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DEVELOPMENT OF TEACHING MATERIAL BASED ON PLOMP DEVELOPMENT MODEL TO SUPPORT INDONESIAN MERDEKA CURRICULUM ON CHEMICAL BONDING TOPIC IN PHASE E

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Abstract: This research aims to develop teaching materials that support independent curriculum learning by measuring the adequacy and practicality of the Phase E chemical bonding topic. The type of research is Educational Design Research (EDR) using the Plomp development model. This study was conducted in the 2022/2023 academic year at senior high school SMAN 8 Padang, Indonesia. Data were collected using efficacy and utility questionnaires. As a result, we found that the valid categories have an average relevance of 0.85 in developing teaching materials. Utility test results for student answers show an average of 93% practicality in the very practical category, and utility test results for teacher answers show an average of 97% practicality in the very practical category. Overall, the results demonstrate that developing teaching materials that support independent curriculum learning using Phase E chemically bonded materials is valid and practical. Chemical bonds are a vital material taught in Phase E. The chemical bonds described in this article include ionic and covalent bonds. This textbook provides definitions of ionic and covalent bonds, examples of assignments, and discussions. In addition, primary chemistry education is explained with examples of how chemical bonds are applied in everyday life to make it easier to understand chemically bonded substances. The material includes practice assessment questions to check how well students understand the material. This material is expected to be useful for teaching and learning activities for teachers, and it will be easy for students to learn and understand.

Keywords: *Teaching materials, Independent Curriculum, Plomp, Chemical Bonding*

INTRODUCTION

Improving the quality of education is the main challenge in developing education in Indonesia. The Covid-19 pandemic has hit the world in various parts of life, including education [1-3]. The learning crisis that has long occurred, and exacerbated by the Covid-19 pandemic, has made learning loss a condition where students lose the competencies they have learned. Students cannot complete classroom learning and experience burnout because they do not master learning [4]. Significant learning loss is seen in the achievement of literacy competencies and numeracy. In this case, curriculum changes were made to adjust to the existing circumstances [5].

The curriculum is the spirit of education. Education in Indonesia always changes from time to time. This curriculum change cannot be avoided, but it must be lived [4,6]. The curriculum is dynamic, which means it is not fixed. Changes in the curriculum are certainly caused by several factors, both internal and external, so the curriculum must be flexible and follow the changing times of students. The curriculum, which is a program, will be meaningless if it is not implemented into learning [1].

Nadiem Makarim, Minister of Education, Culture, Research and Technology of the Republic of Indonesia (Kemendikbud Ristek RI), announced a policy on independent learning. Self-directed learning reduces the burden on educational institutions and encourages students to be more innovative and creative [7]. Changes in the curriculum require teachers and learners to be able to answer the demands of the curriculum [8]. Teachers have the freedom to create learning that is educational and fun. Teachers must plan, implement, evaluate, and follow up on these evaluations. Merdeka Learning also provides opportunities for students to develop their talents. Students are also expected to have 4C skills: critical thinking, communication, collaboration, and creative thinking and action [9].

Based on the Minister of Education and Culture Number 22 of 2016 regulation concerning Process Standards for Primary and Secondary Education, teaching materials are useful for increasing efficiency and effectiveness in learning. Many learning resources, including printed materials, electronic materials, the surrounding environment, and other relevant sources, can be used. Learning tools are learning resources teachers and students use to achieve the Panacasila learner profile and Learning Outcomes according to the independent curriculum. So it is very important to develop teaching materials to support learning according to the independent curriculum.

Teaching materials are very important in conducting education. Materials make learning easier for teachers and easier for students to learn. Materials are designed and produced according to the needs and characteristics of the materials

presented and follow an appropriate curriculum. [10]. Teaching materials are one of the supporting factors in improving the quality of education. Teaching materials developed must be by the needs of teachers and students [11].

Chemistry is part of Natural Sciences or science, a collection of knowledge systematically arranged and generally limited to natural symptoms [12]. Chemistry has many fields of study that study facts, concepts, laws, and theories related to everyday life. Chemistry has many fields of study where each material is arranged sequentially and interconnected [13]. So students must understand the concepts to avoid difficulties in studying chemistry. Chemical bonding is one of the most important learning topics taught to students. Students need to understand the concepts of why and how chemical bonds occur. Chemical bonds are the basis for understanding further material, such as writing chemical reactions and understanding the basic laws of chemistry, chemical equilibrium, and thermodynamics. So students need to learn chemical bonding material [14].

