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Development of Three-Tier Diagnostic Test Instrument to Measure Misconceptions of Class XI Students on Reaction Rate Materials

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Abstract
This study aims to measure and detect student misconceptions that occur in the concept of reaction rate based on the diagnosis results of Grade XI Negeri 2 Kabanjahe students and to show subconceptions that experienced both high and low misconceptions. The study was conducted in March–April 2022. The type of research used is Research and Development with ADDIE development. Methods used are tests, anchors, interviews and documentation. The diagnostic test developed is a threetitier multiple choice diagnostic test consisting of an answer choice, reason and confidence level. Validation result by validator indicates the developed instrument is valid. The validity of the developed test is 20 valid problems and 10 invalid problems. Reliability test results show a reliability figure of 0.85. The highest percentage of misconceptions in collision theory is 51.5% and the lowest percentage of misconceptions in reaction order and reaction rate equations is 26.72%. The percentage of students who understand the concept of reaction rate is 35%. The percentage of categories did not understand the concept of reaction rate by 27% and the percentage of misconceptions of reaction rate by 38%.

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reaction rate, misconception, three-tier multiple choice

Abstrak
Penelitian ini bertujuan untuk mengukur dan mendeteksi miskonsepsi siswa yang terjadi pada konsep laju reaksi berdasarkan hasil diagnosis siswa kelas XI SMA Negeri 2 Kabanjahe dan menunjukkan sub konsep yang mengalami miskonsepsi tinggi maupun rendah. Penelitian ini dilaksanakan pada Maret-April 2022. Jenis penelitian yang digunakan adalah penelitian pengembangan (*Research and Development*) dengan pengembangan ADDIE. Metode yang digunakan adalah tes, angket, wawancara dan dokumentasi. Tes diagnostik yang dikembangkan adalah tes diagnostik *three-tier multiple choice* yang terdiri dari pilihan jawaban, alasan dan tingkat keyakinan. Hasil validasi oleh validator menunjukkan instrumen yang dikembangkan valid. Validitas tes yang dikembangkan sebanyak 20 butir soal valid dan soal yang tidak valid sebanyak 10 butir soal. Hasil uji coba reliabilitas menunjukkan angka reliabilitas sebesar 0,85. Persentase miskonsepsi tertinggi yaitu pada konsep teori tumbukan sebesar 51,5% dan persentase miskonsepsi terendah pada konsep orde reaksi dan persamaan laju reaksi sebesar 26,72%. Persentase siswa yang memahami konsep laju reaksi sebesar 35%. Persentase kategori tidak memahami konsep laju reaksi sebesar 27% dan persentase kategori miskonsepsi konsep laju reaksi sebesar 38%

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Introduction

Learning is the process of teacher interaction with students, students to students, and the source of learning to students in a learning environment. A good learning process will have a good effect on students' behavioral changes (Nurhayati et al., 2019). Chemistry is the study of the composition, structure, and properties of matter or matter from the atomic to molecular scale and their changes or transformations and their interactions to form matter found in everyday life (Dwinata et al., 2016). Reaction rate material is one of the concepts that can be understood well when connecting three levels of representation containing macroccopic, submicroscopic and symbolic representations simultaneously which makes the material difficult for students to understand (Nurpratami et al., 2015). Misconceptions are concepts that are inconsistent with or different from concepts and understandings that are believed to be true by the scientific community or experts in the field (Yulianti, 2008). Misconceptions in chemistry lessons will be very fatal because chemical concepts are interrelated with each other, so that misconceptions at the beginning of learning will affect further lessons, this will lead to the low ability of students and not achieving complete learning (Jannah et al., 2017). Misconceptions that occur in students as a result of students' difficulties in understanding concepts can be identified using diagnostic tests (Shalihah et al., 2016).

Three-tier multiple choice is one type of diagnostic test that is used to distinguish between students who lack knowledge (do not understand the concept) and students who experience misconceptions (Ardiansah et al., 2018). The three-level diagnostic test has three levels, the first is to ask students' knowledge of multiple choice concepts. The second level is the students' reasoning from the process of answering at the first level. The third level is a question about students' beliefs about the answers to the first and second levels. This is one of the advantages of this instrument because basically in the world of education it is very important to distinguish the level of student understanding so that the right teaching method can be chosen in the learning process in the classroom (Maulini et al., 2016). Therefore, the three-level multiple choice diagnostic test is considered more accurate to identify students' misconceptions because it is equipped with belief questions (Saat et al., 2016).

