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Development of Structured Essay Diagnostic Test of Chemistry (SEDToC) to Investigate Senior High School Student's Misconception of Hidrolisis Material

Farhan Febly[1], Zonalia Fitriza*[1]

Departement of Chemistry, Universitas Negeri Padang
Padang, Indonesia

Abstract — Research from various sources proves that the number of students' misconceptions about hydrolysis material is still high, with a minimum number of 23% spread across all concepts related to hydrolysis material. Various diagnostic tests have been developed, but the diagnosis can be biased cause risk of guessing remains and sometimes inconclusive. Developed in the form of an open essay diagnostic test that does not allow guesswork, but the analysis takes a long time. SEDToC is an instrument to investigate students' understanding of chemical concepts. Students' answers were more focused and structured by structured essay. Each question requires a limited answer to a certain concept so that it is easier to analyze. The purpose of study was to identify the misconceptions of students in Hydrolysis Chemistry Learning using Structured Essay Diagnostic Test of Chemistry (SEDToC), this type of research is research and development (R&D) consists of three main stages Defining the content, Obtaining information about students' misconceptions and developing a Diagnostic Test. This diagnostic instrument is valid and has a reliability of 0.92 of cronbach alpha reliability. The results of this study indicate that there are misconceptions of each indicator. Criteria for students' misconceptions, they are still included in the low category. The average percentage of students who understand is 64%, misconceptions are 16%, and 23% not understand.

Keywords—Misconception; Hydrolysis; SEDToC Test; Diagnostic test; Structured Essay.

I. INTRODUCTION

Thinking processes that come from the wrong prerequisite knowledge will cause misconceptions in students, because initial knowledge is the provision of students to develop and understand more complex knowledge. [1]. Misconceptions will hinder learning abilities and interfere with the absorption of students so that it is difficult to master further concepts from the material in question [2]. Salt hydrolysis is one of the materials considered difficult by most students. Based on the identification of high school chemistry materials that are difficult in the view of teachers and prospective teachers of hydrolysis chemistry is one of them [3]. Only a small number of students have succeeded in achieving the minimum completeness criteria ([4] [5]), indicated by the low results of the National Examination [6]. Research from various sources proves that the low value of students is caused by students' misconceptions about hydrolysis material, with a minimum number of 23% spread over all concepts related to hydrolysis material. ([7] [8] [9]) only a small percentage of students understand the concept of hydrolysis, even 9.36% of students guess the answer [10].

Identification of misconceptions in students is one step to overcome misconceptions [2]. Prerequisite material relates to more complex material. Students must be able to relate the new knowledge they want to understand with their prior knowledge [1].

Corresponding Author: Zonalia Fitriza

Information regarding students' conceptual understanding can be generated through diagnostic tests, so that they can help identify students who have learning difficulties [1].

Various diagnostic tests have been developed and the most popular is the two-level multiple-choice diagnostic test because the evaluation results of multiple-choice diagnostic tests are easy to assess, administer, easy to obtain validity and reliability. However, this causes the diagnosis to be biased and sometimes inconclusive [11] multiple choice instruments cannot represent the expected identification [12]. Although the subsequent three-tier and four-tier multiple choice was developed with added confidence levels, the risk of guessing remains [10]. This test has also been developed in the form of an open essay diagnostic test that does not allow guesswork, that is students write and think about their own understanding, but the analysis takes a long time [11].

SEDToC is an instrument to investigate students' understanding of chemical concepts, in this study it is about hydrolysis material. SEDToC questions are structured from basic concepts to more complex concepts. The structured essay test was chosen because students' answers were more focused and structured. Each question requires a limited answer to a certain concept so that it is easier to analyze [13]. Thus, SEDToC can find out students' understanding of concepts and misconceptions about hydrolysis. SEDToC investigates concepts that cause misconceptions and thus hinder conceptual knowledge. learners. Thus, through this SEDToC, teachers can identify students' misconceptions well.

