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Interactive Android Module Development Containing Three Chemical Representation Levels on Material of Salt Hydrolysis

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Abstract

Three chemical representation is an important aspect of chemistry learning. However, the database study shows that interactive chemistry learning media containing three levels of representation is not available. This research aims to develop and assess the feasibility of an interactive Android-based learning module for senior high school students containing three chemical representation levels on the material of salt hydrolysis. The study was conducted using research and development (R&D) method. Stages of research were conducted as follows, analysis, development process, product validation and assessment. The Android module was subsequently validated by media and concept experts and then limitedly assessed by five chemistry teachers and ten senior high school students. The instrument used was validated by an instrument expert. The validation results by media and concept experts indicated that the media was valid in terms of media performance and salt hydrolysis material. Based on teachers' and students' assessments, the media received a score of 87.5% and 83.0%, with very good category. It can be concluded that the interactive Android-based learning module containing three chemical representations on the material of salt hydrolysis was successfully developed and can be tested extensively in senior high school. The developed media closed a significant gap in the need of interactive chemistry learning media containing three levels of chemical representation, especially in the material of salt hydrolisis.

Keywords: android-based learning module, learning media, salt hydrolysis, three chemical representation levels

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1. Introduction

Chemistry is a science subject closely related to the laboratory (DeKorver & Towns, 2015). Expected learning outcomes of chemistry subjects in senior high school are understanding microscopic structures and observing physical and chemical properties. One of the chemistry subject's aims in Indonesia is recognizing and solving the problem and having the laboratory skill and its application for daily life (Permendikbud, 2016). This is in line with the idea of chemistry knowledge, which can be represented in three ways, i.e. macroscopic, microscopic, and symbol representation (Luviani, Mulyani, & Widhiyanti, 2021; Sujak & Daniel, 2018). However, most students find difficulties in understanding chemistry because of its complexity, abstract, and unobservable chemical concept (Upahi & Ramnarain, 2019). Most students have problems connecting microscopic, macroscopic and symbolic levels (Susilaningsih, Wulandari, Supartono, Kasmui, & Alighiri, 2018; Min Zahrotil. Umami, Rubi'ah. Rubi'ah, Sri. Wardani, & Cepi. Kurniawan, 2020). Therefore, it is crucial to solving these problems.

Salt hydrolysis is one of the materials in chemistry subjects that have misconceptions at the symbolic level and microscopic level (Min Zahrotil Umami, Rubi'ah Rubi'ah, Sri Wardani, & Cepi Kurniawan, 2020). The misconception is commonly produced from students' inability to visualize structures and processes at the microscopic or molecular level (Atkinson, Croisant, & Bretz, 2021). In understanding the concept, a tiered approach from a simple concept to a higher-level concept is needed. Explaining phenomena that are seen with the senses at the macroscopic level must be precise and in accordance with the microscopic and symbolic level so that there is no misconception about the concept of chemical matter (El Kababi, Atibi, Radid, & Benmassaoud, 2017; Upahi & Ramnarain, 2019). Then, it is important to visualize the microscopic structure and relate it to the macroscopic level to help the students understand salt hydrolysis. It can be done through the use of learning media (Helsy, Maryamah, Farida, & Ramdhani, 2010; Russell et al., 1997).

Learning media is something that can convey messages, make communication effective, stimulate students' thoughts, and boost the learning process (Kirkwood & Price, 2005). Visual-based media is a powerful learning medium to enhance students' ability to visualize microscopic representation and relate it to macroscopic and symbolic ones (Dutton & Loader, 2005). This way can be delivered in book-based media. However, it has many disadvantages, such as non-interactive media and static visuals (Lewalter, 2003). Video-based media can overcome problems that book-based media cannot overcome. It easily visualizes and relates three-level representations (Eilam & K. Gilbert, 2014; Troseth, Russo, & Strouse, 2016).