RESEARCH METHODS

Population And Sample

Population is the overall research subject that has the quality determined by the researchers (Sugiyono, 2015). The population in this study was all XI MIPA students in Kabanjahe State High School 2 Kabanjahe. The determination of the research sample is determined by purposive sampling technique, which is the XI MIPA 3 class of 36 students who have been confirmed to have studied reaction rate materials.

Research Procedure

1) **Analysis**

   This stage is the initial stage or preparation for development. Researchers have conducted a literature review to study theories related to the product to be developed. The initial discovery here is a problem. Before conducting research, the researcher must find the problem that lies behind the importance of the research. Literature studies come from books or journals or previous studies that are relevant to this matter. Researchers also conducted field studies to collect data and information and then identify the real situation, especially those related to the development of diagnostic tests on the reaction rate material.

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2) Design

At this stage, the researcher plans a learning goal based on the basic competencies of the 2013 curriculum applicable in schools to design test instruments to be developed. Early product development in this study began by determining the material used in diagnostic tests. Then the researcher determines basic competencies as a reference to determining competency achievement indicators. Continue with creating a problem grid, writing problem items, answer keys and scoring guidelines.

3) Development

The three-level multiple-choice diagnostic test instrument is validated first to the expert validator before being given to the student. Suggestions from the validator were made to revise the test instrument. Next, a small-scale test in class XII was conducted on 20 students. Small-scale test result data are used to test the feasibility of the test instrument (knowing whether the item is good or not) using five parameters, namely: a) validity; b) reliability; c) difficulty level; d) differentiating power and e) smoothing. Empirical validation is performed only at the core of the question (without reason).

4) Implementation

The implementation was carried out with a wide-scale test of the XI MIPA class of 36 students, students used differently than students on small-scale trials. Wide-scale test results data are used to measure students' misconceptions according to the outcome interpretation guidelines. The product revision was done through the student response sequence given after the student worked on the problem. The revised product at this stage is assumed to be the final product of the three-level multiple-choice diagnostic test instrument.

Data Analysis

The statistical formulas used include:

a) Validity test

The instrument to be used in this study must be able to measure or reveal data from the variables that have been studied. The formula used to calculate the biserial coefficient between the item scores and the total test score is:

$$r_{pbis} = \frac{Mp - Mt}{SDt} - \sqrt{\frac{p}{q}}$$ (Triyono, 2013)

b) Reliability Test

Reliability shows the instrument can be trusted as a data collection tool. Reliability aims to determine the extent to which a measuring instrument can be trusted and reliable. A test is said to be reliable if it shows the same results even though the test is repeated. In this study, to see the level of instrument reliability, calculations were carried out using the Kuder-Richardson (K-R-20) formula as follows:

$$r_{11} = \left[\frac{n}{n-1}\right]\left[\frac{S^2 - \sum pq}{S^2}\right]$$

c) Difficulty Level

The level of difficulty of the items is obtained from the ability or ability of the trainees to answer these questions, not from the point of view of the teacher in conducting analysis during the preparation of the questions (Bagiyono, 2017). To test the level of difficulty of each item can be calculated by the formula:

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$$P = \frac{B}{T}$$

d) Distinguishing Power

Distinguishing power is the ability of an item to distinguish between high-ability students and low-ability students. An item is declared eligible if D ranges from +0.20 to +1.0 which can be calculated by the formula:

$$D = \frac{BA}{JA} - \frac{BB}{JB}$$ (Silitonga, 2014)

e) Distractor

Arikunto (2008:220) explains that a distractor can be said to function properly if the distractor has great appeal for test takers who do not understand the concept or lack mastery of the material. According to Arikunto (2012), the distractor is considered bad if the distractor is not chosen at all by the test taker because the distractor looks too misleading. On the other hand, a well-functioning distractor is a distractor or distractor that is chosen by at least 5%. If it is chosen evenly, it is said to be very good.

f) Interpretation of Three-Tier Multiple Choice Diagnostic Test Results

The interpretation of the results of the three-level multiple choice diagnostic test is divided into three categories, namely understanding, not understanding, and misconceptions (Peşman & Eryilmaz, 2010).