II. METODOLOGY

The research conducted is a type of research and development (R&D). To be able to produce products that are needs analysis, the effectiveness of the product needs to be tested by experimentation [14]. The research method used by the author is to use the diagnostic test method [15] modified by [13] with the final result in the form of a Structured Essay Diagnostic Test of Chemistry (SEDToC). This method consists of 3 general stages: Defining the content, obtaining information about students' misconceptions, Developing a Diagnostic Test. A description of the activities carried out at each stage is as follows:

1. Defining the Content

   Has four steps:

   a. Indentifying propositional knowledge statements: Basic competency analysis including concepts related to hydrolysis based on Indonesian curriculum (crucial concepts).

   b. Developing a concept map: Make a concept map with a proportional statement, concurrently with the concepts that exist in the hydrolysis material.

   c. Relating propositional knowledge to the concept: adjustment of curriculum analysis with concept maps, to ensure appropriate instruments.

   d. Validating the content: validation by lecturers and chemistry teachers about proportional statements and concept maps.

2. Obtaining Information About Students Misconceptions

   a. Examining related literature: In the form of journal analysis related to misconceptions of concepts related to hydrolysis material

3. Developing a Diagnostic Test

   Developing a Diagnostic Test consists of three steps:

   a. Developing Structured Essay Diagnostic Test of Chemistry: Develop a test with the topic of Hydrolysis based on a validated propositional report. the instrument is arranged hierarchically from questions to identify basic concepts and sequenced so that the answer to the previous question becomes a prerequisite for the next question.

   b. Designing a specification grid: Linking the grid and questions is also related to the demands of KD (level of knowledge) based on the curriculum. Includes all prepositional and concept statements in the concept map.

   c. Continuing refinements: Some of the trials carried out in this step are

1) Validition of SEDToC
2) Reliability
3) Difficulty index and discrimination index

This study uses data collection methods with literature studies, tests, non-tests (questionnaires/questionnaires). The instruments used in this research are Literature Study Instruments, Validation Instruments and Test Questions. Furthermore, the data processing techniques of this research are in the form of validity tests, reliability tests, difficulty index and discrimination index.

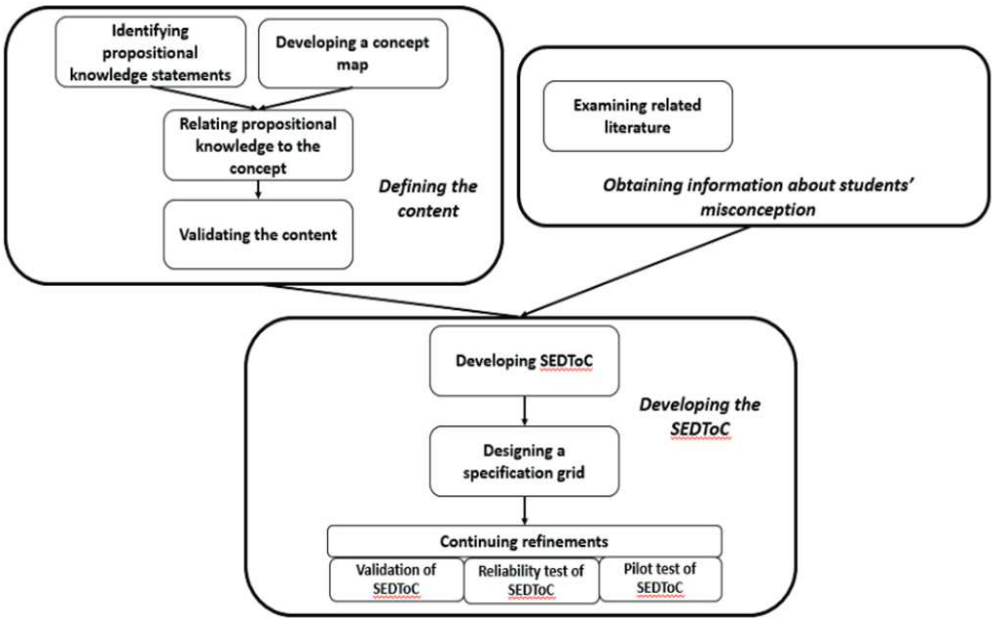

Figure 1. Development Method of SEDToC

III. RESULT AND DISCUSSION

First step, in the first stage there are 12 concepts identified in the hydrolysis material, 9 prerequisite concepts identified in the acid-base solution material, 3 prerequisite concepts identified in the solution reaction equation material and 7 prerequisite concepts identified in the stoichiometric material. The propositional statements of all categories are presented in table 1. Second, develop a concept map based on propositional knowledge statements. Starting with analyzing concepts and arranging hierarchically from the concept of hydrolysis to the concept of stoichiometry. There are 32 concepts identified from concepts derived from stoichiometry to hydrolysis as described in table 1. All concepts contained in the hydrolysis material are arranged in a hierarchy where the concepts in the hydrolysis material are in the initial hierarchy, prerequisite concept 1 (acid-base) is in the hierarchy after the concepts of hydrolysis material, prerequisite 2 (solution reaction equation) is in the hierarchy after the concept of prerequisite 1 and so on until the stoichiometric material. Third, the existence of a concept map needs to be ensured that all propositional statements involved are within the scope of the concept map. Last, propositional statements and concept maps were validated by three chemistry lecturers and two teachers. So that the final results of propositional statements and concept maps are influenced by the validator's suggestions.