Aliyah, Susilaningsih, Kasmui, Nurchasanah, and Astuti (2018) developed the concept-map media containing multi-representation on the topic of buffer and hydrolysis. Julia, Rosilawati, and Efkar (2016) also developed a module containing multi-representation on the topic of buffer and hydrolysis. However, these media are less interactive and tends to be one-way. These problems can be overcome with Android-based interactive learning media.

Android-based interactive learning media can collaborate with visual and interactive aspects (Saputri, Sukirno, Kurniawan, & Probowasito, 2020). It is also proven to help students relate to three-level representation. This media allows flexibility of the learning process and it can be carried out without time and space limitation (Odewumi et al., 2019; Sari, Fadillah, Jonathan, & Prabowo, 2019). It is supported by the fact that Indonesia is a country with a massive number of Android-based smartphone use (Wirawan, Agushinta R., Muhammad, Saifudin, & Ibrahim, 2013). These advantages make the widespread use of this media to help the learning process (Fitriansyah, Fatinah, & Syahril, 2020; Irwansyah, Yusuf, Farida, & Ramdhani, 2018; Putra, Asi, Anggraeni, & Karelius, 2020). A study on previous research shows that interactive learning media containing three levels of chemical representation has not yet been developed.

According to the explanation, research of interactive android module development containing three chemical representation levels on salt hydrolysis material has been carried out. This research aims to describe the development and the feasibility of interactive learning media through an Android application that consists of three chemical representation levels on salt hydrolysis material.

2. Method

The method of this research is a research and development (R&D) method that is employed to develop a particular product and assess it. Sugiyono pointed out the development steps containing three major steps, i.e., data collection on problem analysis, product development, limited trial and mass production (Sugiyono, 2015). However, the research is limited only to the limited trial. The product developed in this study is an interactive android module development containing three chemical representation levels on the material of salt hydrolysis. The steps in product development were detailed as follows.

2.1 Analysis

Analysis was conducted before the development of the media. The analysis carried out is needs analysis. It is important to ensure that the learning media developed is suitable for the needs. A needs analysis consisted of front-end analysis and student analysis. They were conducted using a literature review analysis.

2.2 Instrument Development

The instruments were for media and concept experts, chemistry teachers and high school students. The instrument to study the feasibility of the product was used by chemistry teachers and high school students. The instrument was composed of four aspects, i.e., the module, android applications, interactive multimedia, and integration of three levels of chemical representation aspects. The instrument was developed based on a literature review on the criteria of good learning media. Prior to use, the instrument was validated by an instrument expert.

2.3 Product Development

The content was collected from the chemistry curriculum for senior high school in Indonesia in the material of salt hydrolysis. Video for macroscopic representation was made in the chemistry laboratory, Faculty of Science and Technology, Universitas Islam Negeri Sunan Kalijaga. The learning media was developed using *software construct 2* from Scirra and built using *Website 2 APK Builder* from https://website-toapk.com/download.html.

2.4 Expert Validation

Prior to assessment, the product was validated by experts, i.e., a media expert and a concept expert. A media expert is an expert with well understanding in android-based learning media. A concept expert is a chemistry lecturer with good knowledge of chemistry specifically in salt hydrolysis material. Experts gave advice and checked the developed media. The experts checked the developed learning media based on the list provided and gave a valid mark if the media has met the tested points' criteria. This step necessary to ensure the developed product has appropriate for the salt hydrolysis material.

2.5 Product Assessment

The android module was assessed by five chemistry teachers of senior high school in Yogyakarta, Indonesia. The product was also tested limited to ten senior high school students of class XI in Yogyakarta to obtain the response on the ease and the usefulness of the product.

