The making of e-module based in inquiry on chemical bonding concept with representation ability oriented

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Abstract. This study aims to produce teaching material products in the form of electronic modules with inquiry learning steps on the concept of chemical bond with representation ability oriented (macroscopic, submicroscopic, and symbolic) and find out the feasibility based on responses from experts and student respondents. The research method used is the Design Based Research (DBR) method with the ADD model covering the stages of analysis, design and development to be able to produce products in the form of electronic modules that are displayed in the form of text, images, animation, flash and video. Validation of the content and display aspects was carried out through consideration of three experts. In general, the results of the average value of the validation test in the form of rcount are between 0.77-0.81 so that the module is declared valid. Furthermore, the product was tested to 15 student respondents using a feasibility test instrument. The results of the feasibility test show that the percentage of feasibility in each aspect is in the range of 90-98% which agrees to all criteria. This shows an electronic module that has been made feasible to use.

1. Introduction
Chemistry is the science of matter relating to the composition of substances, structures, properties, interactions and changes in them [1]. Chemistry has three levels of representation, namely macroscopic, microscopic, and symbolic [2]. Through these representations, the phenomena of the physical world in matter, phenomena, and processes at the macroscopic level can be interpreted and predicted using the submicroscopic world [3]. Research shows the relationship between macroscopic, submicroscopic and symbolic levels in chemicals is a source of difficulties for many students [4]. This is supported by research that explains that students prefer to memorize the equations of chemical formulas (symbolic) without understanding the macroscopic and submicroscopic aspects [5].

Chemical concepts have various phenomena that cannot be discussed directly, such as molecular structure and interactions between atoms, molecules and ions [6]. One concept in chemistry that addresses this matter is chemical bonds [1]. Chemical bonds are abstract with concrete examples because we can only discuss the nature of the compound without knowing how these atoms bind to each other [7].

Based on the research, students still have difficulty understanding the material of chemical bonds as a whole covering the three levels of representation. The level of difficulty is related to this level model with an inappropriate mental model [8]. No one can explain precisely the phenomena that occur and students cannot understand the reason for the formation of bonds [7].
One of the causes that the students cannot visualize with a good level of representation is because all the books used in learning still use chemical representations which are only centered on symbolic levels [9]. Based on research on the analysis of chemical bonding material in high school textbooks, the criteria for representation connectedness are still low [10].

The way to overcome the difficulties in explaining the phenomenon of abstract chemical bonds is by using representational abilities [11]. Therefore, we need a media that can explain the level of representation. One of the media used to help teaching and learning with technology [12]. Based on studies on the use of Information and Communication Technology (ICT) can help students visualize chemical concepts that are abstract at the macroscopic, submicroscopic, and symbolic level [13].

One of the information and communication technology communication products in the world of education is the e-module. The E-module was chosen because it is an independent learning tool that contains material, methods, and facilitating methods designed systematically with direct feedback [14]. In general, the e-module displays content in the form of videos or animations that are equipped with text [15].

The selection and utilization of appropriate learning media on relevant learning theories will have a positive impact on the success of the learning process [16]. One of the appropriate agreements to be integrated into e-module as a solution in presentation material is inquiry. Inquiry design to direct students in learning that involves through the process of thinking and activities such as scientists so that it is effective in learning [17]. Based on the research that has been done, it shows that the use of inquiry-based modules is effective in improving student learning outcomes [18].

Some research on the development of e-modules as a medium for student learning [15, 19] shows that e-modules are worthy of being used as learning media that can help students understand chemical concepts. Besides that, specifically for chemical bonding materials, research has been developed in the form of chemical representation based e-books [20]. However, e-module research that the author has done has never been done.

Therefore, e-module based in inquiry on chemical bonding concept with representation ability oriented are developed as media that can be used in learning on abstract chemical bonding material. Based on the description of the background above, a study will be carried out entitled "The Making of E-Module Based in Inquiry on Chemical Bonding Concept with Representation Ability Oriented".

2. Methodology

The research method used is Design Based Research (DBR), where this method is based on the development of educational materials in the form of products that can support the learning process. There are at least 5 stages in this method which are then abbreviated as ADDIE (Analysis, Design, Development, Implementation, and Evaluation) [21]. However, in this study only three stages were carried out, namely Analysis, Design and Development.

In the Analysis Phase, needs analysis, concept analysis, concept maps, material indicators, chemical representation, content analysis and planning are carried out. Then in design analysis, it is done by making flow charts and storyboard designs. The e-module was then designed by combining text, image, video, animation and flash to present the concept of chemical bonds through a capability-oriented representation and representation approach. After the e-module prototype is produced, it is tested on a limited scale through validation and feasibility tests.

In this study the data are qualitative and quantitative. Qualitative data analysis is done by describing the results of the stages of product making, product display, and data from the validation test and feasibility questionnaire. While the quantitative data consists of two stages, namely the analysis of data on the Likert scale questionnaire and the processing of Guttman scale questionnaire data [22].

3. Result and discussion

The resulting e-module was made based on the need for teaching materials that can visualize chemical representations as a whole including macroscopic, submicroscopic and symbolic representations of chemical bonding material. E-modules are presented in the form of animations, videos and images that
are equipped with text. E-module was chosen because it is a tool or means of self-learning that contains material, methods, and methods of evaluating that are designed systematically with direct feedbacks [15].

The stages of inquiry learning used in the presentation of material in electronic modules are intended to make the module more directed, systematic and provide an inductive thinking process towards the user so that it can provide a meaningful learning experience in understanding each concept contained in the electronic module [17].