Second stage, SEDToC is influenced by the analysis of literature related to the level of misconceptions of concepts related to hydrolysis material which concludes that there are students' difficulties in understanding concepts related to hydrolysis. The conclusion from the examination of literature that students have misconceptions in the topic of hydrolysis is to relate the understanding of acid and base according to experts, determine acids and bases, relate scientific knowledge to their own knowledge, understand scientific language in chemistry, use pH determination calculations, show submicroscopic descriptions

of salts in chemistry. Water and relate the effects of Ka, Kb, volume, and concentration on the salt solution ([7],[9],[16], [17], [18], [19], [20], [10], [8], [21]).

The results from both stages are used to develop a chemical structured essay diagnostic test. This test consists of 5 questions with a total of 18 questions about hydrolysis material. The questions are arranged from the basic concept of hydrolysis prerequisites, namely stoichiometry 4 questions, then followed by a reaction equation for 2 questions, acid and base reactions 4 questions and 8 questions for hydrolysis material consisting of 4 questions for GPA 3.11.1 and 4 questions for GPA 3.11.2 An example of the SEDToC set for an acid buffer solution is presented in Figure 2.

Table 1. Pengetahuan Proposisional Materi Hidrolisis

Hydrolysis Material	**Prerequisite Concept 1**	**Prerequisite Concept 2**	**Prerequisite Concept 3**
IPK 3.11.1 **1.** Hydrolysis is a reaction process of anions or cations of a salt, or both with water [22] 2. Hidrolisis total yakni sifat keseluruhan larutan bergantung pada kekuatan asam relatif atau kekuatan basa dari ion yang dipisahkan [23] 3. Partial hydrolysis is a process of partially hydrolyzing a salt by producing a product in the form of anions (OH^-) or cations (H^+) [23] 4. Anion hydrolysis is a salt hydrolysis process that produces anions (OH^-) [22] 5. Cation hydrolysis is a salt hydrolysis process that produces cations (H^+) [22] **IPK 3.11.2** 1. The pH of a solution is defined as the negative logarithm of the hydrogen ion concentration (mol/L) [22]	Acid and Base **Prerequisite 1.1 – 1.5** 1. Weak acids ionize only to a certain extent in water [22] 2. Weak bases, like weak acids, only ionize to a certain extent in water [22] 3. Strong bases ionize completely in water [22] 4. Strong acids are assumed to be completely ionized in water [22] 5. Equilibrium H_2O for small indicated reactions act as acids and bases resulting in a concentration of ions H_3O^+ and OH^- [26] **Prasyarat 2.1 – 2.10**	Solution Reaction Equation **Prerequisite 1.1-1.5** 1. An equilibrium reaction is an equilibrium reaction that involves writing an equation with the same number of each type of atom on both sides [27] 2. Ionization reaction is a reaction that dissolves all ionic substances that dissociate into ions [23] 3. Degree of ionization ability to dissociate separately to produce ions [23].	Stoichiometry **Prasyarat 2.4 - 2.10** 1. The mole is the amount of substance that contains the elementary entities in an atom [27] 2. Molarity is expressed as the amount of solute dissolved in a certain amount of solution [23]

