Development physics representational fluency instrument test of electrostatic concept

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Abstract. Physics representational fluency instrument test of electrostatic concept have been developed. The instrument's form of multiple-choice that consist of 20 item electrostatic in physics context to assess pre-service physics teachers' representational fluency. The test includes four component of representational fluency: constructing single representation, constructing multiple representation, translating between representation and reviewing single representation. Representational fluency test is developed using Design and Development Research (DDR) method with four phases consists of analysis, design, development, and evaluation. Validation the structure of the test is consulted with a member of expert academic staff in the field of physics education. After design test and expert review, the test was implemented with 57 pre-service physics teacher. From 20 item of representational fluency test there was 15 item of the test is valid and reliable.

1. Introduction
In the science community, scientific knowledge is communicated through various modalities such as text, images, and mathematical equations. Science teachers have to master representational communication and be aware of students' difficulties in understanding science concepts. Teachers should acquire extensive knowledge of uses in scientific representations, representations, and representational characteristics to describe and explain phenomena, explain complex concepts and interrelationships, demonstrate various linear or non-linear processes, present spatial and temporal, and the dimensions of the phenomenon. The use of representations to understand phenomena and develop students' thinking skills through representations like scientists do, science teachers must be fluent, proficient, and efficient in the use of representations [1].

According to the literature, representational fluency is defined and categorized as student's ability to use, assess, criticize, and manipulate representation [1]. A recent insightful representational fluency is handling inter-representational transformations and combining recognition and conversion competencies [2]. Representational fluency is translating between representations and making meaning in metavisualization competencies [3]. In a very specific and focuses representational fluency is the ability to translate between representations [4] and [5]. Representational fluency is defined as students' fluency in answering questions posed by using more than one representation and translating between representations correctly [6]. In our definition, representational fluency is the ability to construct single representations, translate between representations, multiple representations and review representations that pre-service physics teachers have to master. We are interested in how fluent pre-service physics
teachers are in developing a single concept in a single representation, developing the same concept in multiple representations, translating one representation concept into another and reviewing someone developing a single representation in the static electricity domain.

Development of representational fluency test for teacher training programs are not provided. Existing ones before was representational fluency survey (RFS) for university physics students that consist of a seven item, which is a broad scale multiple-choice survey, that involves the participant solving problems that are difficult due to the representations in the question, rather than the level of physics content knowledge [3], representational fluency in physics and mathematics in the case of linear functions for 9th grade students [5], and representational fluency test for students of electrical engineering in electricity topic [6]. In contrast with the broad scale representational fluency test, we developed the physics representational test fluency (PRFT), our work focuses on the ability to construct representations, the ability to translate between them and ability to review the representation for preservice physics teacher.

The representational fluency tests developed previously were all in the form of multiple choice [3], [5] and [6]. Therefore, in this study a representational fluency test in the form of multiple choice. This study aims to develop a valid and reliable representational fluency so that it can be used to measure the representational fluency of pre-service physics teachers. Preservice physics teacher who are representationally fluent will be able to use them with ease, be able to process information in a variety of representations, be able choose the best representations for a particular purpose, will think in the language of representations, and then will view the world through a representational lens [3]. Preservice physics teacher representational fluency could improved using exercises and well-designed teaching strategies [1] and this PRFT could be used as instrument such test.

2. Method
Trough an observational, non-experimental study design, this research is used to test the validity and reliability of an instrument being developed to assess physics representational fluency of electrostatic concept. Design and development research (DDR) is method that is used in this research. Four phases of DDR that as shown in the Figure 1 consist of 1) analysis, 2) design, 3) development, 4) Evaluation [7]. This study took place in the departement physics education locate in Bandung.

