Design and development of representational fluency test in physics

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Abstract. The purpose of this research is to design and develop test representational fluency in physics course for electricity topic for students of electrical engineering. The representational fluency test used system Design and Development Research (DDR) with four phase of development consists of analysis, design, development, and evaluation. The test was validation by five expert judgement. The test consists of 20 item multiple choice. After design test and expert review and validation. This research was conducted at the Universities in Lampung and was implemented with 25 participants. The result in this research was the test is valid and reliable to program implementation.

1. Introduction
Communications is part of way of working in 21st century skills [1]. Communication could be supporting with representation. Representation is important in learning for use in student in engineering [2]. In science, representations is very important too [3] and make communication effective and efficient. Representations is consisting of verbal, mathematical, picture, graphs, tables, diagram [4,5]. Representational fluency is cognitive competence [6,7]. Representational fluency is the fluency of students answering the questions asked using more than one representation and correctly translating between representations. Representational fluency is the ability of students to represent concepts and accurately translate between representations [8]. Students who can solve problems with multi-representations can train the representational fluency. But in fact, students are still having trouble solving problems using more than one type of representation. Physics test instruments used during lectures also still train many types of mathematical representations. So that students have difficulty understanding other types of representation.

Physics in the electrical engineering is one of the compulsory subjects. Physics in the electrical engineering is very useful to help students solve problems. The topic of electrostatic and electrodynamic in physics course is closely related to the topics of advanced electrical engineering course.

The representational fluency is interpreted as the fluency of students answering the questions asked using more than one representation and correctly translating between representations. In this study the representational fluency is interpreted as the ability to translate between representations [5]. Representational fluency is measured by developing representational fluency test. Therefore, this study purpose to develop a valid and reliable representational fluency test so that it can be used to
measure the representational fluency of student. The representational fluency test (RFT) are presented in the multiple-choice test.

2. Methods
Method in this research used design and development research (DDR). DDR types product and tool research have four phases. The four phases consist of 1) analysis, 2) design, 3) development, 4) Evaluation [9]. This research will be conducted on students for physics course at one of University in Lampung and the topic is electricity.

![Figure 1. Design and Development Research (DDR) (adoption by Richey and Klein, 2007)](image)

Based on Figure 1, there are four phases. At the first phase is analysis learning outcome physics course in engineering. In this phase, researcher identify topic, select topic to be developed they are electrostatic and electrodynamic. At the second phase is design. In this phase, researcher design matrixes test representational fluency. At the third phase is development. In this phase, validations test representational fluency, revision from expert judgement, and field testing the test representational fluency. The fourth phase, revision test representational fluency after field testing.

3. Result and Discussion
3.1. Analysis
The physics course is one of the subjects in the electrical engineering study program. In the first phase, namely analysis, determine the topic of physics course. After that determine the learning outcome, then determine the learning outcomes of the study program then determine the learning outcomes of the course.

3.2. Design
At the design stage, it starts from making representational fluency test matrix. The topic chosen in the physics course consisted of two topics namely electrostatic and electrodynamic. The question consists of 20 item multiple choice. The electrostatic problem consists of 10 questions and the electrodynamic problem consists of 10 questions. Test items are formulated with transitions from six representations: verbal, mathematics, picture, table, diagram, and graph. This result 20 test items in nine representation transitions: Verbal to Mathematics (VM), Verbal to Picture (VP), Verbal to Graph (VG), Picture to Verbal (PV), Picture to Mathematics (PM), Picture to Table (PT), Picture to Diagram (PD), Graph to Verbal (GV), Graph to Mathematics (GM).

3.3. Development
In the development test phase, 20 questions about the representational fluency test were tested for validation by the expert judgment. The test of representation is corrected based on suggestions and criticisms from the expert judgment. After test representation fluency was corrected and then tested in 25 students.
3.4. Evaluation
In the evaluation phase of the representational fluency test, validity and reliability were tested using SPSS. Reliability results with Cronbach’s alpha 0.784 is acceptable and the categorized as having middle reliability [10]. This is in line with stating that 0.45-0.98 is acceptable [11]. While the results of item validity per question can be seen in Figure 2.