The principle of an independent curriculum is flexible, where teachers and learners are free to control the educational process. A curriculum with flexible principles provides flexibility to education units and educators to adapt, add subject matter content, and adjust the curriculum to the characteristics of students. The Chemistry Subject Teachers Assembly in Padang City agreed to teach chemical bonding material in phase E, but back again from schools, teachers, and students. The teaching materials that teachers and students widely use do not include chemical bonding material, so teaching materials are needed that contain chemical bonding material that explains chemical concepts in everyday life according to the demands of the independent curriculum.

Based on the description above, the importance of teaching materials developed with chemical bonding material to support learning in accordance with the independent curriculum can be seen. Therefore, the current study focuses on developing Teaching Materials to Support Independent Curriculum Learning on Chemical Bonding Material Phase E. This research is expected to be useful and has a positive impact, especially on teachers and students in learning activities.

RESEARCH METHODS

The type of research used in this study is educational development research, also known as educational design research (EDR). This development aims to find solutions to educational problems and increase knowledge about educational interventions to design and further develop them [15]. This development research model consists of several stages: introduction, development or prototyping, and assessment [15] [16]. But in this study, only up to development or prototyping.

Table 1. The stages of developing teaching materials to support independent curriculum learning on chemical bonding material in phase E.

Preliminary Research		Need, and Context Analysis Literature Review Development of Conceptual Framework
Development or Prototyping Phase	Prototype I	*Revised*
	Prototype II	Self-evaluation *Revised*
	Prototype III	Expert review One-to-one evaluation *Revised*
	Prototype IV	Small group *Revised*

Development, or prototyping, is a research microcycle. This development, or prototyping, will result in stages, namely prototype I, prototype II, prototype III, and prototype IV, which are formative evaluation results. Formative evaluation is a systematic assessment (including research design, data collection, data analysis, and reporting) that is very important in each stage of the prototype to reveal the shortcomings of an object and generate suggestions for improvement, as well as improve the prototype of a quality intervention. While the summative evaluation is conducted to prove the effectiveness of the intervention [17].

Data analysis in this study used descriptive statistics to obtain averages and percentages. The validation analysis technique is based on categorical judgments modified from Boslaugh. The researcher gave the validation instrument sheet to the validator to assess the product.

The validator's assessment was analyzed using the formula with Aiken's validity [19]; the formula is stated as follows:

$$V = \frac{\Sigma s}{n\,(c-1)}$$

(s = r - I0)

Description:
V : Index of agreement on item validity
S : The assigned score minus the lowest score. The category used, where r is the validator's preferred score, and I0 is the lowest score in the scoring category.
n : Number of validators
c : The number of categories chosen by the validator
The validity assessment criteria using Aiken's V scale are categorized in Table 2 below.

Table 2. Aiken's V Index Criteria

Aiken's V scale	Validity
V < 0.8	Invalid
V ≥ 0.8	Valid

[20]

Table 3. Criteria for Practicality Level

Interval	Criteria
86% - 100%	Very Practical
76% - 85%	Practical
60% - 75%	Practical enough
55% - 59%	Less Practical
≤ 54%	Not Practical

[22]

Practicality assessment criteria are categorized in Table 3. Practicality instruments in the form of student response questionnaires and chemistry teachers. The teacher activity observation sheet aims to obtain data on implementation observations related to the use of teaching materials developed [21]. Practicality analysis is expressed in the following formula:

$$\text{NP} = \frac{\text{R}}{\text{SM}} \text{ x } 100$$

Description:
NP: Percentage value sought or expected
R : Score obtained
S : Maximum score

RESULTS AND DISCUSSION

Preliminary Research

Need and Context Analysis

At the needs analysis stage, observations were made through interviews with chemistry teachers in several schools, namely public high school 8 Padang and Padang State University Laboratory Development high school. This research aims to discover the problems and obstacles experienced by teachers and students related to learning chemistry on chemical bonding material.

