Development of an online mathematical misconception instrument

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Abstract. The misconception is one phenomenon that often occurs in the fields of science, including mathematics. To find a solution, diagnostic needs to be done about misconceptions on the basic concepts of mathematics. The purpose of this study was to develop an online diagnostic misconception test instrument. The research method used is development research using the ADDIE model. There are five stages of research, namely: analyze, design, develop, implement, and evaluate. Proof of validity is done using the Aiken index involving five judgment experts. The validation results show that the instrument has high content validity. Likewise, with the results of the instrument trials, it shows that the instruments developed are valid and reliable. These results indicate that the developed instrument can be used for misconception diagnostic tests of basic mathematical concepts. The instrument can be used to diagnose misconceptions among students, students, teachers and other communities.

1. Introduction
Problems understanding of mathematics, in general, occur because they do not know the concepts and misconceptions [1,2]. The misconception is not the same as not knowing the concept [3]. The misconception is a wrong understanding of a concept, but it is not realized [4]. A person who experiences misconceptions has high confidence in the concept being understood. In fact, the concept understood is contrary to the theory that is accepted scientifically [5]. As a result, misconceptions will occur repeatedly [6] and can cause difficulties in understanding higher mathematical topics [7]. The existence of misconceptions needs to be addressed immediately by making a diagnosis first. Especially for prospective teacher students, mathematical concepts must be understood properly and correctly.

At this time, much research on misconceptions. Most of the misconception research is carried out in the fields of physics, chemistry, biology, and mathematics. Specifically in mathematics, the research conducted is more likely to diagnose misconceptions [5,8]. The results of research on misconceptions on mathematics occur in various algebraic concepts [2,6,9], starting from the concept of addition and subtraction [10], multiplication and division [11,12], both for integer and fraction operations [9,13]. All of these studies used instruments to detect misconceptions using tests and interviews in person [5], not online.

Our previous research successfully revealed that one of the problems in studying mathematics is the occurrence of misconceptions [7]. Misconceptions occur in a variety of basic mathematical concepts [14]. Therefore, this research aims to develop a misconception detection instrument for basic mathematics. The instrument developed is based online so that it can be easily used. Another advantage of the online misconception diagnostic instrument is the presence of feedback in the form of diagnostic test results that are directly sent automatically via email.
2. Method
This research is development research conducted using the ADDIE model. The ADDIE model consists of five phases, namely analyze, design, develop, implement, and evaluate [15]. Product development in the form of a misconception diagnostic test instrument is carried out using a combination of Google Forms, Google Sheets, Google Doc and Autocrat. The product implementation was carried out at IAIN Ponorogo, involving 60 students. While the evaluation of the instrument was carried out using a content validity test and a reliability test.

The validity of the contents of the instrument was proven by involving five experts in the field of mathematics education and learning evaluation. The determination of the content validity index uses the Aiken index as in equation 1 below.

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

(1)

Where \( V \) is the rater agreement index regarding item validity, \( s = r - l_0 \) where \( r \) is the rater choice score and \( l_0 \) s the lowest score in the category used, while \( r \) is the number of types to choose from [16,17]. The validity index interpretation refers to Table 1.

| Validity Index \((V)\) | Interpretation |
|----------------------|----------------|
| \( 0 \leq V \leq 0.4 \) | Invalid         |
| \( 0.4 < V \leq 0.8 \) | Medium validity |
| \( 0.8 < V \leq 1 \)  | Very valid      |

Table 1 shows that an instrument item is said to be very valid if its Aiken validity index is more than 0.8 [18].

