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Analisys of Chemical Misconceptions of Stoichiometry Materials Using Certainty of Response Index

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Abstract

The 2013 curriculum emphasizes students to understand and appreciate how to get a concept so that understanding concepts in chemistry learning is needed to master the material as a whole. The purpose of this study was to analyze students' misconceptions using the Certainty of Response Index (CRI) on the stoichiometric material. This research is a pre-experimental research with one group pre-test post-test design. The population in this study were all students of class X MIPA SMA N 1 Demak with a research sample consisting of 35 students conducted by purposive sampling technique. Data collection techniques using 20 multiple choice diagnostic test questions are reasonable. The stages of data analysis are processing and analyzing student answers and determining whether students understand the concept, misconception or do not understand the concept by looking at the conformity with the confidence level index (Certainty of Response Index). Misconceptions are still found in all stoichiometric concepts, which include indicators of the basic laws of chemistry at the pretest of 30.5% (medium)-posttest 22.5% (low), the indicator of relative atomic/molecular mass and the concept of mole pretest 35.5% (moderate) and posttest 22.72 (moderate), and the calculation of the limiting reagent stoichiometry at the pretest was 31.70% (medium) and the pretest was 22.72 (low).

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INTRODUCTION

Chemistry plays an important role in people's lives because humans every day cannot be separated from chemical substances. Chemistry belongs to the natural sciences (IPA) group, which studies the specific symptoms that occur in substances and everything related to substances composition, structure and properties, transformation, dynamics and energetics of substances. Chemical science learns about knowledge in the form of theories, concepts, principles, rules, facts, descriptions, chemical intelligence and also the process of discovery (Ministry of Education, 2008). The material presented in chemistry learning is loaded with complex concepts and is partly considered abstract, so a correct understanding of the basic concepts that build the concept is needed (Pine et al., 2001); (Monita & Suharto, 2016). Many chemistry concepts must be absorbed and understood by students in such a short period of time that most students consider chemistry lessons to be difficult lessons. As a result, students who consider this, are less successful in learning to understand chemical concepts and have difficulty in associating one concept with another concept that has a complete and correct relationship (Utami & Wulandari, 2016).

The results of observations that have been made at three State High Schools Demak class XI IPA are known that the learning outcomes of stoichiometric concept students are still low. This is indicated by many students' daily repeat grades from the 2014/2015–2017/2018 school year cannot achieve classical completion. Some of the difficulties experienced by students are abstract nature of chemistry, concepts learned very much, concepts that one is a prerequisite for the next concept, and low ability of students in mathematical operations. Students in general tend to learn by memorization rather than understanding the concept of the material. This causes most of the concepts of chemistry lessons to become abstract concepts for students, so that students do not have an understanding of chemical concepts that are of a nature. At the beginning they studied chemistry.

Students who have not achieved class compliance in school are given the opportunity by teachers to participate in the remedial program. Remedial program is carried out so that the students concerned can achieve classical completion. The observation results showed that the remedial program carried out by teachers on students who had not achieved classical completion was carried out by providing repeat questions to be done. The problem given is similar to the previous replay question, it's just that some teachers replace it with different numbers for calculation questions and change concept questions. Students are given the opportunity to study independently for some time before working on the replay question again.

In the study (Lestari et al., 2021), a review and compiled a literature containing misconceptions that had been researched by previous researchers on the concept of chemical bonds. Research that has been done Ozmen (2004) successfully reviewed the research of misconception on the concept of chemical bonds that had previously been done by other researchers. The review began research into misconceptions from 1978 by Wheeler & Kass, to 2003 by Ozmen & Ayas. The concept of chemical bonding is one of the concepts that often cause misconceptions in students and is a precondition concept for later concepts (Hughes et al., 2013);(Vrabec & Prokša, 2016). According to (Patil et al., 2019), educators need to know the misconceptions experienced by their students in order to make efforts to correct misconceptions. This can give direction to educators to do learning well so that student learning outcomes are more optimal. Therefore, Salirawati & Wiyarsi (2012) conducted instrument development research to detect the presence of chemical misconceptions, especially the concept of chemical bonds in students. (Usu et al., 2019) said that most students have the motivation to learn to be able to do national exam questions quickly without understanding the concepts of the subjects tested on the National Exam. In addition, most educators will change their teaching methods by emphasizing to students how to answer National Exam

questions instantly. Thus it will cause errors of concept or commonly called misconceptions, especially misconceptions in students to the subjects tested in the National Examination, especially chemistry subjects. According to (Rahmawati et al., 2019) there should be an analysis of misconceptions in students for chemistry subjects, especially the concept of equilibrium.