Based on the results of observations made at high schools in Padang City that have implemented an independent curriculum. Observations were made by interviewing chemistry teachers. The observations show that in the learning process, teachers and students use teaching materials, including Ministry of Education teaching materials and books that discuss the appropriate material, and some also use additional references such as searching the internet and other relevant sources. The observation results also show that chemical bonding material is taught in phase E. The teacher stated that from the teaching materials used at school, not all teaching materials discuss chemical bonding material. Judging from the needs and characteristics of students, it is very important to learn chemical bonding material to achieve the expected learning objectives.

From the results of the interviews, it was concluded that teachers and students stated that the teaching materials used for learning activities did not discuss chemical bonding material.

At the context analysis stage, it aims to explore the problem to find solutions or appropriate interventions to overcome problems in the coverage needs analysis of learning achievement and the expected learning objectives on chemical bonding materials.

Literature Review

The literature study stage is carried out by analyzing journals, books, and other reading sources. From similar research entitled "Development of Teaching Books for Class VIII Semester II Based on Science Process Skills to Improve Student Learning Outcomes," the results of data analysis research show the average score of the validity of teaching books in the aspects of content and presentation of 86.5% with a very valid category and the linguistic aspect of 88.5% very valid category. The analysis of teacher responses to the practicality of coursebooks showed an average score of 87.5% with a very practical category, and student responses to the practicality of teaching materials showed an average score of 82.3% with a very practical category [23]. Further, from the analysis results of the journal entitled "Flipped Classroom Guided Inquiry-Learning Systems on Thermochemical Materials for High School XI Years." The development model for this study is his Plomp development model [24]. From the reference, it is obtained that the development of teaching materials can be a solution to supporting independent curriculum learning.

Development of Conceptual Framework

Development, or prototyping, is a research microcycle. This development, or prototyping, will result in stages, namely prototype I, prototype II, prototype III, and prototype IV, which are formative evaluation results.

Prototype I

The prototype I stage is to design and develop teaching materials to support independent curriculum learning on chemical bonding material in phase E. The components of the teaching materials are the deepening of chemical bonding material, supporting information, and practice questions. In the teaching materials, there are instructions that can provide information about the book's contents, such as a preface, concept map, sample questions and discussion, activities, comprehension tests, and chemical literacy.

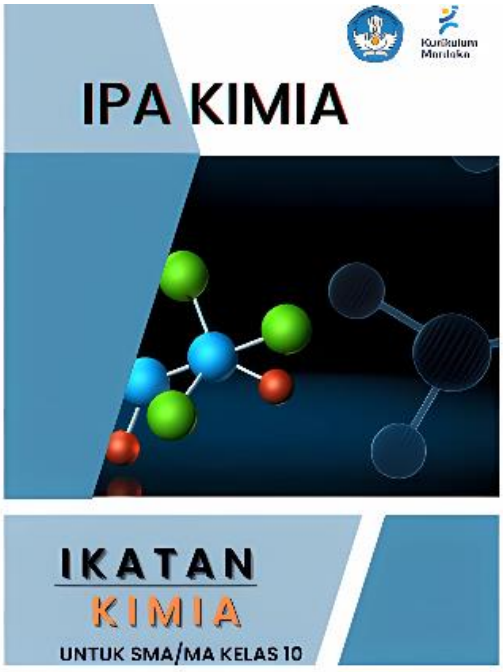


Figure 1. The cover of the teaching material.

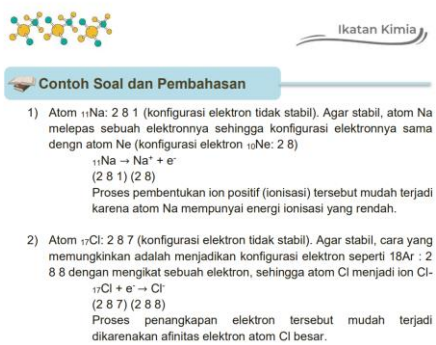


Figure 2. It contains problem-solving strategies that can help students work on the problems.

Figure 3. Chapter cover, containing chapter title, learning outcomes, learning objectives, and Pancasila learner profiles related to the material in the chapter.