Teachers and students assessed the media using the table containing four categories, and then the result was converted into score (Table 1). Hereafter, the average score was converted back into the media feasibility category (Table 2). The data were analyzed by calculating the average score with the formula,with $\overline{X}$ as an average score, ΣX as a total score, and N as the number of assessor.

$$\overline{X} = \frac{\sum X}{N}$$

Table 1. Conversion Guideline from Category Into Score

Category	Score
Very Good	4
Good	3
Poor	2
Very Poor	1

Table 2. Average Score Conversion Guideline

Formula	Category
$X \geq \overline{X}_i + 1.SBi$	Very Good
$\overline{X}_i + 1.SBi > X \geq \overline{X}_i$	Good
$\overline{X}_i > X \geq \overline{X}_i - 1.SBi$	Poor
$X < \overline{X}_i - 1.SBi$	Very Poor

with $\overline{X}_i$ as ideal average score

$\overline{X}_i = {}^1/_2$ (ideal max score + ideal minimum score)

and SBi as ideal standard deviation

SBi = ${}^1/_6$ (ideal max score - ideal minimum score)

3. Result and Discussion

3.1 Analysis

The analysis stage was done before product development to ensure the usefulness of the product. It covered front-end analysis and student analysis. Front-end analysis is carried out using a literature study. The results obtained indicate the lack of learning resources that contain microscopic levels. Commonly, the learning media used by students are textbooks with the lack of three levels of chemical representation content, especially in salt hydrolysis material (Addiin, Ashadi, & Masykuri, 2016; Min Zahrotil. Umami et al., 2020). Whereas the role of learning media cannot be separated and is essential in the learning process (Isworini, Sunarno, & Saputro, 2015).

Student's analysis shows that generally in the learning process tends to use macroscopic and symbolic representation only. The use of chemical models is also not connected with two real targets, i.e. macroscopic and microscopic levels. Models are often only seen as symbols that are interpreted in a mathematical or computational context. It causes students to be obstructed to be mastering representational abilities (Atkinson et al., 2021).

3.2 Instrument Development

An instrument as a crucial tool to measure validity and usability was developed. The instrument development was based on a theoretical study conducted on the criteria for good instructional media application. The instrument was used after being validated by an instrument validator lecturer. The instruments were made for concept and media experts, as well as chemistry teachers and senior high school students of class XI.

The instrument to check concept validity consisted of content eligibility, material presentation, language aspect, and integration of three levels of chemical representation. The instrument for media validation was consist of module aspect, interactivity-navigation-feedback, screen design, android application, and interactive multimedia.

The instrument to study the feasibility of the product was used by chemistry teachers and high school students. The instrument was performed in the table containing module aspects, Android application aspects, interactive multimedia aspects, and integration aspects of three chemical representation levels. The module aspects consist of self-instructional, self-contained, stand-alone, adaptive, user friendly, content eligibility, language aspect, and media presentation indicators. Android application aspects has interactivity-navigation-feedback, screen design, and usability indicators. Interactive multimedia aspects provide the characteristics and functions of the learning media indicators. Integration aspects of three chemical representation levels aspect were used to find the integration of three levels representative levels of the media in salt hydrolysis material.

3.3 Product Development

The product developed consisted of three representatives of chemistry levels of salt hydrolysis material. It has the video and explanation of hydrolysis on acid salt, basic salt, neutral salt, and salt composed of weak acid and base. It also provides the exercise of the material to enhance the user to check the understanding.

The product was developed using *software construct 2* from Scirra and built using *Website 2 APK Builder*. Generally, the development process could be divided into two parts, parts, namely in the display section in the layout sheet (Figure 1a) and for the coding section was executed in the event sheet (Figure 1b). Each layout sheet had its pair of event sheet and its coding.

