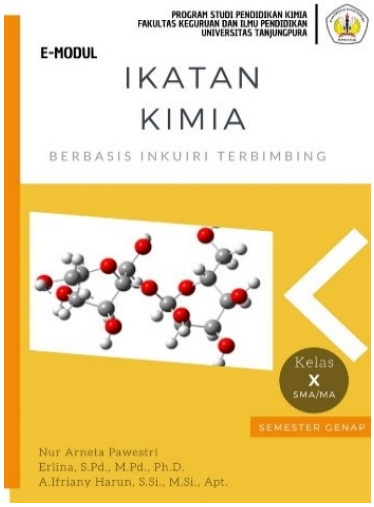


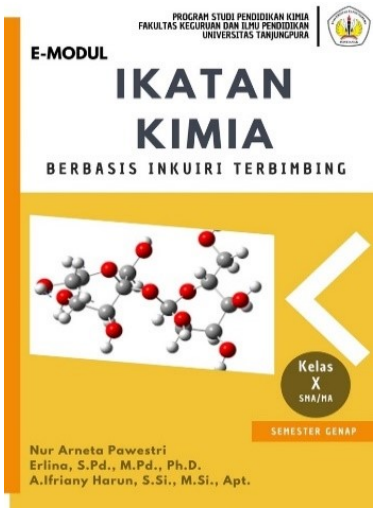
Use a maximum of 2 types of fonts on the front cover.





Increase the font size in the title on the front cover.





Correct the writing of "e-module" in the introduction to "E-module".

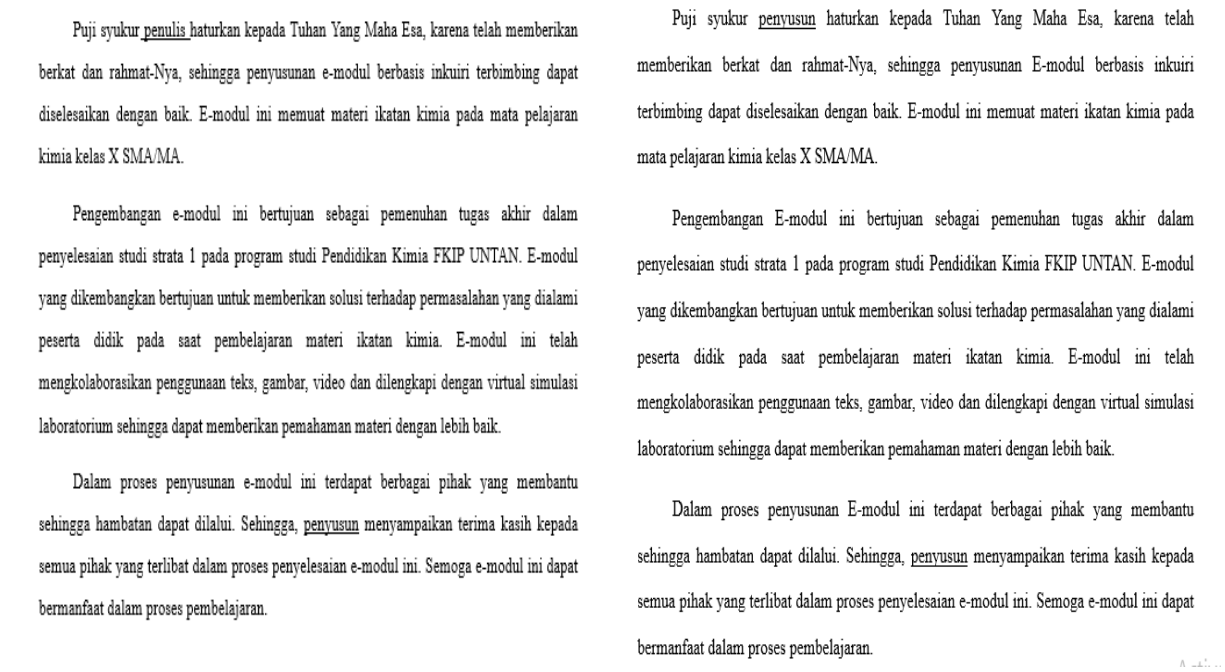
Kata Pengantar

Puji syukur penulis haturkan kepada Tuhan Yang Maha Esa, karena telah memberikan berkat dan rahmat-Nya, sehingga penyusunan e-modul berbasis inkuiri terbimbing dapat diselesaikan dengan baik. E-modul ini memuat materi ikatan kimia pada mata pelajaran kimia kelas X SMA/MA.