2. pOH is the negative logarithm of concentration OH^- [24] 3. $[H^+]$ concentration of H^+ ions that come from the reaction of an acidic substance with water [25] 4. $[OH^-]$ is the concentration of OH^- ions derived from the reaction of an alkaline substance with water [25] 5. Salts derived from strong bases and strong acids produce neutral solutions (pH=7) [24] 6. A salt of a strong base and a weak acid is dissolved in water, the resulting solution is basic (pH>7) [24] 7. Salt involves the reaction of a strong acid and a weak base, the solution will be acidic (pH<7) [24] **8.** Salts of a weak base and a weak acid are acidic if the acid ionization constant (Ka) is greater than the base ionization constant (Kb) (pH<7) [26] **9.** 9. Salts of a weak base and a weak acid are basic if the acid ionization constant (Ka) is less than the base ionization constant (Kb) (pH>7) [26] **10.** The salt of a weak base and a weak acid are neutral if the acid ionization constant (Ka) is the same as the base ionization constant (Kb) (pH=7) [26].	1. Ka is the equilibrium constant for the ionization of the acid [22] 2. Kb is the equilibrium constant for the base ionization reaction [23] 3. Kw is the ionic equilibrium constant for water [23] 4. Neutralization reaction is a reaction between an acid and a base to produce water and a salt, which is an ionic compound composed of cations other than H^+ and anions OH^- or O^{-2} [22]		3. Volume is a measure of the amount of space content of an object/material [24] 4. Mass is a measure of the amount of content in a material object [24] 5. The atomic mass (relative) is equal to the mass of 1 mole of atoms of the element expressed in grams [23] 6. The molecular mass (relative) is equal to the mass of 1 mole of the compound expressed in grams [23]

1. Calculate the moles of:
   a. 1,6gr NaOH 0,1 M
   b. 50 ml CH_3COOH 0,8 M
   c. 200 ml H_2SO_4 0,2 M
   d. 5gr AgOH 0,4 M

   Ar H=1, O=16, Na=23, Ag=108
2. Write down
   a. Ionization reaction of the following compounds, based on moles in problem no 1

$$NaOH_{(aq)} \xrightarrow{H_2O_{(l)}} \text{----} + \text{----}$$

Mole ---- ---- ----

$$H_2SO_{4(aq)} \xrightarrow{H_2O_{(l)}} \text{----} + \text{----}$$

Mole ---- --- ----

Equilibrium reaction of the following compounds, based on moles in problem no 1:
diet: degree of ionization of acid/base = α

$$CH_3COOH_{(aq)} \overset{H_2O_{(l)}}{\rightleftharpoons} \text{----} + \text{----}$$

mole before rx	a		
mole rx	aα	aα	aα
mole after rx	(a − aα)	aα	aα

$$AgOH_{(aq)} \overset{H_2O_{(l)}}{\rightleftharpoons} \text{----} + \text{----}$$

mole before rx	a		
mole rx	aα	aα	aα
mole after rx	(a − aα)	aα	aα

3. Based on the acidic and basic compounds in problem no (1 and 2), calculate moles before reaction and moles after reaction from the neutralization reaction between :
   a. Strong base compound and ½ moles of strong acid compound
   b. Weak bases and ½ moles of strong acids
   c. Strong bases and weak acids
   d. Weak bases and weak acids
4. Based on the reaction in problem 3 (a, b, c, d), what are the properties and reactions that occur in the solution of the product in water:
   a. Product 3a
      Properties: (acid salt/basic salt/neutral salt)
      The reaction that will occur:

      Product 3a + $H_2O_{(l)} \longrightarrow$ **I** + **J**

      I + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)

      J + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)
   b. Product 3b
      Properties: (acid salt/basic salt/neutral salt)
      The reaction that will occur:

      Product 3b + $H_2O_{(l)} \longrightarrow$ **K** + **L**

      K + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)

      L + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)
   c. Product 3c
      Properties: (acid salt/basic salt/neutral salt)
      The reaction that will occur:

      Product 3c + $H_2O_{(l)} \longrightarrow$ **M** + **N**

      M + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)

      N + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)
   d. Product 3d
      properties: (acid salt/basic salt/neutral salt)
      The reaction that will occur:

      Product 3d + $H_2O_{(l)} \longrightarrow$ **O** + **P**

      O + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)

      P + $H_2O_{(l)} \longrightarrow$ ---- + ---- (hydrolyzed/not hydrolyzed)

5. Based on the properties known in question no 4, what is the correct pH of the salt solution from the above problem (4a, 4b, 4c, 4d) is..
   Ka = 1,75 x 10^{-5}
   Kb = 1,1 x 10^{-4}
   Explain :
   a. pH 4a..!
   b. pH 4b..!
   c. pH 4c..!
   d. pH 4d..!