The product development was followed by designing the media with the following steps,

a. Making application display designs such as: splashscreen, background, button icons as navigation buttons (Figure 2a), such as page navigation buttons, indicators, material, practice questions, about and help page (Figure 2b). They were created using CorelDraw X7 software.
b. Creating content pages, i.e. pages containing contents according to curriculum, indicators, materials, exercise questions, and help pages. The design and layout were done using CorelDraw X7 software. The curriculum used follows Permendikbud No. 24 2016, and the indicators used are breakdowns from the syllabus. For exercise, there are ten questions in which each number has five variations of questions (Figure 2c). Therefore, it will be displayed randomly when it is opened. The "about" page contains information about the application and the developer. While the "help" page contains info content about some navigation button features in the application.
c. Making video three levels of chemical representation. The video contains salt hydrolysis material with three levels of chemical representation (Figure 2). The video content for the macroscopic level was made in the chemistry laboratory of UIN Sunan Kalijaga. Video for the microscopic level was created by combining step-by-step screenshots on Avogadro software. While at the symbolic level, reaction description was made on CorelDraw X7 software. Then each video at each level of chemical representation was combined into one video created using movie maker software.
d. The product developed provides an interactive learning media containing the material of salt hydrolysis with three levels representative of chemistry. It has videos at macroscopic, microscopic, and symbolic levels in the example of salt with acid characteristics (Figure 3), base, neutral and the salt composed with weak acid and base (Figure 4)

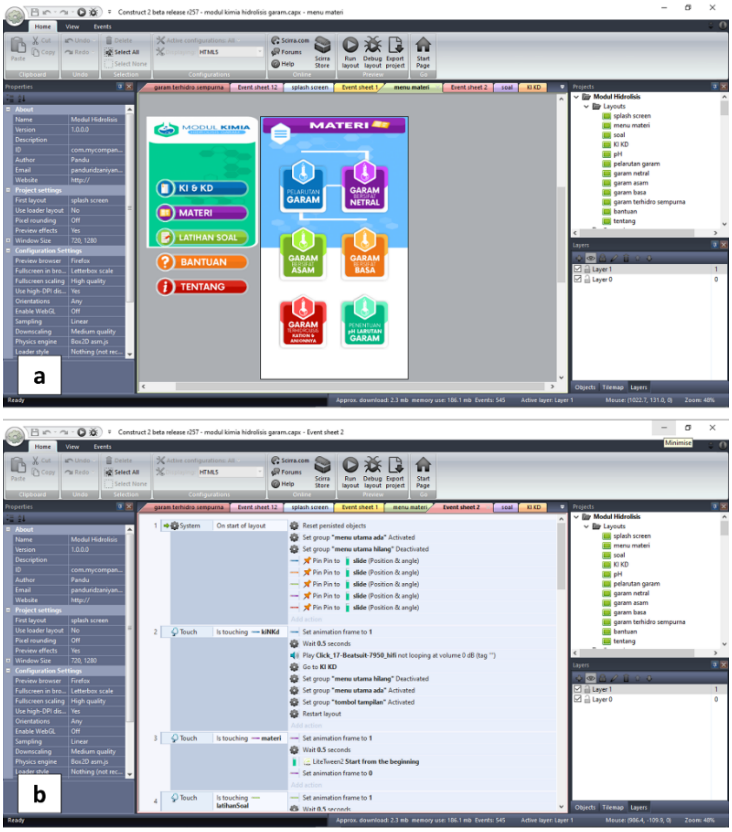

Figure 1. The Development Process of (a) Display Section and (b) Coding Section for The Learning Media of Interactive Android Module Development