Maratusholihah et al., (2017) conduct research to determine the misconceptions experienced by students on the concept of acid base. His research is not only done to find out the misconceptions experienced by students but also explores the concepts that cause students to have learning difficulties. According to (Wiwiana et al., 2020) students who have learning difficulties tend to easily experience misconceptions. In addition, it is also explained the cause of misconceptions in students. The cause of the misconception is obtained through interviews with students about the reasons for the answers expressed by students. In addition to Pinarbasi (2007), (Hidayat et al., 2020) also conducted research by conducting an analysis of students who experienced misconceptions on the concept of acid base. According to (Kartal et al., 2011) the high level of misconceptions experienced by students, is based on low student understanding.

Student misconceptions can be identified using several methods, one of which is using the Certainty of Response Index (CRI) method (Sadhu et al., 2017). The modified CRI method can overcome problems that tend to be unsure of what learners answer, in this method also allows learners to provide reasons for the answers that learners choose so that they can reveal the location of student misconceptions based on the reasons that learners write (Waluyo et al., 2019). Based on the description mentioned above, researchers are interested to find out more about the concept of students of class X senior high school state 1 Demak with the research title "Analysis of Chemical Misconceptions of Stoichiometric Materials Using Certainty Of Response Index (CRI)".

METHOD

This research is an experimental study with the design of one group pre-test post-test design. Pre-experimental research is research conducted to test the impact of a treatment (intervention) on the results of research controlled by other factors that may affect those results. The population in this study is all students of class X MIPA SMA N 1 Demak. The research sample consisted of 35 students. This sampling is done by purposive sampling techniques, which is the selection of samples based on certain purpose considerations. Considerations are given by teachers who teach chemicals at senior high school state 1 Demak, based on the results of documentation studies and preliminary studies. The data collection technique used in this study is to use tests. This research data is in the form of learning results obtained from daily repeat scores and student activities obtained from observation results. Initially the sample is given a pretest before direct learning on the stoichiometric concept material using the stoichiometric concept module. Then tested with a daily repeat (posttest) equipped with a two-tier diagnostic test type misconception detection assisted by CRI. The daily replay test in the form of multiple choice reasoned as many as 20 questions. The questions used represent 5 indicators of learning, including (1) balancing chemical reactions; (2) substances that have the same mass, have the same number of particles; (3) gases that have the same temperature, pressure and volume, have different numbers of molecules; (4) determination of the number of molecules of the reaction product produced at the end of the reaction; (5) determination of the mass or volume of the substance through the limiting reagent.

Based on the question instructions, students were asked to respond to one scale of six CRI scales called six scales (0-5) on each test item. Here are six scales in CRI:

Table 1. Certainty of Response Index Response Scale

CRI	Criterion	Category	
		right	wrong
0	(Totally guessed answer): if answering a question is 100% guessed	TP	TP
1	(Almost guess) if answering the percentage of guess elements between 75%-99%	TP	TP
2	(Not sure) if answering the percentage of guess elements between 50%-74%	TP	TP
3	(Sure) if answering the percentage of guess elements between 25%-49%	P	M
4	(Almost certain) if answering the percentage of guess elements between 1%-24%	P	M
5	(Certainly) if answering the question there is no guess element at all (0%)	P	M

To make it easier for students to determine the CRI scale, in this study applied operationalization of the six CRI scales. By listing it on the student's answer sheet. Based on the acquisition of data for each student, then the data is analyzed based on the combination of the answers given (right or wrong) with CRI (low or high). So that it can be known the percentage of students who understand concepts, misconceptions, and do not understand concepts. In Table 2. it is a provision to determine these criteria.