Figure 2. Example of SEDToC of Hydrolysis Topic

In the developing stage, the validity and reliability of the SEDToC need to be tested because these two things are important for evaluating the measurement of the instrument [28]. Validity focuses on what is measured by an instrument while reliability concerns the certainty obtained from using the instrument. In this study, the measurement of validity using a Guttmann scale questionnaire is in the form of a collection of questions with yes or no answers to obtain one aspect that can be used as a validator [28]. Based on the reliability of Cronbach Alpha SEDToC determined statistically to show the instrument that has been built is feasible for research purposes [29].

SEDToC is valid based on examination by five validators after revisions have been made to several parts of the instrument. There have been several revisions to the SEDToC draft, such as changing compounds to ensure students understand how divalent ions determine the pH value on hydrolysis. In addition, revision of the answer key and also there are typos in some words. A valid SEDToC was given to 20 students of SMAN 1 Lubuk Alung to test the reliability of this diagnostic test. Reliability is determined by comparing Cronbach's Alpha with the minimum Cronbach. The Cronbach Alpha value of SEDToC is 0.92 higher than 0.6 as the minimum cronbach. When higher than 0.6, SEDToC is reliable [29].

The difficulty index of the questions starts from 0 to 1 which is said to be easy if the P value is 0.7, while DI 0.3 < P 0.7, difficult if 0.3 The SEDToC questions on hydrolysis material have an average difficulty index of 0.6 with categories medium. The discrimination index on the average SEDToC question for each item is 0.44 with a good and acceptable category [30].

The valid and reliable SEDToC is ready to be used in investigating student conceptions and finding out their difficulties in understanding the concepts of hydrolysis. In this case, the scoring system is objectively true or false which means that when a student's answer does not match the answer key, the score is 0. However, when the answer is the same as the answer key, the score is 1. A score is assigned to each sub-question at SEDToC. For example, question set 1 on acid buffer solutions consists of 13 questions with question 1 having 5 sub-questions. Each sub-question will score 1 for a correct answer and 0 for an incorrect answer. This assessment will help the tester to identify concepts that are difficult for students to understand and will also identify concepts that cause misconceptions.

Table 2. Contoh penskoran soal SEDToC

No	Question	Scoring	
		Correct	Incorrect
1	Hitunglah Mol dari: Ar H=1, O=16, Na= 23, Ag=108		
	a. 1,6gr NaOH 0,1 M	1	0
	b. 50 ml CH_3COOH 0,8 M	1	0
	c. 200 ml H_2SO_4 0,2 M	1	0
	d. 5gr AgOH 0,4 M	1	0

To see the level of understanding of students on hydrolysis material and prerequisite concepts, students are grouped into the categories of Not Understanding Concepts (NU), Misconceptions (M) and Understanding Concepts (UC) [31], then the percentage of students' level of understanding on each indicator can be obtained. The results of this study indicate that there are misconceptions of each indicator. Criteria for students' misconceptions, they are still included in the low category. The average percentage of students who understand is 64%, misconceptions are 16%, and 23% not understand**.** The achievement of hydrolysis material competence and prerequisite concepts is shown in Table 3 as follows.

Table 3. Percentage of Students' Understanding of the Indicators of Achieving Competency in Hydrolysis Material and Prerequisite Concepts

Indicator of Achievement of Hydrolysis Material Competence and Prerequisite Concept		Question Number	NU	M	UC	Criteria
			Percentage			
Stoichiometry		1	0,0	3,0	98,0	Low
Equation Solution Reaction		2	0,0	18,0	83,0	Low
Acid-Base		3	10,0	10	73,0	Low
3.11. Analyze ions in salt solution and relate their pH	3.11.1 Analyzing the ionic balance in a salt solution	4	45	8	48	Low
	3.11.2 Analyze the relationship between pH and ionic equilibrium in a salt solution	5	60	19	20	Low
	average		23	12	64	

IV. CONCLUSION

SEDToC is an instrument to determine students' understanding of chemical concepts, in this research it is about hydrolysis. SEDToC questions are arranged from basic concepts to more complex concepts, namely hydrolysis material. Several prerequisite concepts such as stoichiometric material, chemical equations, acids and bases are involved in this instrument. As a good instrument, this test has met the criteria of validity and reliability. In addition, the have difficulty index of 0.6 with medium categories and the discrimination index on the average SEDToC question for each item is 0.44 with a good and acceptable category. An objective scoring system will help examiners to check students' conceptions. Using SEDToC test we get criteria for students' misconceptions, they are still included in the low category. The average percentage of students who understand is 64%, misconceptions are 16%, and 23% not understand.

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