Answers Argumentation Instrument to Strengthen Conception Diagnostic Test on The Concept of Chemical Kinetics: Validity aspect

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Abstract. Diagnostic tests that have developed so far are used to determine whether students have misconceptions or not, even though through this test (in the form of multiple-choice tier test) it still has disturbing factors. This factor comes from the students themselves, the trial-and-error factor. Therefore, to strengthen the identification of students' conceptions, an instrument is needed. The development of an answer argumentation instrument aims to ascertain whether students have experienced misconceptions. The answer argumentation instrument refers to the diagnostic four tier test instrument that has been developed by the researcher. In this study, the development of the instrument was implemented for students who were programming the Chemical Kinetics course. The answer argumentation instrument was validated by 5 raters to obtain content validity and construct validity data. The validation results show that the answer argumentation instrument as an instrument to strengthen the identification of students' conceptions is valid in terms of content and constructs. The instrument can be used to strengthen the conclusions of grouping students based on their conceptions.

Keywords: Answers Argumentation Instrument, Misconception, Validity, Chemical Kinetics.

1 Introduction

Chemistry is called the central science because its existence serves as an edge for almost all other sciences [1]. Chemical kinetics is one of the material courses delivered at the secondary school level as well as in universities and chemical kinetics occupies a central position in describing and understanding the dynamic behavior of matter. [2]. Chemistry learning in the classroom and in the laboratory aims to provide students with all knowledge related to chemistry, helping students to clearly understand the basic concepts and the relationships between them through teaching strategies that minimize misconceptions. Therefore, chemical phenomena at various levels of chemical representation must be understood by chemistry students comprehensively because otherwise students may experience understanding the wrong concept but believe it to be something right. This is a phenomenon of misconception.

If individuals have accurate prejudices, it will increase the ease of learning new information correctly, but on the contrary, if these individual prejudices are not in accordance with what is agreed upon by experts, it will result in misconceptions [3]. Misconceptions of experience occur when students observe phenomena found in everyday experience, while prior knowledge, language and cognitive development can also be the cause of misconceptions [4]. Many factors cause misconceptions and other learning difficulties and one of them is the failure of students to understand the nature of chemical entities [5]. Misconception is a problem that continues to occur in the world of education and can cause obstacles in individual understanding of interrelated concepts. This is because matter or concepts in chemistry will always relate to each other [6, 7].

Checking whether or not misconceptions occur in students can be done with a diagnostic test. In the 4-tier diagnostic test, the researcher arranged a four-level diagnostic test by including the possibility of misconceptions in the alternative answers at tier 1 along with reasons at tier 3 and at tiers 2 and 4 the respondents' beliefs [8]. However, as with two-tier tests, on four-tier tests students’ answer choices at the answer level (tier 1) can influence their answer choices at the reasoning level (tier 3) for a question [9, 7]. Therefore, students who have been detected early experiencing misconceptions through diagnostic tests need to also explore the root causes of misconceptions by providing follow-up questions that strengthen students' arguments regarding the choice of answers in diagnostic tests.

One of the things that can be used to ensure students’ conceptions are right or wrong after being diagnosed using a diagnostic test is to know what students think.

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This can be done by asking students to argue about phenomena and claims related to concepts that have been asked in the diagnostic test but in a different way. Arguments have been used, among others, in knowledge representation, explanation, elaboration of evidence, and decision making [10]. In addition, because argumentation is a social, and rational activity that aims to convince others by justifying a proposition or denying a proposition according to one's beliefs [11, 12], then it will be stronger reason someone categorized his conception. In argumentation (written or dialogical) support is needed so that students are helped when interpreting experimental data, building coherent arguments based on data, and using reasoning at various representational levels [13]. The data from argumentation of answer can be used as a source of information about how the student's mindset and how to reduce misconceptions.

The contributions of argumentation activities in science class is to support access to cognitive and metacognitive processes of scientists as well as to train students' critical thinking skills [14]. Thus, through the delivery of written arguments, students have used their cognitive abilities and critical thinking skills in assessing the truth of a claim on the phenomena presented.

2 Research Method

The research on the development of this answer argumentation instrument refers to the Barkman's development model which consists of 6 stages, namely: a) identification of objectives, b) indicators and data sources, c) specification of each outcome indicator, d) time plan for running the instrument or conducting observations, e) instrument design, and f) testing and revision of the instrument [15].