![Figure 1. Scheme of design and development research](image)

First step in developed the PRFT was analysis, started with literature review on existing test instruments related to representational fluency and determine the topic of physics course. In the second step was designed matrixes test representational fluency, base on this matrixes an initial pool of over 20 items was developed. In the third step PRFT then consulted and checked by discipline experts (lecturers and postgraduates) for construct validity. Component of the PRFT related to test item number was shown in Table 1.

| Table 1. PRFT Component Related to Test Item Number |
|-----------------------------------------------|
| PRFT Component                      | Test Item Number |
| Constructing Single Representation   | 4, 6, 7, 10, 12, 13, 17, 18, 20 |
| Constructing Multiple Representation | 11, 15, 19      |
| Translating Between Representation   | 1, 2, 3, 5, 8, 16 |
| Reviewing Single Representation     | 9, 14          |
After validation by expert, PRFT was tested to 57 preservice physics students and item analysis was carried out. Reliability and validity were determined through standard statistical analysis. Using its result, several items were deleted. In this study Pearson’s product moment test, i.e. measuring the correlation between the score of each item and the total score was used to test content validity. Cronbach’s alpha was used to analyzing the estimation of the consistency among items in the instrument reliability test. The final version of the RFT inventory contains 15 items that to be the important representations in static electricity for preservice physics teacher.

3. Result and Discussion
Validity and reliability of PRFT was tested using SPSS 20. Validation is an important process to ensure that the developed instrument is able to measure what it intends to measure and reliability refer to the consistency of the score obtained [8]. Content validity for PRFT was measured statistically using Pearson’s product moment. The table’s $r$ value for 57 samples ($n$) was 0.266. Results of item validity compare with table’s $r$ validity can be seen in Figure 2.

![Figure 2](image)

**Figure 2.** Results of item validity compare with table’s $r$ validity

Figure 2 shows that 5 invalid items of PRFT, i.e. item no. 2, 9, 10, 16 and 20. These items were not included in subsequent analysis. The range of $r$ value for invalid items was -0.02 – 0.24. The instrument that have been developed, after passing through validity test had 15 item with the distribution of component PRFT as show in Table 2.

| PRFT Component Related to Item Number Validity |
|-----------------------------------------------|
| PRFT Component             | Test Item Number |
| Constructing Single Representation | 4, 6, 7, 12, 13, 17, 18 |
| Constructing Multiple Representation      | 11, 15, 19       |
| Translating Between Representation        | 1, 3, 5, 8       |
| Reviewing Single Representation            | 14               |

Reliability refers to a measurement that yields consistent results every time it is being used. Reliability of 15 item of PRFT with cronbach's alpha was resulted 0.707. The alpha test being developed by Cronbach was the test used to test the internal consistency among items statistically. PRFT is acceptable with the categorized having middle reliability (0.45-0.98).

After analyzed validity and reliability, the 15 items was analyzed in the average of difficulty index and the average of discrimination index. The average of difficulty index for 15 item was 0.50 with the standard deviation was 0.12. The average of difficulty index of 15 item PRFT in moderate interpretation ($0.30 \leq p \leq 0.70$). The difficulty index with interpretation easy only two item and difficulty index with interpretation moderate 13 items. Scatter plot of difficulty index can be seen at Figure 3.
The distribution percentage of difficulty index can be seen at Figure 4. There was 87% ($0.30 \leq p \leq 0.70$) in moderate interpretation and 13% ($p > 0.70$) with easy interpretation.

The average of discrimination index for 15 item PRFT was 0.37 with the standard deviation was 0.12. The average discrimination index is reasonably good ($0.30 \leq D \leq 0.39$). Scatter plot of discrimination index can be seen at Figure 5.

The distribution percentage of difficulty index and discrimination index can be seen at Figure 6. There were 40% ($D > 0.40$) very good, 27% ($0.30 \leq D \leq 0.39$) reasonably good and 33% ($0.20 \leq D \leq 0.29$) in marginal item.
4. Conclusion
Using Design and development research (DDR) method in this research and data analysis, it can be concluded that, of the 20 items that have been developed, there are 15 items that are categorized as valid. The fifteen questions that were declared valid had a Cronbach Alpha reliability level of 0.707. This shows that the fifteen items have high reliability, so that they can be used to validly and reliably measure the representational fluency of students. In addition, the fifteen test items represent the four aspects of representational fluency, namely: constructing single representation, constructing multiple representation, translating between representation and reviewing single representation.

5. References
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