Table 2. CRI Provisions to Distinguish Know Concepts, Misconceptions, and Not Understanding Concepts

Answer Criteria	Low CRI (<2.5)	High CRI (>2.5)
Correct Answer	Correct answer but low CRI means not understanding the concept (lucky guess)	Correct answer and high CRI means mastering the concept well
Wrong Answer	Wrong answer and low CRI means not understanding the concept	Wrong answer and high CRI means misconception

RESULTS AND DISCUSSIONS

Analysis of student test results using the Certainty of Response Index (CRI) with questions in the form of open-reason multiple choices, the percentage of students' understanding is grouped into categories of understanding concepts well, understanding concepts but not sure, misconceptions and not understanding concepts for each item of question as many as 20 items and each indicator can be seen in Table 3. Students experienced a misconception in each point of the question given from numbers 1 to 20 with the largest percentage of misconceptions occurring in question number 2 which is 46%. Here's a tabulation of student data understands, misconceptions and does not understand concepts.

Table 3. Percentage of Students Based on CRI (Pre-test) index

No	Sub-concepts	No .	Percentage		
			Understand (P)	Misconception (M)	Don't Understand (TP)
1	Basic laws of	4	0	17	83

	chemistry	17	19	34	47
		18	23	29	48
		20	32	42	26
Average			18,5	30,5	51,0
2	Relative atomic/molecular mass and Mole Concept	2	50	34	16
		5	35	49	16
		3	23	52	52
		16	34	23	43
		19	32	11	57
		8	26	32	39
		12	32	38	30
		9	28	42	30
		7	37	21	42
		10	25	49	26
		11	23	43	34
Average			31,4	35,8	35,0
3	Limiting Reagents	1	0	17	83
		6	28	26	46
		13	12	23	65
		14	21	47	32
		15	25	31	44
Average			17,2	28,8	54,0
Overall Average			22,37	31,70	46,67
Category			Low	Keep	Keep

The results of this pretest show that the level of student misconceptions in senior high school state 1 Demak is still in the medium category. The problems that have the highest degree of misconception are in the subconceptions of relative atomic mass, relative molecular mass and the concept of moles. In the sub-concept of the basic laws of chemistry the largest percentage is in questions number 20 and 17 with a percentage of 42% and 34% respectively. Furthermore, in the sub-concept of Relative atomic mass/molecule and the Concept of Mol about 2,5,3,8,12,9,10, and 11 with the largest percentage of the number 3. The sub-concept of reagents limiting the highest percentage of misconception is contained in question number 14. Overall the category of understanding (P) in this pretest is in the low category, misconceptions with a percentage of 31.70% of medium categories and do not understand the concept of 46.67%.

Table 4. Percentage of Students Based on CRI index (Posttest)

No	Sub-concepts	No.	Percentage		
			Understand (P)	Misconception (M)	Don't Understand (TP)
1	Basic laws of chemistry	4	32	16	52
		17	41	19	20
		18	48	23	29
		20	46	32	20
Average			41,75	22,5	30,25
2	Relative atomic/molecular mass and Mole Concept	2	68	27	5
		5	55	25	20
		3	50	20	30
		16	43	23	34
		19	59	10	31
		8	41	26	30
		12	48	30	22

		9	47	28	25
		7	67	13	20
		10	55	25	20
		11	47	23	30
Average			52,72	22,72	22,45
3	Limiting Reagents	1	43	12	45
		6	54	12	32
		13	38	12	50
		14	49	21	30
		15	41	25	34
Average			45,00	16,40	38,20
Overall Average			46,49	20,54	30,03
Category			Keep	Low	Low

The results of this posttest show that the level of student misconceptions at senior high school is still in the low category. The misconception with the largest percentage in this posttest is found in the indicator determining the relative atomic mass / relative molecule and the concept of mole with a percentage of 22.72%. The lowest misconception on the limiting reagent indicator with a percentage of 16.40. Overall, the concept understanding criteria with an average of 46.49 are in the medium category, misconceptions with an average of 20.54 with low categories and do not understand concepts with a percentage of 30.0 It is in the low category. Results in this posttest decreased in misconceptions and incomprehension of concepts in students.

