Research Article

Development and Validation of a Virtual Test Based on Three Level Chemical Representation to Measure Student Understanding of Hydrolysis of Salt

Dian Mayangsari, Nahadi *, Harry Firman

Department of Chemistry Education, Universitas Pendidikan IndonesiaJl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia

ORCID
Nahadi: https://orcid.org/0000-0002-0975-7419
Harry Firman: https://orcid.org/0000-0001-7743-4729

Abstract.
This study aimed to develop and validate virtual tests based on three levels of chemical representation that can measure students' understanding of salt hydrolysis. This study used development and validation methods, which consisted of 4 phases. First, the determination of the purpose and the scope of the test. Second, the development and design of the test Third. The validation, selection of items and scoring guidelines. Lastly, the assembly and evaluation of the test. The instruments used were a content validation sheet for experts to judge and an interview sheet for students. The participants were 11th grade senior high school students from three different schools in Karawang with 60 total respondents, and six of them were interviewed. The results showed that the virtual test containing 33 multiple choice items was valid with the Content Validity Index (CVI) value for macroscopic, submicroscopic, and symbolic level items being 1. The Virtual test was also reliable, with Cronbach's alpha value for macroscopic, submicroscopic, and symbolic level items, respectively, being 0.605, 0.614 and 0.644. The results of this research can be used to measure students' understanding of hydrolysis of salt based on three-level chemical representation.

Keywords: virtual tests, chemical representation, salt hydrolysis

Corresponding Author: Nahadi; email: Email: nahadi@upi.edu

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1. INTRODUCTION

One of the goals of chemistry learning in high school is that students are able to understanding the basic concepts of chemistry [1]. Mastery of concepts is necessary and becomes one of the main focuses of learning [2]. Concepts in chemistry are presented in three levels of chemical representation consisting of macroscopic, submicroscopic, and symbolic representations. Macroscopic is an aspect that explains phenomena that can be observed in everyday life. Submicroscopic is an aspect that describes the level of abstract particles. Symbolic representation is an aspect that includes all kinds of signs to represent concepts and ideas in chemistry [3]. The three levels of chemical representation are interrelated in the process of developing chemical concepts [4].

One of chemical concepts involving three levels of chemical representation is salt hydrolysis [5]. Mastery of the concepts of salt hydrolysis is interesting to study because this material is hard for students to understand [6]. Salt hydrolysis is abstract and complex because it relates to other materials, namely acid-bases [7]. To measure the mastery of the concept of salt hydrolysis based on three levels of chemical representation, an assessment tool is needed that can measure the ability. In schools, the teaching and study of the concept of salt hydrolysis generally emphasize more on macroscopic and symbolic aspect [8]. Students who can solve mathematical problems are considered to have mastered the concept of salt hydrolysis. There is a difference between understanding the concept and algorithmic problem-solving [2]. Such an assessment will give results that are not optimal because the picture of mastery of the concept of intact salt hydrolysis has not been achieved.

Research on the development of three-level chemical representation test instruments has been carried out, among others, on electrolyte and non-electrolyte solution materials [9], and buffer solutions [10]. The test instruments used are multiple choice and essays using paper known as Paper Based Tests (PBT). PBT has disadvantages such as limited the form of display is only two limited dimensions, processing results that take a long time, cost a lot and spend much paper [11]. One of the innovations that can be done to overcome these problems is to use virtual test with an online system.

A virtual test is a test that uses software that can load multimedia such as images, text, graphics, diagrams, animations, and videos [12]. The use of visual forms in the test can support the display of chemical representations, help students understand the statement items presented, and make the test more interactive [13]. Online testing is commonly used in the era of the Industrial Revolution 4.0 (4IR) that involving the technology virtually [14]. Online tests have several advantages, including being more practical, reducing paper use, saving time, saving costs, and also the test results can be known directly for the feedback [15]. Online testing is also an effective solution during the Covid-19 pandemic currently sweeping the world of education. During the pandemic, the government implemented a physical distancing policy that requires students to learn from home. The implementation of distance learning is possible and facilitated by the internet network [16]. Based on the description above, researchers feel the need to develop an online virtual test based on three levels of chemical representation that can measure student's concept mastery on hydrolysis of salt.