Next, determine the reliability of the instrument using the KR-21 test as in equation 2 below.

\[ r_u = \frac{k}{(k-1)} \left( \frac{s^2 - \sum p_i q_i}{s^2} \right) \]  

(2)

Where \( r_u \) is the instrument reliability coefficient, \( k \) is the number of questions, \( s^2 \) is the total score variance, \( p_i \) is the proportion of subjects who answered correctly on an item, and \( q_i = 1 - p_i \) [19]. The interpretation of the instrument reliability coefficient refers to Table 2 below.

| Reliability Coefficient \((r_u)\) | Interpretation |
|---------------------------------|----------------|
| \( 0 \leq r_u \leq 0.2 \)       | Unreliable     |
| \( 0.2 < r_u \leq 0.4 \)       | Not reliable   |
| \( 0.4 < r_u \leq 0.6 \)       | Reliable enough|
| \( 0.6 < r_u \leq 0.8 \)       | Reliable       |
| \( 0.8 < r_u \leq 1.0 \)       | Very reliable  |

This fundamental mathematical misconception diagnostic instrument is called reliable if the instrument reliability coefficient is more than 0.8 [20].
3. Result and Discussion

3.1. Result

3.1.1. Analyze
In the analyze phase, various basic mathematical concepts and procedures for determining misconceptions are identified. The basic concepts of mathematics that will become test material include the types of numbers, addition, subtraction, multiplication, division, rank, and comparison, both for integers, fractions, and decimals. Details of the material that becomes material areas listed in Figure 1 below.

Figure 1. Basic Mathematical Concept Maps

Figure 1 shows that the basic mathematical concept map is used as a misconception test material. From the 20 concepts, 20 questions were chosen in the following order.

Furthermore, determining the occurrence of misconceptions is done using the level of subject confidence in the answers. The level of confidence consists of two choices, namely sure and not sure/doubtful. Determination of the occurrence of misconceptions in a person refers to Table 3 below [7].

Table 3. Techniques for Determining Misconception

| Answer  | Confidence Level       | Category                              |
|---------|------------------------|---------------------------------------|
| True    | Sure Right             | Understand the concept well           |
| True    | Not Sure/Hesitating    | Not/have not understood the concept well |
| False   | Sure Right             | Misconception                         |
| False   | Not Sure/Hesitating    | Not/have not understood the concept well |

Table 3 shows that misconceptions occur when the subject answers questions incorrectly but has a level of true belief. If the subject is uncertain or doubtful about the answer, then the subject does not or does not understand the concept well. Whereas a subject is called to understand the concept well if the answer given is correct and sure that the answer is correct.

3.1.2. Design
In this phase, the online application design is done to detect misconceptions. Application development is designed in six stages as Figure 2 below.
Figure 2 shows that the development consists of six steps, starting from the compilation of question scripts, question entry on Google Forms, processing data in Spreadsheets, creating a report on the results of misconception diagnostic test results using Google Documents, making reports on the results of misconception diagnostic tests using Autocrat, and sending reports the results of the misconception diagnostic test directly through the email registered on the form.

3.1.3. Develop
At the developmental stage, an online misconception diagnostic test instrument is developed. A total of 20 items were arranged with material grids, as listed in Figure 1. Furthermore, development was carried out according to the design in Figure 2. The development process was carried out using Google Forms, Spreadsheets, Google Documents, and Autocrats. Misconception diagnostic tests are prepared using Google Form, and the results are stored on Google Sheets. Next, the processing of diagnostic test results is carried out according to Table 3. The results are in the form of conclusions about the understanding of a person's concepts on each of the basic mathematical concepts being tested. The results are then sent directly via email using the Autocrat application. The product developed in the form of an online misconception diagnostic test can be accessed through the link [https://bit.ly/Tes-Diagnostik-Miskonsepsi](https://bit.ly/Tes-Diagnostik-Miskonsepsi).

3.1.4. Implement
After completion of development, the next stage is usage. The instrument in the form of a misconception diagnostic test is used to diagnose the occurrence of misconceptions. There were 70 respondents consisting of 60 students, 4 teachers, and 6 lecturers. The results of using the developed online misconception diagnostic test are listed in Figure 3 below.