Table 5. Results of pretest and posttest misconception analysis

No	Analysis	Pretest	Posttest	Decline/increase
1	Understand Concepts	22,37	46,49	24,12
2	Misconceptions	31,70	20,54	11,16
3	Not Understanding the Concept	46,67	30,03	16,64

Table 5. Explained that, in the analysis of concept understanding there was an increase of 24.12%, misconceptions decreased by 11.16% and in the analysis of not understanding the concept of students decreased by 16.64%. This proves that the stoichiometric concept module is able to reduce misconceptions in students by 11.16%. To find out the points of the problem that is perceived and the point of the problem that is not understood (do not understand) in groups can be seen from the CRI value for the wrong answer associated with the fraction value. CRIs scores can be obtained from dividing the total CRI score for the wrong answer by the number of students who answered the wrong question. As for getting fraction grades, namely by dividing the total students who answer correctly with the total of all students. Fraction is the number of students who answer correctly, with fractional values can be known the number of students who answered incorrectly. Table 6. is a tabulation of CRIs and F value data.

Table 6. CRI Values for Incorrect Answers (CRIs) and Fractions (F)

No	Sub-Concepts	Question Number	Pretest			Posttest		
			CRIs	F	Category	CRIs	F	Category
1	Basic laws of chemistry	4	3,33	0,09	M	3,5	0,6	M
		17	3,18	0,04	M	3,03	0,6	M
		18	2,73	0,73	TP	2,63	0,42	M

		20	2,67	0,74	TP	3,48	0,71	TP
2	Relative atomic/molecular mass and Mole Concept	2	2,28	0,11	M	2,87	0,24	M
		5	2,77	0,68	TP	2,65	0,29	M
		3	2,48	0,5	TP	2,98	0,35	M
		16	2,63	0,36	M	3,18	0,65	M
		19	3,25	0,4	M	2,69	0,88	TP
		8	2,53	0,53	TP	2,73	0,53	M
		12	2,59	0,88	TP	2,49	0,4	M
		9	2,40	0,9	TP	2,38	0,9	TP
		7	3,38	0,58	M	2,78	0,36	M
		10	3,04	0,29	M	2,67	0,78	TP
		11	2,92	0,68	TP	2,92	0,68	TP
3	Limiting Reagents	1	2,18	0,86	TP	2,38	0,9	TP
		6	3,61	0,78	M	2,67	0,78	TP
		13	3,48	0,71	M	2,87	0,41	M
		14	2,58	0,84	TP	2,53	0,53	TP
		15	2,25	0,85	TP	3	0,66	M

The existence of fractional values is needed to analyze the point of the problem as a whole, between the many groups of students who answer right and wrong. If the CRIs value is above the threshold of 2.5 and the low fraction value (<0.5) then it can be decided that the question belongs to the category that is perceived. If the CRIs value is above the threshold of 2.5 even exceeds three with a high fraction value (>0.5) then the problem is still categorized as a question that students conceptualize. However, if the CRIs score is below the threshold of 2.5 and the value of the low fraction (< 0.5) or high (> 0.5) then the problem belongs to the category of questions that students do not understand. Based on the explanation above, from Table 6. It can be analyzed that students tend to experience misconceptions on each sub-concept of stoichiometry. Based on the data, the results showed that the CRI method was effective for analyzing students who experienced misconceptions. As for the grouping, the level of understanding of students is analyzed based on the level of understanding of individual students and the level of understanding of students in groups. Students experience misconceptions or do not understand concepts can be distinguished by seeing whether or not the answer to a question and seeing the high or low index of certainty of answers (CRI) that students provide so as to produce student percentage data based on answers and indices (CRI) in the category of understanding, misconceptions, not understanding concepts.

Data from the results of the analysis can be used to obtain data on the next diagnosis interview. To find out the question items that students conceptualize and do not understand students can be known by calculating cri scores for incorrect answers then combined with fractional values that can be seen in Table 6. Percentage of students who understand concepts, misconceptions, and do not understand the concepts in each of the questions tested in Table 1. It shows that of the 20 questions of each subcontract, there are still many that students are conceptualized and also many that students understand, while students who do not understand the concept are few.