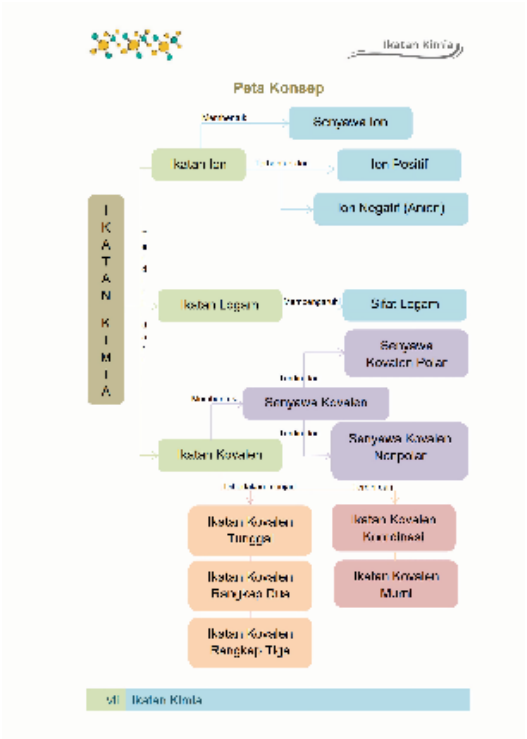
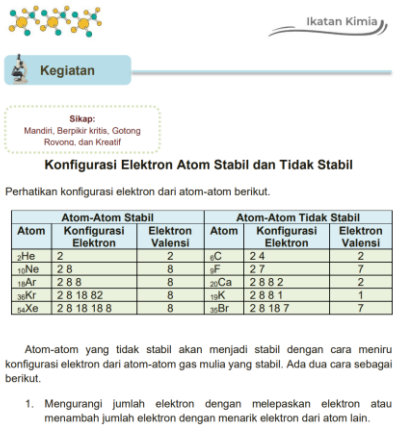


Figure 4. Describing the interrelationship of the subject matter to be studied.



Ikatan Kimia

Kegiatan

Sikap:
Mandiri, Berpikir kritis, Gotong Royong, dan Kreatif

Konfigurasi Elektron Atom Stabil dan Tidak Stabil

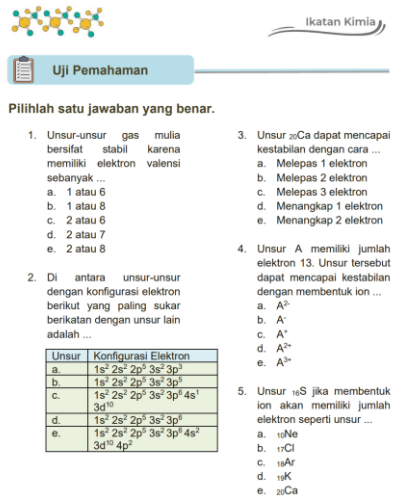
Perhatikan konfigurasi elektron dari atom-atom berikut.

Atom-Atom Stabil			Atom-Atom Tidak Stabil		
Atom	Konfigurasi Elektron	Elektron Valensi	Atom	Konfigurasi Elektron	Elektron Valensi
$_{2}$He	2	2	$_{6}$C	2 4	2
$_{10}$Ne	2 8	8	$_{9}$F	2 7	7
$_{18}$Ar	2 8 8	8	$_{20}$Ca	2 8 8 2	2
$_{36}$Kr	2 8 18 82	8	$_{19}$K	2 8 8 1	1
$_{54}$Xe	2 8 18 18 8	8	$_{35}$Br	2 8 18 7	7

Atom-atom yang tidak stabil akan menjadi stabil dengan cara meniru konfigurasi elektron dari atom-atom gas mulia yang stabil. Ada dua cara sebagai berikut.

1. Mengurangi jumlah elektron dengan melepaskan elektron atau menambah jumlah elektron dengan menarik elektron dari atom lain.

Figure 5. In the form of assignments independently or in groups to apply the material learned.



Ikatan Kimia

Uji Pemahaman

Pilihlah satu jawaban yang benar.

1. Unsur-unsur gas mulia bersifat stabil karena memiliki elektron valensi sebanyak ...
   a. 1 atau 6
   b. 1 atau 8
   c. 2 atau 6
   d. 2 atau 7
   e. 2 atau 8