2. RESEARCH METHOD

This study uses development and validation methods that aim to produce a virtual test that can measure students' conceptual mastery of the salt hydrolysis [17]. The instruments used content validation sheet, and student interview sheet. The stages of research conducted are as follows: 1) Determination of the purpose and scope of the test; 2) Development (design) of the test: the preparation of a virtual test grid on the salt hydrolysis; 3) Validation test by five experts judgement, selection of items and scoring guidelines; 4) Assembly and evaluation of tests: making virtual tests based on valid items using class marker software, then conduct trials to students at XI grade as many as 60 people from 3 different schools in Karawang. The data in this study include the specification of the test, content validity, reliability and the student's response to virtual test developed. Validation results were calculated using the CVR (Content Validity Ratio) that proposed by Lawshe. According to Lawshe, when the validator consists of five members, the minimum CVR value for the item that can be said to be valid is 0.99 [18]. After calculating the CVR value for each item, then the CVI (Content Validity Index) is calculated, which is the average value of the overall CVR of the items that have been valid. Reliability test using Cronbach's Alpha formula with interpretation from Sujarweni [19].

3. RESULTs AND DISCUSSION

The first stage of this research is to determine the purpose and scope of the test conducted by tracing the Core Competencies and Basic Competencies of salt hydrolysis materials in class XI chemistry subjects based on the 2013 Indonesian Curriculum. The basic competencies are as follows: 3.11 Analyze the balance of ions in a saline solution and calculate its pH [20]. Furthermore, to limit the scope of the test, the basic competencies are reduced to several indicators that have been adjusted to the sub-material hydrolysis of salts and the type of level of chemical representation. The second stage of the research is to arrange a virtual test grid that becomes the test specification. The virtual test grid mastery of the concept of salt hydrolysis based on three levels of chemical representation can be seen in Table 1.

Based on Table 1, the indicators are divided into three sub-materials, namely: type of salt hydrolysis, properties of salt solution and pH of the salt solution. There are 20 indicators made into 54 multiple choice items consisting of 18 macroscopic level items,

TABLE 1: Grid of chemical representation instruments for salt hydrolysis materials.

Sub-Material of Salt Hydrolysis	Level of Chemical Representation	Indicator	Item Number
Types of salt hydrolysis	Macroscopic	analyze the type of salt hydrolysis based on the data and the experimental results presented.	1-6
	Sub-microscopic	identify the type of salt that undergoes hydrolysis based on the submicroscopic video presented.	7-9
		represent the type of salt information presented in submicroscopic images.	10-12
	Symbolic	classify several salt solutions that undergo certain types of hydrolysis based on the data on acids and bases that form the salts presented.	13-15
		determine the hydrolysis reaction equation based on the information on the type of salt presented.	16-18
Properties of salt solutions	Macroscopic	predict the experimental results of salt solution properties based on the salt information presented.	19-21
		classify some salt solutions according to the properties of the salt correctly based on the experimental results presented.	22-23
		check the experimental results according to the nature of the salt solution correctly based on the experimental results presented.	24
	Sub-microscopic	giving example of salt solutions based on information on the properties of salts that undergo appropriate hydrolysis in the presented submicroscopic's video.	25-27
		identify the nature of the salt that undergoes hydrolysis based on the presented submicroscopic's images.	28-29
		rank the basicities of several salt solutions based on the submicroscopic's images presented.	30
	Symbolic	classify some salt solutions according to the properties of the salt based on the reaction equations presented.	31-32
		rank the acid strength of several salt solutions based on the data on the values of K_a and K_b presented.	33
		classify some salt solutions according to the properties of the salt based on the reaction equations presented.	34-36
pH of salt solution	Macroscopic	predicting the pH value of a salt solution based on the experimental results presented.	37-39
		check the experimental results of the pH test of several salt solutions according to the salt solution.	40-42
	Sub-microscopic	analyze the effect of salt solution concentration on the pH value of the salt solution based on the submicroscopic video presented.	43-44
		predict the pH value of the salt solution based on the submicroscopic images presented.	45-48
	Symbolic	determine pairs of equations for the hydrolysis reaction of salt and measure its pH value based on the data on the K_a and K_b values presented.	49-51
		calculate the pH of a salt solution accurately based on the data on the mass of salt, volume, and the value of K_a or K_b presented.	52-54

18 submicroscopic level items, and 18 symbolic level items. The indicators used include cognitive levels C1 to C5 according to the classification of Anderson and Krathwohl [21].