Overall, the presentation of the concepts given in e-modules in sequence includes; 1) Introduction; 2) Octet Rules; 3) Lewis Structure; 4) Ion Bonds; 5) Covalent Bonds; 6) Metal Bonds are arranged based on the steps of inquiry learning and are displayed in three levels of representation including macroscopic, submicroscopic and symbolic. Views that represent the macroscopic aspects can be seen in Figure 1.

The image presents the ion bond form provided in the salt composition. On this page the sub concept of ion bonds begins with the phenomenon of forming the properties of ionic compounds in salt. Suggestions for users to read the discourse given later can answer questions. Phenomenon that represents the macroscopic representation of ionic bonds. In addition, users can also simulate the delivery of electric current between salt and sugar used for the direct process that occurs. Macroscopic phenomena are tangible and visible phenomena, such as chemical phenomena that occur in everyday life or on a laboratory scale that can be seen directly [23]. Furthermore, the display represents the aspects that can be seen in Figure 2.

**Figure 1.** Macroscopic representation.

**Figure 2.** Submicroscopic representation.
The image presents the hydration process in NaCl compounds which are displayed in the form of molecular animation. This page aims to explain submicroscopically how the compounds of salt (NaCl) when dissolved in water. In addition, this page reinforces the previous page regarding the delivery of electric current by a salt solution. The salt dissolution process is given through molecular animation when Na\(^+\) and Cl\(^-\) are in water solvents. Users are asked to predict events that occur during the hydration process so that it can refer to a conclusion that Na\(^+\) and Cl\(^-\) ions will be surrounded by water molecules according to their electrostatic forces. Submicroscopic representations can be presented in the form of expressions of words, two dimensions, three-dimensional images both silent or moving (animation) or simulation [23]. Furthermore, images that represent symbolic aspects can be seen in Figure 3.

**Figure 3.** Symbolic representation.

The picture beside presents the process of forming ion bonds which are displayed in the form of static structures of each atom representing symbolic representations. On this page the user is asked to fill in the Na and Cl atomic configurations to analyze how the two elements bind. Symbolic representations relate to symbols of atoms, molecules and compounds, both in the form of images and algebraic processes [24].

Chemical teaching materials must have connections between the three levels of representation, namely macroscopic, submicroscopic, and symbolic [6]. The use of different chemical representation models in the form of text, images, graphics, animations, and simulations can facilitate the development of students’ ability to connect the three levels of representation [24]. The use of all three chemical representations completely is believed to have a good impact on learning outcomes [7].

The material presented in this module is based on the steps in inquiry learning. This is because inquiry learning can encourage students to learn through active involvement with concepts and principles that enable them to find principles for themselves [25]. Overall, the concept hierarchy is made inductively so that users must go through various stages and processes first to arrive at a conclusion. Good teaching materials have characteristics that can provide material inductively [26].

The E-Module display then carried out validation and feasibility tests covering four aspects, namely aspects of material presentation, aspects of representation, aspects of evaluation and aspects of display and navigation. The validation test was carried out by three validators consisting of two material experts (chemistry education lecturers) and one media expert (informatics lecturer). While the feasibility test was conducted on student respondents as many as 15 people. This test was conducted to find out the responses related to the e-module prototype that was made. The results of the validation test can be seen in Table 1. While the results of the feasibility test can be seen in Table 2.
Table 1. Overall validation test result.

| No. | Rated Aspect                | r count | r critical | Result |
|-----|----------------------------|---------|------------|--------|
| 1.  | Material presentation aspects | 0.80    | 0.30       | Valid  |
| 2.  | Chemical representation aspect | 0.81    | 0.30       | Valid  |
| 3.  | Evaluation aspect            | 0.81    | 0.30       | Valid  |
| 4.  | Display and Navigation aspect | 0.78    | 0.30       | Valid  |
|     | Average r count              | 0.80    | 0.30       | Valid  |

Table 2. Overall feasibility test result.

| No. | Rated Aspect                   | Average (%) |
|-----|-------------------------------|-------------|
|     |                               | Yes | No |
| 1.  | Material presentation aspects  | 96  | 4  |
| 2.  | Evaluation aspect              | 98  | 2  |
| 3.  | Display and Navigation aspect  | 90  | 10 |
|     | Average percentage             | 94.6 | 5.3 |

Table 1 shows that all the components of the validation test results are declared valid and show a high interpretation value with a calculated value greater than 0.30 [22]. The highest r count is in the material presentation aspect and the evaluation aspect with value 0.81. While the lowest r count is in the display and navigation aspects with value 0.78. Table 2 shows that the results obtained from the feasibility test of electronic modules based in inquiry on chemical bonding concept with representation ability oriented received good responses from respondents. In general, the responses of respondents who agreed to the material presentation aspect were 96%, the evaluation aspect was 98% and the display and navigation aspects were 90% so that the module could be categorized as feasible and ready to be used as a learning resource on the concept of chemical bonds. An electronic module or module has eligibility criteria with a percentage qualification (%) as follows: 90-100 is declared very feasible, 80-89 is declared feasible, 70-79 is declared feasible, 60-69 is declared inadequate, and <60 is declared inadequate [27].

4. Conclusion
Based on the results of the research that has been carried out produced teaching materials in the form of electronic modules that have the characteristics of material presentation in inquiry by linking three levels of chemical representation (macroscopic, submicroscopic, and symbolic) that are displayed in the form of text, images, animation, flash, and video. Validation of the content and display aspects was carried out through consideration of 3 experts. In general, the results of the average value of the validation test in the form of r count are between 0.77-0.81 so that the module is declared valid. Furthermore, the product was tested to 15 student respondents using a feasibility test instrument. The results of the feasibility test show that the percentage of feasibility in each aspect is in the range of 90-98% which agrees to all criteria. This shows an electronic module that has been made feasible to use.

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