2. Di antara unsur-unsur dengan konfigurasi elektron berikut yang paling sukar berikatan dengan unsur lain adalah ...

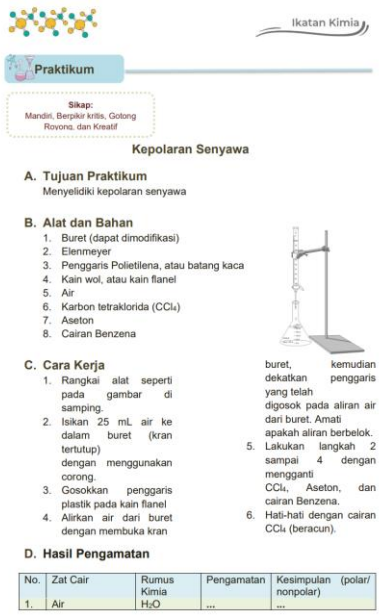
Unsur	Konfigurasi Elektron
a.	$1s^2\ 2s^2\ 2p^5\ 3s^2\ 3p^3$
b.	$1s^2\ 2s^2\ 2p^5\ 3s^2\ 3p^5$
c.	$1s^2\ 2s^2\ 2p^5\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$
d.	$1s^2\ 2s^2\ 2p^5\ 3s^2\ 3p^6$
e.	$1s^2\ 2s^2\ 2p^5\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^2$

3. Unsur $_{20}$Ca dapat mencapai kestabilan dengan cara ...
   a. Melepas 1 elektron
   b. Melepas 2 elektron
   c. Melepas 3 elektron
   d. Menangkap 1 elektron
   e. Menangkap 2 elektron

4. Unsur A memiliki jumlah elektron 13. Unsur tersebut dapat mencapai kestabilan dengan membentuk ion ...
   a. A^{2-}
   b. A^{-}
   c. A^{+}
   d. A^{2+}
   e. A^{3+}

5. Unsur $_{16}$S jika membentuk ion akan memiliki jumlah elektron seperti unsur ...
   a. $_{10}$Ne
   b. $_{17}$Cl
   c. $_{18}$Ar
   d. $_{19}$K
   e. $_{20}$Ca

Figure 6. Located in each subchapter to test mastery and understanding of the learning process.



Ikatan Kimia

Praktikum

Sikap:
Mandiri, Berpikir kritis, Gotong Royong, dan Kreatif

Kepolaran Senyawa

A. Tujuan Praktikum
Menyelidiki kepolaran senyawa

B. Alat dan Bahan
1. Buret (dapat dimodifikasi)
2. Elenmeyer
3. Penggaris Polietilena, atau batang kaca
4. Kain wol, atau kain flanel
5. Air
6. Karbon tetraklorida (CCl_4)
7. Aseton
8. Cairan Benzena

C. Cara Kerja
1. Rangkai alat seperti pada gambar di samping.
2. Isikan 25 mL air ke dalam buret (kran tertutup) dengan menggunakan corong.
3. Gosokkan penggaris plastik pada kain flanel
4. Alirkan air dari buret dengan membuka kran buret, kemudian dekatkan penggaris yang telah digosok pada aliran air dari buret. Amati apakah aliran berbelok.
5. Lakukan langkah 2 sampai 4 dengan mengganti CCl_4, Aseton, dan cairan Benzena.
6. Hati-hati dengan cairan CCl_4 (beracun).

D. Hasil Pengamatan

No.	Zat Cair	Rumus Kimia	Pengamatan	Kesimpulan (polar/ nonpolar)
1.	Air	H_2O	...	...

Figure 7. A practicum activity can be practiced in groups to apply the material learned.

Prototype II

Prototype II is the result of the formative evaluation of the self-evaluation of prototype I. At this stage, researchers checked the completeness of the teaching material components [25]. From the results of the self-evaluation, the design and components of teaching materials and student activities in the teaching materials that have been developed are complete, so no revisions are needed to prototype I.

Prototype III

Prototype III results from a formative evaluation from an expert review and a one-to-one evaluation from prototype II. At the expert review stage, the assessment instrument used was a validation questionnaire. Validation data was obtained from 3 chemistry lecturers and two chemistry teachers. Several suggestions and inputs were obtained from the results of validation with experts that could be used as guidelines in revising prototype II. Suggestions and input from validators, namely, (1) some pictures are still unclear, (2) add examples of chemical bonding material related to everyday life.

The data that has been obtained will be processed using Aiken's V scale. From the data processing, the validity value of the development of teaching materials to support independent curriculum learning on chemical bonding material with an average of 0.85 with a valid category was obtained. These results indicate that the development of teaching materials developed is valid regarding content, presentation, language, and graphics. The following validation results can be seen in the following bar chart.

Literasi Kimia

Tahukah KAMU ?