The next stage is the validation test. Two aspects are assessed, namely the suitability of the indicator with the items and the suitability of the aspect of chemical representation with the items. In the validation process there are indicators that are changed according to the validator's suggestion, namely the indicator for calculating pH at numbers 52-54 is replaced with the same indicator as used for numbers 49-51. The indicators of counting are not part of the representation of a concept. As Holme said, there is difference between understanding the concept and algorithmic problem-solving [2]. When the validator consists of five members, the minimum CVR value for the item that can be said to be valid is 0.99 [18]. Recapitulation of CVR value for each chemical sub-representation can be observed in Table 2.

Table 2: Recapitulation of CVR values for each chemical sub-representation.

Macroscopic Level Items		**Submicroscopic Level Items**		**Simbolic Level Items**	
Item Number	**CVR**	**Item Number**	**CVR**	**Item Number**	**CVR**
1	1	7	1	13	1
2	1	8	1	14	1
3	1	9	1	15	1
4	1	10	1	16	1
5	1	11	1	17	1
6	-0.2	12	0.6	18	1
19	1	25	1	31	1
20	1	26	1	32	1
21	1	27	1	33	0.6
22	1	28	1	34	1
23	1	29	1	35	1
24	0.6	30	0.6	36	1
37	1	43	1	49	1
38	1	44	1	50	1
39	1	45	1	51	1
40	1	46	1	52	1
41	1	47	1	53	1
42	1	48	1	54	0.2
CVI	1	CVI	1	CVI	1

Based on Table 2, the CVR values of 54 items are in the range of -0.2 to 1. In each sub-representation, there are 16 valid items because they have a CVR value of more than 0.99, namely 1, and 2 items are invalid because they have a CVR value of less than 0.99. In macroscopic items, the 2 invalid items are numbers 6 and 24 which have CVR values respectively -0.2 and 0.6. In submicroscopic items, the 2 invalid items are numbers 12 and 30 which have CVR values of 0.6. In symbolic items, the 2 invalid items are numbers 33 and 54 which have CVR values respectively 0.6 and 0.2. The CVI value for macroscopic, submicroscopic, and symbolic level items is 1. The valid items indicate that the items are in accordance with the indicators to measure student's concept mastery [12]. The researchers selected 48 items to 45 items to make the total items at each level of chemical representation equal. Items number 15, 42 and 46 are discarded because these types of questions were already represented by other numbers. So, the instrument consists of 15 macroscopic level items, 15 submicroscopic level items and 15 symbolic level items.

The valid items are converted into virtual test forms. For Illustrator used CC 2019, video animation used Ms. Power Point recorded by Powersport Screen Recorder, then digitizing the problem using class marker software. Display of virtual test items can be seen in Figure 1.

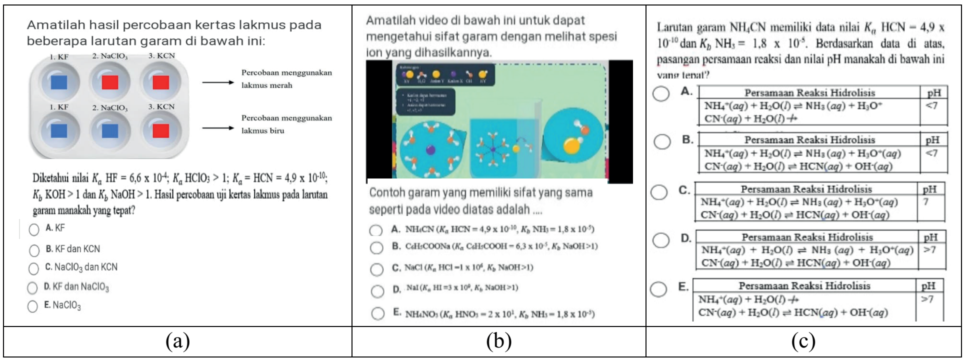

Figure 1: Display of virtual test items, a) macroscopic level item, b) submicroscopic level item, c) symbolic level item.

Figure 1 (a) is an example of a macroscopic level item; students are asked to check which experimental results are correct. Figure 1(b) is an example of a submicroscopic level item that presents a molecular video related to the reactions that occur in particles in solution. Students are asked to give an example of a salt solution that has the same properties as the information in the video. Figure 1(c) is an example of a symbolic level item; students are asked to determine pairs of equations for the hydrolysis reaction of salt and estimate its pH value based on the data on the K_a and K_b values presented.