Tabel 1. Interpretation of Results Three-Tier Multiple Choice Diagnostic Test

No	Category	Type				
		Answer	Score	Reason	Score	Confidence
1	Understanding	True	1	True	1	High
2	Not	True	1	True	1	Low
	Understanding	True	1	False	0	Low
		False	0	True	1	Low
		False	0	False	0	Low
3	Misconceptions	True	1	False	0	High
		False	0	True	1	High
		False	0	False	0	High

Result And Discussion

Result of Research

1. Analysis Phase (Analysis)

a. Study of literature

Literature study aims to find information and references that are relevant to the problem under study and serve as a reference in research. Based on the results of the literature study, information was obtained through the results of previous studies in the form of journals and theses which were used as references by researchers in conducting research. Then an analysis was carried out on some of these references so that information was obtained that to determine students' knowledge in understanding the concept of reaction rate, it could be seen from the sources of errors that allowed students' misconceptions so that students had difficulty understanding the concept of reaction rate.

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b. Curriculum Analysis

At this stage, the researcher conducted an analysis of the applicable curriculum. Based on the results of an interview with one of the chemistry teachers at SMA Negeri 2 Kabanjahe, information was obtained that the curriculum applied was the 2013 curriculum. However, chemistry learning activities that took place in the classroom were still dominated by teachers, where there were still students who tended to be passive. Teachers have not implemented a three-level diagnostic test as an evaluation tool at the end of learning to determine students' understanding of the concept of reaction rate material.

c. Student Analysis

At this stage the researcher conducted an analysis of the students through interviews with one of the chemistry teachers at SMA Negeri 2 Kabanjahe. Information was obtained that the knowledge of class XI MIPA students had varying abilities, including students with low, medium and high abilities. This is based on various factors, namely the different interests and abilities of each student in chemistry subjects, especially the reaction rate material. The low ability of students is one of the impacts of the impact of the Covid-19 pandemic. There are several other factors, namely teacher-centered learning so that students tend to be passive in seeking and learning the concept of reaction rate, and students tend to memorize formulas in chemistry learning which causes the teacher difficulty in identifying students' conceptual knowledge.

2. Design Phase (Design)

This stage begins with the selection of KD from the 2013 curriculum. So that the main design is obtained which can facilitate teachers in developing indicators and can assist in preparing the required instruments. The next step is to determine learning indicators on the reaction rate of the material. The question grid is the basic framework used to compile the questions to be made. This is in accordance with the research of Asmalinda (2019) which explains that at the design stage a question grid is made to facilitate the preparation of diagnostic test items. The questions that are made are adjusted to the indicators of achievement of learning questions that have been determined. The components in the designed problem grid include: indicator questions, cognitive level of questions, number of questions and number of questions (Asmalinda et al., 2019).

3. Development Phase (Development)

Before being given to students, the three-level multiple-choice diagnostic test instrument was validated in advance to the Expert Review. The validation of the questions contains the validator's assessment of three aspects, namely: material, construction and language. At this validation stage, the validator assesses 18 aspects related to the designed three-level diagnostic test. Of the 30 items, there are 4 items that require revision according to the expert validator's advice and 26 items that are classified as good. Then a small-scale test was conducted on the XII MIPA class students involving 20 students. The number of items tested was 30. The average student's response to the response sequence was 78.82%. The results of the instrument function analysis from small-scale trials are described as follows:

a. Validity

A test item is said to be valid if the test item has great support for the total score which results in the total score being high or low, in other words that the test item has parallels with the total score.

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Table 2. Validity Test

Criteria	Question Number	Total	Persentage
Valid	1, 4, 6, 8, 9, 10, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 27, 28, 29, 30	20	67%
Invalid	2, 3, 5, 7, 11, 12, 13, 19, 25, 26	10	33%
	Total	30	100%

b. Reliability

The purpose of conducting a reliability analysis of the test instrument is to determine the level of stability/consistency of the test instrument, so that the instrument used always gives consistent results. Based on the results of small-scale trials, a reliability of 0.85 was obtained.

c. Difficulty Level

Analysis of the level of difficulty of the test is used to find out which questions are included in the easy, medium or difficult categories.

Table 3. Difficulty Level Test

Category	Question Number	Total
Easy	12	1
Medium	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 17, 18, 19, 24, 30	16
Hard	11, 14, 15, 16, 20, 21, 22, 23, 25, 26, 27, 28, 29	13
	Total	30

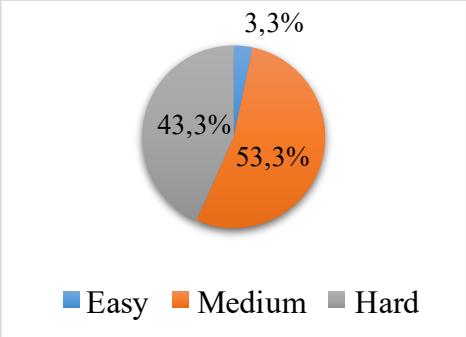

Figure 3.1 Difficulty Level Analysis

d. Distinguishable Power

Distinguishable power is used to determine the ability of a question to distinguish students who have high abilities and students who have low abilities.