Kata Pengantar

Puji syukur penyusun haturkan kepada Tuhan Yang Maha Esa, karena telah memberikan berkat dan rahmat-Nya, sehingga penyusunan E-modul berbasis inkuiri terbimbing dapat diselesaikan dengan baik. E-modul ini memuat materi ikatan kimia pada mata pelajaran kimia kelas X SMA/MA.

Choose one of the author's or compiler's sentences in the preface, consistent with the author's or compiler's words.



Puji syukur penulis haturkan kepada Tuhan Yang Maha Esa, karena telah memberikan berkat dan rahmat-Nya, sehingga penyusunan e-modul berbasis inkuiri terbimbing dapat diselesaikan dengan baik. E-modul ini memuat materi ikatan kimia pada mata pelajaran kimia kelas X SMA/MA.

Pengembangan e-modul ini bertujuan sebagai pemenuhan tugas akhir dalam penyelesaian studi strata 1 pada program studi Pendidikan Kimia FKIP UNTAN. E-modul yang dikembangkan bertujuan untuk memberikan solusi terhadap permasalahan yang dialami peserta didik pada saat pembelajaran materi ikatan kimia. E-modul ini telah mengkolaborasikan penggunaan teks, gambar, video dan dilengkapi dengan virtual simulasi laboratorium sehingga dapat memberikan pemahaman materi dengan lebih baik.

Dalam proses penyusunan e-modul ini terdapat berbagai pihak yang membantu sehingga hambatan dapat dilalui. Sehingga, penyusun menyampaikan terima kasih kepada semua pihak yang terlibat dalam proses penyelesaian e-modul ini. Semoga e-modul ini dapat bermanfaat dalam proses pembelajaran.

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Next, test the responses of students to the e-module based on the assessment instruments listed in Table 11.

Table 11. Student Response Test Assessment Items

No.	Rating Items
	Material Aspect
1	The material in the e-module is easy to understand
2	The use of e-module makes learning situations boring
3	The material is presented in an orderly manner
4	The material presented is too long
5	The questions contained in the e-module were able to test my understanding
6	The questions presented are too difficult for SMA/MA students
7	The e-module does not help me improve my understanding of the process of forming chemical bonds
	Language Aspect
8	The use of sentences and language in the e-module is easy to understand
9	The language used is too monotonous
	Media Aspect
10	The use of images, videos, simulations in e-module makes it easier to understand the formation process
11	The pictures and videos presented add to the confusion in understanding chemical bonding material
12	The E-module is easy to use
13	The order and layout of the material in the e-module makes learning difficult
14	Font selection and size can be read clearly

In the student response test questionnaire, it is equipped with 14 assessment items to assess aspects of the material, language, and media in the e-module. Students assess

the e-module based on these three aspects so that users can find out the attractiveness of the e-module. The results of the student response test assessment are interpreted in Figure 5.