Apakah kamu tahu bahwa *liquefied petroleum gas*, atau sering dikenal LPG yang digunakan untuk keperluan memasak. Saat kita memutar kompor, kita akan mendengar suara desis gas yang keluar. LPG adalah gas yang didinginkan, dan dicirkan dibawah tekanan besar untuk dipompa kedalam silinder.

Komposisi LPG adalah campuran gas hidrokarbon yang mudah terbakar. Hidrokarbon merupakan senyawa yang terdiri dari Karbon, dan Hidrogen dihungkan dengan ikatan kovalen, umumnya campuran propana (C_3H_8), dan butana (C_4H_{10}). Pada propana, dan butana terjadi ikatan kimia kovalen dengan rantai tunggal.

Sebuah atom Karbon memiliki empat elektron valensi yang dapat dibagi dengan empat atom lainnya. Karena Hidrogen adalah satu elektron pendek untuk konfigurasi stabil, maka membentuk ikatan kovalen dengan berbagi satu elektron dengan Karbon.

Selain pada LPG, unsur yang paling melimpah ketiga di alam semesta yaitu Oksigen (O_2). Kita tidak bisa hidup tanpa adanya Oksigen. Oksigen tidak ditemukan dalam bentuknya, Sebagian besar terjadi sebagai molekul diatomic (O_2), dimana memiliki enam elektron valensi. Dua atom Oksigen masing-masing berbagi dua elektron untuk membentuk ikatan kovalen rangkap dua.

Figure 8. Teaching materials after revision, with clearer pictures and explanations of examples of chemical bonds in everyday life.

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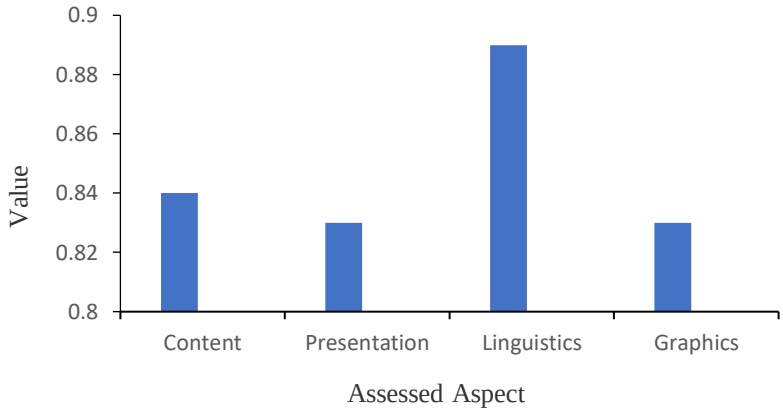

Figure 9. Validity value

It is not only the adequacy of the teaching materials developed but also their applicability to teachers and students that proves the quality of the product based on research. It includes products that are easy to develop and practical. If both are available, it is a practical product. Practical results were obtained from a small group trial conducted on nine students in phase E. The research instrument used is a practicality questionnaire for teacher and student responses. The results of the small group test on students obtained an average practicality value of 93% with a very practical category. The teacher's response obtained an average practicality value of 97% with a very practical category. The level of practicality of the teaching materials developed was assessed from the aspects of ease of use, appearance, time efficiency, and benefits. The following practical results can be seen in the following bar chart.