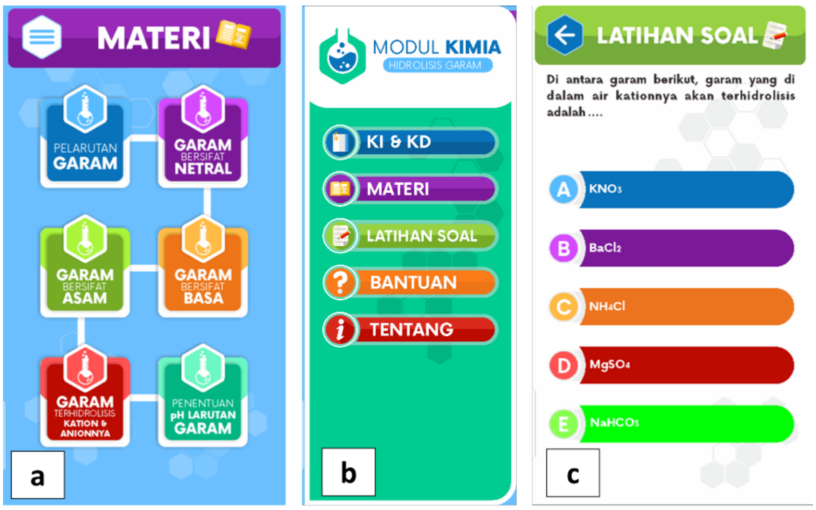

Figure 2. The Appearance of (a) Navigation Buttons and Main Menu Background, (b) The Sidebar, and (c) Random Exercise

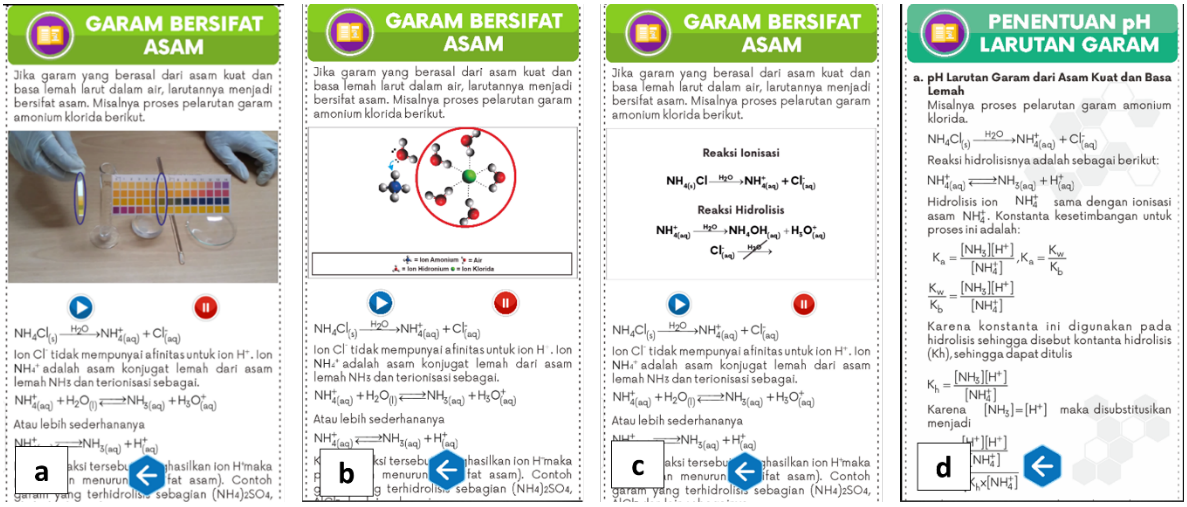

Figure 3. The Appearance of the Video at (a) Macroscopic, (b) Microscopic, and (c) Symbolic Levels with (d) the Calculation of pH.