There are 19 questions of argumentation answers have been developed based on diagnostic questions of 4 tier test of chemical kinetics material that have been developed Yonata et al. (2021). The subjects of this study were 5 raters, with expert judgment, to obtain data on the content and construct validity research variables from the validator or rater. Each rater evaluates and score every question set number by giving scale 0 (not valid) to 4 (very valid). The raters evaluate content validity and construct validity.

The content validity analysis uses the Aiken validity coefficient (V) as shown in Equation (1), while the construct validity analysis uses the median data rater.

\[
V = \frac{\sum S}{n(c-1)}
\]

3 Result and Discussion

3.1 Identification of objectives

The purpose of preparing this instrument is to produce supporting instruments to ensure the classification of students into knowing concepts or misconceptions. The supporting instrument of the four-tier test diagnostic test that has been developed by Yonata et al. (2021). In this developed instrument, students will write their arguments (by writing also supporting evidence) against the claims and facts that have been presented in the questions. Written argumentation is generating, considering, and comparing arguments where assignments and data sets will show the quality of the argument’s students produce [13].

3.2 Indicators and data sources,

In developing an appropriate assessment instrument, researchers need to consider several things, such as the purpose of the test and the performance standards of the examinees [18]. The result indicators and data sources in this research use argumentative questions and answers in the form of justifying or blaming the claims presented.

3.3 Specification of each outcome indicator,

Researchers tried to get reinforcing data related to student categorization decisions (based on the results of students in answering four-tier diagnostic test).

3.4 Time plan for running the instrument or conducting observations,

This research to develop the “Answer Argumentation Instrument” starting after developing a valid four-tier diagnostic test for chemical kinetics concept.

3.5 Instrument design

Essay items require students to formulate (write) answers that provide more freedom for respondents to answer questions, so that students' answers must be supporting by evidence. In this instrument, students are presented with phenomena and facts, then claims are provided based on phenomena and facts.

3.6 Testing and revision of the instrument

The research follows pilot test by determining validity of Answer Argumentation Instrument’s content and construct. The content validity result of each test number showed in Table 1, while in Table 2 presents median data of construct validity. Content validity and construct validity ware assessed by 5 raters. With the total score range is 5 (score 0-4) and the number of raters is 5, the values of S and V for the 19 developed questions are presented in Table 1. Based on the data in Table 1 and with reference to the validity
criteria according to Aiken [16], question number 9 is not valid in terms of the suitability of the presentation in the form of narration/image phenomena related to the specified chemical topic. The indicator for question number 9 is “If the phenomena, facts, and claims related to the uncatalyzed reaction curve and catalyzed reactions are provided, students can determine the correct assessment of the truth of the claim along with the evidence and explanations submitted to support the assessment of the claim”. From raters comment to this question are the use sentence and term in phenomena is confusing. Good arguments are obtained from data and other supports that are not confusing, detailed and not long-winded. Scientific argument is a formal method of taking a position and debating what you want your audience to believe based on a clearly defined topic with clear, direct arguments and evidence [19]. While the other questions have been considered valid with a value of $V\geq 0.8$ (for 5 raters with 5 score ranges).

Here is presented one of the questions that valid from content and construct validity, question no. 15, in Figure 1. The indicator for this question: If phenomena, facts, and claims are provided regarding data on initial concentrations of reactants vs reaction rates as well as rate constant values, students can determine correctly the assessment of the truth of the claim along with evidence and explanations submitted to support the assessment of the claim. In this instrument, the phenomena presented are in accordance with the concepts that have been asked in the four-tier diagnostic questions. After presenting the phenomenon students are presented with facts related to the phenomenon. The facts presented in some questions are not necessarily true, because the aim of the researcher is to lead students’ opinions both to the truth of the facts and vice versa. Furthermore, the claims are presented based on the facts provided. Likewise with facts, the claims presented in some questions are not always true.

After the phenomena, facts, and claims are presented, students are asked to evaluate these claims and facts to determine their opinion regarding the truth of the claims. Students are also asked to add evidence supporting the answer and also an explanation related to the relationship between the evidence and the assessment of the claim. The student writes down his acceptance or rejection of the claim by adding supporting evidence for his decision. Through writing students can gain a particular conception of the topic of physical chemistry and develop students' skills in explaining chemical content [20].