The description of student misconceptions in the first indicator is applying the basic laws of chemistry in chemical calculations occurs in Lavoisier's Law and Lussac's Gay Law. Misconceptions that occur in Lavoisier's Law there are several cases including, first the learner mentions that lavoisier's law reads "substances before and after reaction are the same", this is wrong, because if the sound of the Law is so then no reaction occurs. So the correct sound of the law is "the mass of the substance before and after the reaction is the same". Both peseta didik consider all reactions involving Lavoisier's Law then all substances will be used up reacting so that there will be nothing left. In fact, in a chemical reaction not always the mass of the reacting substance (reactant) will be exhausted entirely into the result of the reaction (product). The three learners considered the

reaction index to be the reaction mass. Lavoisier's law applies when the reaction index of the reagent is equal to the reaction index of the reaction result. The misconception that occurs in Lussac Gay Law is that students solve questions about Lussac Gay Law without involving Lussac Gay Law so that there is a mistake in answering. The misconceptions that occur in the first indicator are caused by 1) the low ability of learners to understand the basic laws of chemistry, 2) the low interest in learning learners, 3) easy to memorize but do not understand its meaning, 4) the learning model used is still a conventional model.

The picture of the student's consumption in the second indicator is calculating the relative atomic mass (Ar) and relative molecular mass, the learner is mistaken in understanding the hydrating compound so that it affects when determining the Mr of the hydrating compound. Learners consider the dot separating the two molecules to mean times, so in looking for Mr. from CuSO4.5H2O by multiplying Mr. CuSO4 by Mr. from 5H2O. As for the correct concept that hydrate compounds are compounds containing water crystals so that the molecular mass of hydrating compounds is the molecular mass of compounds added to the molecular mass of the crystalline water that binds to the compound. The factors that affect the student's misconceptions are a) the low ability of learners to understand the third indicator, b) the low interest of learning learners, c) the learning model used is still a conventional model.

The perception of learners on the indicator converts the number of moles by the number of particles, mass and volume of the substance, learners consider that the relative molecular mass is influenced by the compound, even though the relative molecular mass is the result of the sum of the total atomic mass of each constituent element of the compound. Factors that affect the student's misconceptions in the fourth indicator are, a) the low ability of learners in understanding basic concepts in terms of converting the number of moles with the number of particles, mass and volume of substances, b) Low interest in learning learners, c) the ability to analyze learners is fairly low, d) learners memorize existing formulas, but do not know when the formula is applied so that students have difficulty in answering the questions that are Given, e) the learning model used is a conventional learning model.

Misconception of learners in the last indicator is applying the use of the concept of mole to complete chemical calculations, learners misunderstand the notion of molality. This resulted in the wrong learners in writing the formula of molality. learners consider that the number of moles of solutes was in 1gram of pure solvent. In fact, if you want to use grams, it is equivalent to 1000 grams which means 1 kg of pure solvent. The misconception of learners that occurs in this indicator is influenced by 5 factors, namely, a) low learners' understanding of the concept of mole, b) low interest in learning learners, c) low ability of learners in analyzing problems, d) learners' ability to memorize formulas without understanding them, e) the learning model applied is a conventional learning model. The misconception of learners on the indicator explains the parts of a reaction equation, learners consider that the index of the compound is equal to the reaction coefficient. The correct concept is that the reaction coefficient in a reaction indicates the number of molecules in the reaction. The misconception of learners in the second indicator is influenced by several factors including, a) the low ability of learners to understand parts of the reaction equation, b) the low interest in learning learners, c) the learning model used is a conventional learning model.

CONCLUSION

Misconceptions are still found in all stoichiometric concepts, which include indicators of the basic laws of chemistry at pretest of 30.5% (medium)- posttest 22.5% (low), relative atomic mass/molecule indicator and concept of mol pretest 35.5% (medium) and posttest 22.72 (medium), as well as calculation of limiting reagent stoichiometry at pretest of 31.70% (medium) and pretest

22.72 (low). Such misconceptions are caused because students master incomplete concepts and connect one concept with another with partial understanding, so students make incorrect conclusions.

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