After the virtual test form is finished, a trial is carried out for students to evaluate the test reliability value. Before determining the reliability value, first determine the validity value based on the results of field trials using Pearson correlation in SPSS 26. The basis for decision making in the validity test is, if the value of r count > r table, the item is declared valid and if the value of r count < r table, the item is declared invalid. The value of r table for 60 respondents is 0.254 [19]. Recapitulation of Pearson correlation values for each chemical sub-representation can be observed in Table 3.

Table 3: Recapitulation of Pearson Correlation values for each chemical sub-representation.

Macroscopic Level Item			Submicroscopic Level Item			Symbolic Level Item		
Item Number	Pearson Correlation	Criteria	Item Number	Pearson Correlation	Criteria	Item Number	Pearson Correlation	Criteria
1	0.382	Valid	6	0.325	Valid	11	0.297	Valid
2	0.384	Valid	7	0.255	Valid	12	0.274	Valid
3	0.335	Valid	8	0.350	Valid	13	0.209	Invalid
4	0.007	Invalid	9	0.436	Valid	14	0.429	Valid
5	0.407	Valid	10	0.185	Invalid	15	0.470	Valid
16	0.082	Invalid	21	0.274	Valid	26	0.436	Valid
17	0.295	Valid	22	0.444	Valid	27	0.395	Valid
18	0.264	Valid	23	0.355	Valid	28	0.489	Valid
19	0.430	Valid	24	0.355	Valid	29	0.473	Valid
20	0.128	Invalid	25	0.469	Valid	30	0.448	Valid
31	0.569	Valid	36	0.162	Invalid	41	0.214	Invalid
32	0.527	Valid	37	0.180	Invalid	42	0.167	Invalid
33	0.362	Valid	38	0.386	Valid	43	0.107	Invalid
34	0.153	Invalid	39	0.159	Invalid	44	0.351	Valid
35	0.277	Valid	40	0.301	Valid	45	0.255	Valid

Based on Table 3, in each sub-representation there are 4 items that are invalid because they have an r count of less than 0.254. The invalid items are numbers 4, 16, 20 and 34 at the macroscopic level, numbers 10, 36, 37, 39 at the submicroscopic level and numbers 13, 41, 42 and 43 at the symbolic level.

To determine reliability, in calculating the Cronbach Alpha value, invalid items are not entered into the data. According to interpretation of Sujarweni, an item is said to be reliable if it has a Cronbach alpha value of more than 0.6. The calculation of the Cronbach alpha value for each chemical sub-representation using SPSS 26 can be observed in Table 4.

Table 4: Recapitulation of Cronbach's Alpha values for each chemical sub-representation.

Macroscopic Level Items		Submicroscopic Level Items		Symbolic Level Items	
Reliability Statistics		Reliability Statistics		Reliability Statistics	
Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
0.605	11	0.614	11	0.644	11
Reliable category		Reliable category		Reliable category	

Based on the Cronbach's Alpha value on Table 4, using the interpretation of Sujarweni, it is known that the virtual test consisting of 11 macroscopic level items, 11 submicroscopic level items and 11 symbolic level items is reliable. It means that the test items that have been developed have a consistency in measuring the mastery of student concepts. When tested on other students with the same conditions produce the same information or close to the same [19].

Interviews of student responses to the virtual test developed were carried out as supporting data in this study. The virtual tests received a positive response from students. The students said that the virtual tests are easy to operate, this is one of the advantages of the online exam system [22]. Then, according to students, virtual tests have an attractive appearance that can minimize stress levels when students read the questions. This is in line with other studies which state that computer or mobile based assessment design provides stress and anxiety reduction [23]. Students also feel that the virtual test can make students easier to understand the subject of the question test. This is because multimedia such as images, videos and animations in virtual test that can build good visualization especially at the molecular level [24].

4. CONCLUSION

The virtual tests developed consist of 33 multiple choice type items (11 macroscopic items, 11 sub microscopic items and 11 symbolic items) which has specific characteristic that is to adjust the indicator of mastery of the salt hydrolysis concept with three levels of chemical representation. The results showed that the virtual test developed was a valid and reliable. The results of the interviews showed that the virtual test got a positive response from students in terms of ease of operation, appearance, grammar, benefits and effectiveness.

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