Table 4. Differential Power Test

Category	Question Number	Total	Persentage
Good	6, 9, 14, 21, 23, 30	6	20%
Enough	1, 4, 8, 10, 12, 15, 16, 18, 19, 20, 22, 24, 27, 28, 29	15	50%
Bad	2, 3, 5, 7, 11, 13, 17, 25, 26	9	30%

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e. Distractor

The goal of a distractor in a small-scale diagnostic test is to trick those who are less able or who don't know, so they can be distinguished from test takers who are able to answer the questions.

Table 5. Distractor Test

Criteria	Question Number	Total
Qualify	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30	24
Not Eligible	11, 12, 13, 14, 15, 29	6
	Total	30

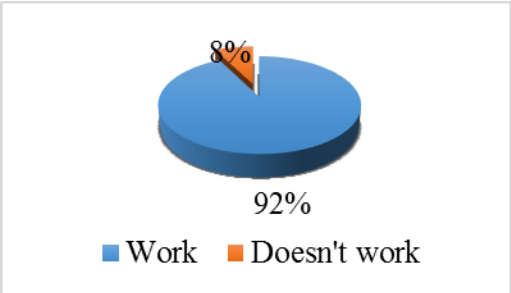

Figure 1. Percentage of Distractor Functionality Answer

There are 120 distractor options, based on Figure 1. showing that the distractor on the usable answer is 111 (92%) and the distractor on the unusable answer is 9 (8%).

***f. Product* Analysis and Revision**

After obtaining the results of the analysis of validity, reliability, level of difficulty, distinguishing power, and distractors, then from each question it is decided which questions are good, questions that need to be revised or which questions should be rejected. Acceptance decisions are made to determine which items can be directly used, used but need revision and cannot be used (rejected).

Table 6. Results of Empirical Analysis of Small-Scale Trials

Category	Question Number	Number Of Questions
Received	1, 4, 6, 8, 9, 10, 17, 18, 20, 21, 22, 23, 24, 27, 30	15
Rejected	2, 3, 5, 7, 11, 12, 13, 14, 15, 16, 19, 25, 26, 28, 29	15

Obtained 15 questions that can be used in large-scale trials. The average result of the student's assessment of the student response questionnaire was 78.82%.

4. Implementation

The implementation phase was carried out by a wide-scale trial using 15 issues that were declared suitable for use. To ensure that the developed test instruments are properly appropriate and can be used to measure and identify misconceptions that students experience. A wide-scale test was conducted in one class, namely the XI MIPA 5 class, with 36 students in the category of not being smart, medium, and smart. After working on the problem, students were given a response ticket. The average student response score was 83.48% which meant a three-tier multiple-choice diagnostic test instrument was included in the criteria.

Interpretation of Three Level Multiple Choice Diagnostic Test Results

To determine the level of students' knowledge of the material concept of reaction rate, an analysis of the results of student answers was carried out on a wide-scale trial. A score of

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1 is given to a correct answer or a correct reason, and a score of 0 is given to a wrong answer or a wrong reason. The level of confidence is categorized as high if it is selected on a scale of 4, 5, or 6 and the level of confidence is categorized as low if it is selected on a scale of 1, 2, or 3.

Table 7. Percentage of Each Category Overall Items

Question Number	Criteria					
	Understand		Don't Understand		Misconception	
	Total	%	Total	%	Total	%
1	16	44,45	8	22,22	12	33,33
4	13	36	5	14	18	50
6	0	0	17	47	19	53
8	10	28	5	14	21	58
9	5	14	12	33	19	53
10	15	42	9	25	12	33
17	13	36	10	28	13	36
18	18	50	8	22	10	28
20	19	53	10	28	7	19
21	15	42	10	28	11	30
22	16	44,44	17	47,22	3	8,34
23	3	8	15	42	18	50
24	10	28	17	47	9	25
27	10	28	11	30	15	42
30	18	50	8	22	10	28
Total	181	503,89	162	449,44	197	546,67
Average	12,07	33,59	10,80	29,96	13,13	36,44