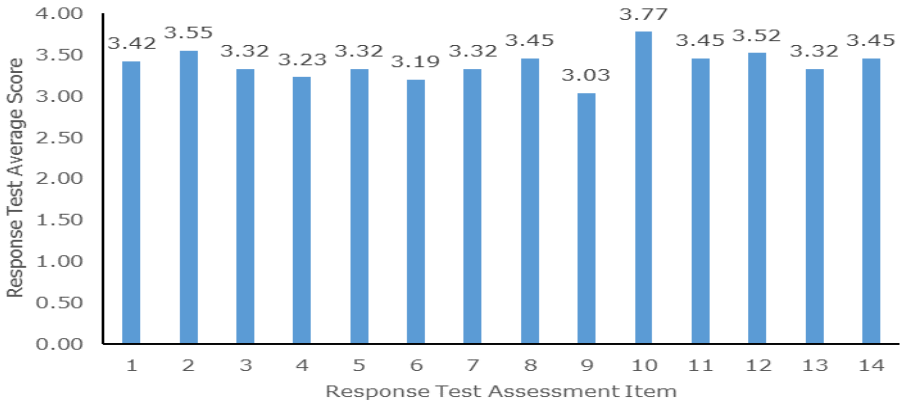

Figure 5. The Average Score of Student Response Test Results Broadly

The results of the student response tests contained in Figure 5 are then calculated using the frequency description table in Table 3. From these calculations, an index score of k = 0.85 is obtained with very good/very attractive criteria. According to Andaria et al. (2021), the score index is still in the good scale category. Students gave positive responses to the assessment items Figure 5 with an average score range of 3.00-4.00 for each assessment item. In the material aspect, the average score given by respondents above 3.00 shows that chemical bonding material can be understood by students in the form of e-module. The use of videos in the presentation of learning materials can help improve the visualisation process, especially in online-based learning (Puspita et al., 2021). The assessment item number 6 has the lowest score with an average score of 3.19. According to the results of the interviews, students in low and medium grades stated that the questions contained in the e-module were considered difficult because the questions were presented in the form of fields and not multiple choices. So far, students are not accustomed to analyzing questions in the form of stories. However, students in high grades think that the questions presented are able to measure students understanding in detail related to increasing mastery of the material. Students in the high class also thought that the questions presented were appropriate because the e-module was also equipped with various features such as a large number of videos and pictures as well as simulations of chemical bond formation. This is in line with the assessment of material experts that the questions presented are in accordance with the guided inquiry learning model because they are able to evaluate students understanding to analyze material mastery. Based on the National Education Standards Agency (BSNP) (2014) the presentation of good material in teaching materials can encourage students to play an active role in the learning process, so they are able to solve problems (Salam et al., 2022). Tests presented in the form of essays can complement the critical thinking process so that students can measure their understanding in accordance with the characteristics of the e-module (Anggraini et al., 2022). The learning process by performing higher order thinking skills can also increase curiosity and reduce students boredom level (Fatmawati et al., 2023). The use of interactive media can also help students in understanding the material compared to conventional media so as to

eliminate boredom during the learning process (Hurrahman et al., 2022). Overall, students gave positive responses on all material assessment items.

In the language aspect, item number 9 has the lowest score, which is 3.03. Based on the results of interviews conducted with students, the use of language in e-module is not much different from textbooks, so students think that chemical terms in e-module are still widely found. Students must know in advance the meaning of chemical terms used in chemical bonding material such as electron configurations, valence electrons, covalent coordination, and delocalization in hybridization. However, the e-module is equipped with a glossary which aims to explain the chemical terms used in the presentation of the material. Glossaries are used in books, papers, and others that list in alphabetical order and are used to help find the meaning of difficult words (Susanti, 2016). Overall, students gave positive responses on all language assessment items.

On the media aspect, item number 13 has the lowest score, which is 3.32. The results of interviews with students stated that they had difficulty accessing certain pages because the e-module did not have the feature to be able to go directly to the specific page they wanted to read. However, the e-module can go directly to a specific page by writing the keywords to be searched on the search feature which will later turn to open the page containing the keywords that have been entered. The score on assessment item 13 is still in the good category (Erlina et al., 2022). e-module also provide an attractive appearance based on the use of selected colours, a combination of animation, images and videos so as to attract user interest (Bungawati & Rahmadani, 2023). Overall, students gave positive responses on all media assessment items.

The results of the response test obtained were then analyzed to obtain a response index score (k=0.85) with very good/very attractive validity criteria. Research conducted by Rosanna et al. (2022) states that the acquisition of this score indicates that the e-module is very good for students to use. The student response questionnaire also stated that the many videos of chemical exploration features (videos, pictures, simulations) that were presented were able to attract students interest in trying to operate the e-module. The choice of colors and fonts used attracts students interest in reading the material presented. According with research Perdana et al. (2017) that good selection of covers and color designs for e-module displays can attract students interest and increase students motivation to read learning material. The students are also interested in trying to arrange chemical bonds through the simulation lab in the e-module. Students try continuously to find several bonds in the compounds presented by determining the valence electrons first. This is in line with Apriani et al. (2021) that the use of modules presented in the form of applications helps students visualise abstract chemical bond concepts so that it attracts students to try to answer questions. The results obtained based on student response trials (k=0.85) show that guided inquiry-based e-module on chemical bonding material are very interesting so no further revisions or improvements are needed (Pawana et al., 2014). This shows that guided inquiry-based e-module on chemical bonding material can be used in the teaching and learning process in class.

Conclusion

Based on the results of research and development that has been carried out, guided inquiry-based e-module on chemical bonding material have a coefficient (k = 1) with a very high validity category. The results of field trials with a wide scale of students gave a positive response (k=0.85) with a very good/very interesting category so that the developed e-module is very feasible to use to help students understand chemical bonding material.

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