Figure 3 shows that the highest development of misconception occurs in the concept of integer multiplication. As many as 91% of respondents experienced misconceptions while the fraction comparison is second with 63 respondents who experienced misconceptions.
3.1.5. Evaluate

At this stage, an evaluation of the instrument in the form of an online misconception diagnostic test is carried out. The evaluation carried out is proving the content validity using the Aiken index and the instrument reliability test using the KR-21 method. The results of the content validity by the expert judgment on each item are listed in Table 4.

| Number | Material                      | Aiken Validity Index ($V$) | Interpretation of the Aiken Index |
|--------|-------------------------------|----------------------------|----------------------------------|
| 1      | Rational and irrational numbers | 0.85                       | Very valid                       |
| 2      | Real and imaginary numbers    | 0.90                       | Very valid                       |
| 3      | Addition of integers          | 0.80                       | Very valid                       |
| 4      | Subtraction of integers       | 0.90                       | Very valid                       |
| 5      | Multiplication of integers    | 0.85                       | Very valid                       |
| 6      | Division of integers          | 0.80                       | Very valid                       |
| 7      | Exponent of integer           | 0.85                       | Very valid                       |
| 8      | Comparison of integers        | 0.85                       | Very valid                       |
| 9      | Addition of fractions         | 0.85                       | Very valid                       |
| 10     | Subtraction of fractions      | 0.85                       | Very valid                       |
| 11     | Multiplication of fractions   | 0.80                       | Very valid                       |
| 12     | Division of fractions         | 0.90                       | Very valid                       |
| 13     | Exponent of fractions         | 0.85                       | Very valid                       |
| 14     | Comparison of fractions       | 0.90                       | Very valid                       |
| 15     | Addition of decimal numbers   | 0.85                       | Very valid                       |
| 16     | Subtraction of decimal numbers| 0.90                       | Very valid                       |
| 17     | Multiplication of decimal numbers | 0.80          | Very valid                       |
| 18     | Division of decimal numbers   | 0.85                       | Very valid                       |
| 19     | Exponent of decimal numbers   | 0.90                       | Very valid                       |
| 20     | Comparison of decimal numbers | 0.85                       | Very valid                       |

Table 4 shows that as many as 20 items developed have an Aiken's validity index of more than or equal to 0.8, so that all items are very valid.

Furthermore, based on the reliability test using KR-21, the instrument reliability coefficient was 0.814. Based on these coefficients, it can be concluded that overall, the instrument in the form of an online misconception diagnostic test developed was very reliable.

3.2. Discussion

Development research using the ADDIE model has been carried out well. It is able to produce the product as planned in the form of an online mathematical misconception diagnostic test instrument. The five stages of the ADDIE model are very effective for developing a product. This is in line with the results of other development research which states that the ADDIE model is very effective [21,22]. ADDIE is designed for the development of learning designs [15,23] has been proven effective for developing learning designs [24,25], including for the development of blended learning [26–28]. In its
development, ADDIE is also effective for developing learning media [29–34] and also other applications [35,36]. The results of this study reinforce the results of various previous findings.

The results of the evaluation of the product developed to indicate that the misconception diagnostic instrument is very valid. Proof of content validity using the Aiken technique is very effective. This is in line with several other studies that also use Aiken's validity [37,38]. The use of Aiken's validity is very appropriate to know the validity of the contents of an instrument. The results also showed that the instrument developed was very reliable. Therefore, the instrument development process using the ADDIE model is very precise and effective to produce a valid and reliable product.

The instrument developed in the form of an online mathematics misconception diagnostic test has met the aspects of validity and reliability. Thus, the instrument can be used to diagnose misconceptions correctly [16,17,39]. The instruments available online make it easy for users to carry out tests. The test results that are available automatically sent via email are also advantages of this developed application.

4. Conclusion
The development of instruments in the form of online misconceptions diagnostic tests can be carried out well using the stages of the ADDIE model development research. The instrument developed was used to diagnose the misconceptions of mathematical basics, which included addition, subtraction, multiplication, division, and rank operations for integers, fractions and decimal forms. Determination of misconception is based on the level of truth of the answers and the level of confidence in the answers. The results of the validation by the judgment expert show that overall the instrument is very valid and has high reliability. Therefore, this instrument can be used to diagnose misconceptions on the basis of mathematics independently. Students, students, teachers or other users can test misconceptions online and will get diagnostic results that will be sent automatically to the registered email.

5. Acknowledgements
Thank you to the Rector of IAIN Ponorogo for providing support to this research through a novice research grant at IAIN Ponorogo. Our gratitude also goes to students as product users and lecturers who become product validators.

6. References
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