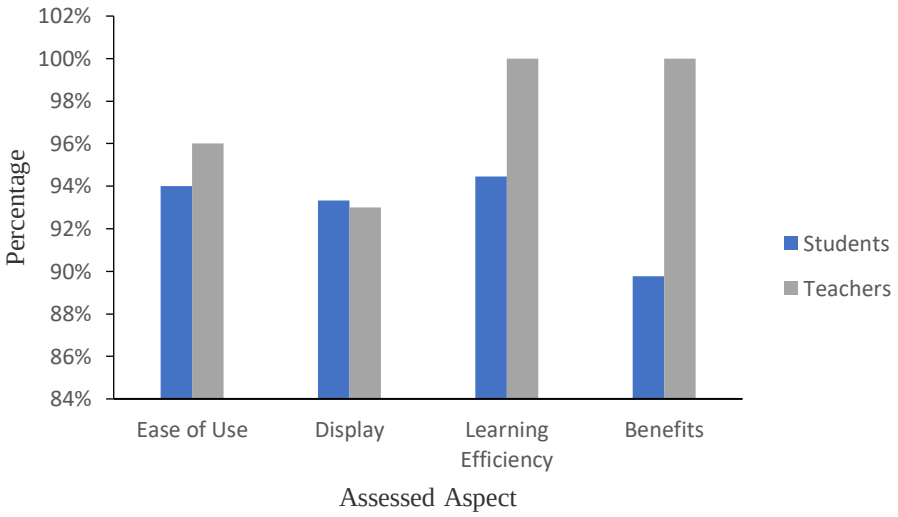

Figure 10. Practicality scores from teachers' and students' test

Chemical bonds are the basis for an advanced understanding of materials, including the representation of chemical reactions and an understanding of the fundamental laws of chemistry, chemical equilibrium, and thermodynamics. Therefore, students need to learn about chemically bonded substances. Learning objectives are formulated in the area of chemically bonded materials. The nature of ionic and covalent bonds should be explained, and students should be able to explain how ionic and covalent bonds are formed. It explains how covalent bonds are formed and helps you understand coordinative covalent, polar covalent, and nonpolarnonpolar bonds.

Chemical bonding is defined as the force that binds together combinations of atoms in molecules or ions in compounds to form electronic configurations like those of noble gases. The ionic bonds discussed in this article are ionic and covalent. Ionic bonds are chemical bonds formed by electrostatic attraction between positive and negative ions: metallic elements and non-metallic elements in general. Ionic bonds have hard and brittle crystal formation properties, high melting points, good water solubility, and electrical conductivity. A covalent bond is a chemical bond

formed by sharing electron pairs between atoms. The teaching materials explain coordinative covalent bonds, polar covalent bonds, and nonpolarnonpolar covalent bonds. The properties of covalent compounds are that they have low melting and boiling points, are insoluble in water, and do not conduct electricity. Learn more about how chemical bonds are formed with illustrations that explain in detail. It contains sample questions and exercises to test students' comprehension skills. In addition to self-assessment, there is also routine chemistry competence.

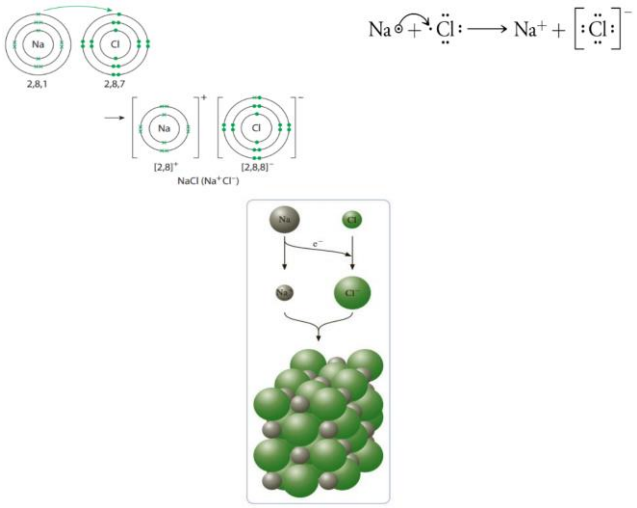

Figure 12. One of the pictures in the question in the teaching materials

One of the key question models that students must answer is shown in Figure 12. Students are expected to analyze chemistry applications in everyday life, especially chemically bonded materials. A common chemical bonding use case is table salt (NaCl). The bond that occurs in table salt (NaCl) is ionic. Students are expected to see a smaller image (ultramicroscope) and use it
to explain how ionic bonds are formed. The developed materials are classified as valid and highly practice-oriented based on the data obtained. This material will benefit teachers and students as one of the materials supporting the self-directed curriculum learning of Phase E chemically bonded materials.

CONCLUSION

The results demonstrate that the Plomp development model can develop materials that support independent curricular learning in chemically coupled Phase E materials. Learning objectives are created using chemically bonded materials. Explain the nature of ionic and covalent bonds and enable students to demonstrate covalent, polar covalent, and nonpolar bonds.

It is expected that the development of this teaching material will serve as reference material, especially when conducting learning activities related to phase E chemically bonded materials, and will serve as a teaching material that supports independent learning in the curriculum. Help students learn and understand chemically bonded materials. The materials developed were rated as effective and highly practical by experts, with an effectiveness score of 0.85, an average utility of student responses of 94%, and an average utility of teacher responses of 96%.

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