Table 1. Content validity using Aiken validity coefficient ($V$) for each question in answer argumentation instrument

<table>
<thead>
<tr>
<th>Rated aspect</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1</td>
<td>s</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>20</td>
<td>19</td>
<td>20</td>
<td>16</td>
<td>16</td>
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<td>20</td>
<td>19</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>V</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>1</td>
<td>0.95</td>
<td>1</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.95</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.95</td>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>A.2</td>
<td>s</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>20</td>
<td>19</td>
<td>20</td>
<td>16</td>
<td>16</td>
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<td>17</td>
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<td>20</td>
<td>20</td>
<td>20</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>V</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>1</td>
<td>0.95</td>
<td>1</td>
<td>0.8</td>
<td>0.8</td>
<td>0.7</td>
<td>0.85</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Note:
A.1 Suitability of questions with indicators
A.2 The suitability of the presentation in the form of narration/pictures with phenomena related to the specified chemical topic.

ARGUMENTATION ON ANSWERS (Problem no. 15)
A. Phenomena

From the reaction: $2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)

When data is obtained in Table 1:

Table 1. Experiments between NO and H_2 at various initial concentrations of reactants

<table>
<thead>
<tr>
<th>No.</th>
<th>[NO], M</th>
<th>[H_2], M</th>
<th>Reaction Rate, M/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.002</td>
<td>0.002</td>
<td>4.10^{-4}</td>
</tr>
<tr>
<td>2</td>
<td>0.004</td>
<td>0.002</td>
<td>8.10^{-4}</td>
</tr>
<tr>
<td>3</td>
<td>0.004</td>
<td>0.006</td>
<td>2.4.10^{-4}</td>
</tr>
</tbody>
</table>

Based on the experimental data, the reaction rate law is obtained $r = k[NO][H_2]$.

If calculated, the value of the reaction rate constant, $k$, is

$r = k[NO][H_2]$ or $k = \frac{r}{[NO][H_2]}$

For data 1 obtained the value of $k = 4.10^{-4}/(0.002\times0.002) = 1 M^{-1} s^{-1}$

If the concentration of the two reactants is 1 M, the value of the reaction rate is 1 Ms

The facts that can be stated from Table 1 in terms of the reaction order of the two reactants are: Based on the data obtained the reaction order is 1 with respect to NO and 1 with respect to $H_2$

The facts that can be stated from the value of $k$ for the data in experiments 1, 2, and 3 are:

Based on the data, the value of $k$ for the experimental data 1, 2, and 3 is the same (1 M^{-1} s^{-1})

The facts that can be stated from the values of $k$ and for the reaction concentration of both reactants are equal to 1 M are: Based on the data, the value of $k$ will be equal to the value of $r$ if the concentration of all reactants is equal to 1 M.

Fig. 1. Developed answer argumentation for question no. 15

Table 2. Construct validity using median data for each question in answer argumentation instrument
<table>
<thead>
<tr>
<th>Rated aspect</th>
<th>Median of question number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>B.1</td>
<td>4</td>
</tr>
<tr>
<td>B.2</td>
<td>4</td>
</tr>
<tr>
<td>B.3</td>
<td>4</td>
</tr>
<tr>
<td>B.4</td>
<td>4</td>
</tr>
</tbody>
</table>

Note:
B.1 Availability of a place to write down the student's alignment with the claims that have been presented.
B.2 Availability of a place to write evidence that strengthens or disproves claims.
B.3 Availability of a place to write an explanation of the relationship of evidence and partiality/rejection of the claim.
B.4 Selection of the type and size of the font used can be read easily.

Based on the data in Tables 1 and 2, the 19 questions contained in the answer argumentation instrument will be considered. This is because the use of argumentation in learning as well as in activities involving cognitive and metacognitive activities needs to be accompanied by valid and clear materials or instructions so that they can encourage students' higher-order thinking skills.

### 4 Conclusion

Answer argumentation instrument that has been developed are valid, but question number 9 must be eliminated because it did not meet the minimum content validity coefficient. The instrument must be able to reveal more deeply whether students really experience misconceptions or do not know the concept, and on the understanding of the prerequisites where students experience initial misconceptions.

Through argumentation, students can explain their understanding and the reasons that accompany it related to the concept. If students experience misconceptions and do not know the concept then the arguments they present provide evidence of understanding which ones are also not known or understood by misconceptions, then educators can prepare things that can cause students to experience cognitive conflicts in order to reduce misconceptions. If the educator is able to identify students' conceptions before the class begin, so learning activity can be modified to train students' arguments to direct them in the correct conception.

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### References

[1] https://doi.org/10.1051/shsconf/202214901007, 01007 (2022) SHS Web of Conferences 149, 01007 (2022) ICSS 2022