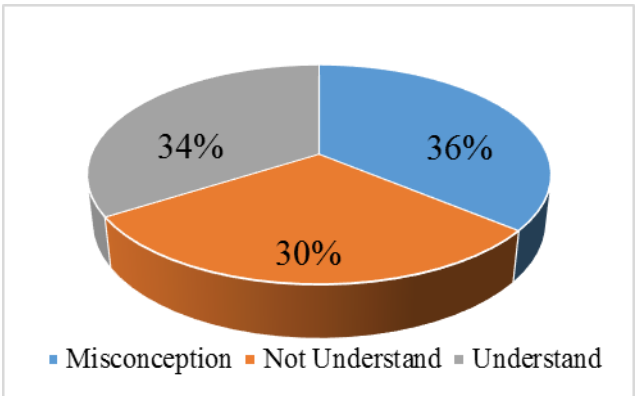

Figure 2. Percentage of Each Category as a whole Item Question

Discussion

Based on research conducted by Fahmi (2017), it is known that students experience misconceptions in the reaction rate material (Fahmi & Irhasyuarna, 2017). Based on the research conducted by Siswaningsih (2014) the results of the research obtained show that students experience misconceptions in the reaction rate material which includes the understanding of the reaction rate and factors that affect the reaction rate (Siswaningsih et al., 2014). This research develops an instrument that is used to identify students' misconceptions about reaction rate material. The results of the research obtained by the researchers in this study are that students experience misconceptions in reaction rate materials, which include

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sub-materials: the concept of reaction rate, collision theory, reaction order, and factors that affect reaction rate. Students often experience misconceptions in the learning process (Fadhilah et al., 2020).

The instrument developed is a three tier multiple choice diagnostic test. Students already have concepts related to chemistry through everyday experiences. Stated that students often interpret their own conceptions that they find difficult according to the preconceptions that students already have (Yunitasari et al., 2013). In the learning process at SMA Negeri 2 Kabanjahe it is still dominated by teachers, through the lecture method so that students tend to be passive and obtain low learning outcomes. this is in accordance with the research conducted by Rosilasari, the low learning outcomes of students generally occur due to several things, namely, (1) students' understanding of a problem has not been completed; (2) the occurrence of misconceptions about essential concepts that interfere with students' understanding of certain concepts; (3) the low quality of learning in class results from the low quality of educators both in terms of mastery of the material or in terms of teaching methods.

Teachers at SMAN 2 Kabanjahe have not implemented a diagnostic test as a student evaluation tool. The teacher only evaluates students through essay questions and multiple choice. According to (Prastyaninda et al., 2014), the first step that must be taken to diagnose misconceptions is to understand where students' misconceptions lie. One of the right steps to diagnose misconceptions is by using a special instrument, namely a diagnostic test given to students after the learning process is carried out. The diagnostic test developed in this study is a three-level multiple-choice diagnostic test accompanied by a choice of reasons and a choice of the level of confidence in the answers and reasons. In addition to identifying students' misconceptions, diagnostic tests can also identify students who understand and do not understand the concept of reaction rate.

Conclusion

Based on the results of research regarding the Development of Three-Tier Diagnostic Test Instruments to Measure Misconceptions of Class XI Students on the Reaction Rate Material, it can be concluded as follows: (1)The developed Three-Tier Multiple Choice Diagnostic Test Instrument has the characteristics of the substance of the instrument to measure misconceptions in the reaction rate material. The question instrument is in the form of three-level multiple choice as many as 15 questions. (2) The test instrument developed for the reaction rate material has met a good classification with the assessment of three expert validators. The validity of the developed test obtained 20 valid items and 10 invalid items. The results of the reliability test showed a reliability score of 0.85. Three-level diagnostic test can be trusted if it is used to identify the level of conceptual understanding of the reaction rate material. (3) Based on the test results the percentage of students who understand the concept is 34%. The percentage of the category of students who do not understand the concept is 30% and the percentage of the category of students who have misconceptions is 36%. (4) The results of the overall analysis of students gave a positive response to the three-tier diagnostic test instrument developed with an average positive response of 83.48% of students.

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Suggestion

Based on the results of the study and the conclusions stated above, the researchers provide some suggestions as follows:

1. It is suggested to the teacher to use a three-level diagnostic test instrument which is considered suitable to identify students' misconceptions on the reaction rate.
2. It is hoped that the three-level diagnostic test can be developed further in the next material.
3. There is a need for improvement learning on the reaction rate material to improve students' conceptions to be better.
4. This research instrument is only limited to one school, namely SMA Negeri 2 Kabanjahe with a sample of 36 students. For further researchers to use the three-tier diagnostic test instrument in schools and it is hoped that they can conduct further research by increasing the sample.

Thank-You Note

Thank you to all those who have played a role in research, thesis writing and journal writing, so that research can run well as well as thesis and journal writing can be completed in accordance with the guidance of the thesis supervisor.

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