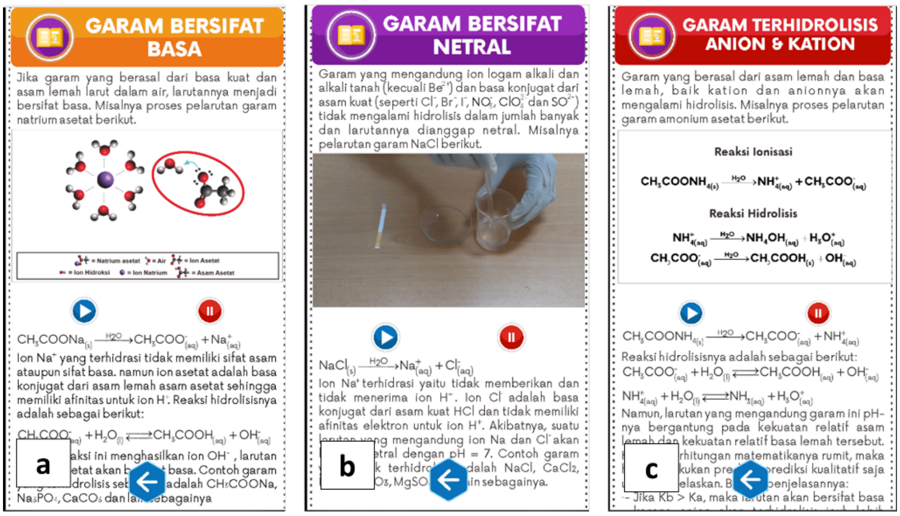

Figure 4. The Appearance of the Video of (a) Microscopic Level of Basic Salt (Sodium Acetate/CH3COONa), (b) Macroscopic Level of Neutral Salt (Sodium Chloride/NaCl), and (c) Symbolic Level of Salt Formed of Weak Acid and Base

3.4 Three Levels Chemical Representation

Three levels chemical representation is attractively and interactively provided on this android module. Figure 3 shows the appearance of video at macroscopic, microscopic, and symbolic levels in the example of salt with acid characteristics. In the macroscopic level (Figure 3a), the video shows the test of ammonium chloride (NH_4Cl) using a universal pH paper indicator. The result can be seen and compared easily with the list of pH universal colour and showed that the colour obtained was acidic. This video was further explained in the microscopic level video (Figure 3b). The microscopic level was performed with the video shows the dissociation of ammonium chloride salt in the molecular level into ammonium ion (NH_4^+) and chloride ion (Cl^-) and those interactions with the water. Then, ammonium ion reacts with the water to form ammonium hydroxide (NH_4OH) and hydronium ion (H_3O^+) or can be easily explained the formation of ammonia (NH_3) and hydrogen ion (H^+). However, the chloride ion is stable in the water. The hydrogen ion obtained from the reaction ion ammonium ion in the water created the solution acidic. This information was well explained at the symbolic level (Figure 3c). The calculation of the acidity degree is presented in Figure 3d. The acidity of the solution depends on the base dissociation constant (Kb) of ammonia.

The media also shows the video with three representative level chemistry of the base and neutral salts. Figure 4a shows the molecular explanation of basic salt of sodium acetate/CH_3COONa that is the representation of the microscopic level. It shows that the sodium acetate dissociates into sodium ion (Na^+) and acetate ion (CH_3COO^+). In the water, the sodium ion is stable. It is different from acetate ion which can react with the water to form acetic acid and hydroxide ion (OH^-). This condition makes the salt solution alkaline.

The salt composed of strong acid and base will produce neutral salt. The macroscopic level video (Figure 4b) shows the test of salt solution with universal pH indicators. Colour changes showed the solution was in neutral condition or pH 7. It was explained that the condition because sodium chloride salt (NaCl) decomposes in the water into sodium ion (Na^+) and chloride ion (Cl^-). Those ions do not react with the water and make the pH neutral.

Three levels representative of salt hydrolysis composed of weak acid and base is also available in the media. The symbolic level of salt formed of weak acid and base (Figure 4c) was explained by decomposing ammonium acetate (CH_3COONH_4) in the water. Its decomposition produces ammonium ion (NH_4^+) and acetate ion ($CH3COO^-$), which further react with water. Ammonium ion as a weak base reacts with the water to form ammonium hydroxide (NH_4OH) and hydronium ion (H_3O^+). While acetate ion as a weak acid form acetate acid (CH_3COOH) and hydroxide ion (OH^-) in the water. The acidity of the salt composed of weak acid and weak base is determined by the value of base dissociation constant (Kb) of weak base and the value of acid dissociation constant (Ka) of weak acid. If Ka is higher than Kb, the solution will be acid and vice versa.

3.5 Expert Validation and Product Assessment

Prior to assessing the product by five chemistry teachers and the response of ten senior high school students, the media was validated by two experts, a media and a concept expert. This process was done to ensure the product fulfils the media criteria to use for learning media and the content is in accordance with the salt hydrolysis material for senior high school students.

Both experts confirmed that the media met the validation points. The concept expert confirmed the media fulfil content eligibility, material presentation, language aspect, and integration of three levels of chemical representation. The media expert ascertained the developed media perform module aspect, interactivity-navigation-feedback, screen design, android application, and interactive multimedia aspect.

The response of the product quality assessment was carried out by five senior high school chemistry teachers (Table 3). The teacher response data obtained an average total score of 45.5 from a maximum score of 52 and an ideal percentage of 87.5% or in the very good category. Further assessment was studied to limited ten senior high school students. The response to the product assessment was carried out limitedly by ten students at Sekolah Menengah Atas Negeri (State Senior High School) 1 Panggang, Yogyakarta, Indonesia. The student response results obtained an average total score of 233 from a maximum score of 280 and with an ideal percentage of 83.0% or in the Very Good category (Table 4). According to these results, the Android module learning media product deserves to be tested extensively. The media freely access on http://s.id/modulhidrolisis-garam.

3.6 Comparison to Previous Research

Previous research on learning media development on salt hydrolysis material had been executed (Table 5). Julia et al. (2016) developed the printed module of salt hydrolysis material containing multiple representation chemistry. However, it is printed-based media. The printed module was not interactive and could cause students to get bored easily (Delpech, 2010).

Ditama, Saputro, Saputro, and Nugroho (2015) developed salt hydrolysis learning media in the form of adobe flash media. However, the developed media only worked on computers or laptops. It makes the product was inconvenient to use. Also, the media of Ditama, Saputro, Saputro, and Nugroho (2015) is absent of three chemical level representations of chemistry.

Both media of Aliyah et al. (2018) and Retno, Saputro, and Utami (2015) were lack of three chemical representations. Also, both media are hard file-based media which is not convenient to carry. It proves this work successfully developed an interactive media containing three chemical representation levels on the material of salt hydrolysis. This study shows that this media has succeeded in closing a significant gap in the need for interactive chemistry learning media containing three levels of chemical representation.

Table 3. Product Assessment by Five Chemistry Teachers in Senior High Schools

Aspect	Total Score	Ideal maximum score	Ideal percentage	Category
Module aspects	28	32	87.5	Very good
Android application aspects	10	12	83.3	Very good
Interactive multimedia aspects	3.8	4	95.0	Very good
Integration aspects of three levels of chemical representation	3.6	4	90.0	Very good
Total percentage	45.4	52	87.5	Very good

Table 4. Product Assessment by Ten Students in Senior High Schools

Aspect	Total Score	Ideal Maximum Score	Ideal Percentage	Category
Module aspects	99	120	82.5	Very good
Android application aspects	102	120	85.0	Very good
Interactive multimedia aspects	32	40	80.0	Very good
Total percentage	233	280	83.0	Very good

Table 5. A Comparison of Media Development on Hydrolysis Material

Learning Media Type	Three Chemical Representation Levels	Category		Reference
		Teacher	Student	
Android	Available	Very good	Very good	This work
Printed Module	Available	-	Very good	(Julia et al., 2016)
Adobe Flash	Not available	Very good	Very good	(Ditama et al., 2015)
Concept Map	Not available	-	Very good	(Aliyah et al., 2018)
Bulletin	Not available	Good	Very good	(Retno et al., 2015)

4. Conclusion

The study successfully developed the interactive Android module containing three chemical representation levels in the salt hydrolysis material. The interactive android module contains macroscopic, microscopic, and symbolic levels in salt hydrolysis material through the video in the android module. The product is feasible with the quality of very good category.

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