![Validation 20 item multiple choice](image)

**Figure 2.** Validation 20 item multiple choice

Based on Figure 2, the 20 items of multiple choice correlations are in the medium and high categories. The 20 items was analyzed, the mean of difficulty index is 0.59 and the standard deviation is 0.13. The mean of discrimination index is 0.51 and the standard deviation is 0.14 (see Table 1).

| Parameter               | Mean | Standard Deviation |
|-------------------------|------|--------------------|
| Difficulty index (p value) | 0.59 | 0.13               |
| Discrimination index    | 0.51 | 0.14               |

The distribution 20 item difficulty index of multiple-choice is acceptable. They are any 90 % or 18 items from 20 item test with moderate item and 10 % or 2 items with interpretation easy. The general discrimination index is very good, there are 90 % or 18 item test and 10% or 2 item with marginal item (see Table 2).

| Parameter               | Item statistic | Interpretation | Total Item (%) |
|-------------------------|----------------|----------------|----------------|
| Difficulty index (p value) | p > 0.70       | Easy           | 10             |
|                         | 0.30 ≤ p ≤ 0.70 | Moderate       | 90             |
|                         | p < 0.30       | Difficult      | 0              |
| Discrimination index (D) | D > 0.40       | Very good      | 90             |
|                         | 0.30 ≤ D ≤ 0.39 | Reasonably good| 0              |
|                         | 0.20 ≤ D ≤ 0.29 | Marginal items | 10             |
|                         | D < 0.20       | Poor items     | 0              |

The distribution percentage of difficulty index and discrimination index can see at figure 3 and 4.
There are only two item difficulty index with interpretation is easy, number 10 and 15. Items difficulty index with moderate item are number 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 20. Two item with discrimination index reasonably good, there are number 1 and 13. Items with discrimination index very good are 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14, 15, 16, 17, 18, 19, 20. The Scatter plot of difficulty index and discrimination index 20 items can see at Figure 5 and 6.

**Figure 3.** Distribution percentage of difficulty index  
**Figure 4.** Distribution percentage of discrimination index

**Figure 5.** Scatter plot of difficulty index  
**Figure 6.** Scatter plot of discrimination index
4. Conclusion
This research a validated 20-item multiple-choice test representational fluency on the topic of electrostatic and electrodynamic. Based on the results, the test has a middle Cronbach’s alpha of 0.784. All of 20-item multiple choice are valid and reliable.

5. References
[1] Griffin P, McGaw B and Care E 2012 Assessment and teaching of 21st century skills New York: Springer
[2] Heywood J 2005 Engineering education: research and development in curriculum and instruction (United States of America: Institute of Electrical and Electronics Engineers John Wiley & Sons Inc. Hoboken) chapter 12 289
[3] Aldrich F and Sheppard L 2000 Graphicacy: the fourth R? Primary Science Review 64 8-11
[4] Waldrip B, Prain V and Carolan J 2006 Learning junior secondary science through multi modal representation Electronic journal of science education 11 1
[5] Ceuppens S, Deprez J, Dehaene W and Cock M D 2018 Design and validation of test for representational fluency of 9th grade student in physics and mathematics: The case of linear functions Physical review physics education research 14 020105
[6] Sandoval W, A Bell P, Coleman E, Enyedy N and Suthers D 2000 Designing knowledge representations for epistemic practices in science learning paper presented at Annual Meeting of the American Educational Research Association New Orlean LA
[7] Gunpinar Y, Pape S J 2018 Teachers’ instructional practices within connected classroom technology environments to support Representational Fluency Journal of Computers in Mathematics and Science Teaching 37 1 27-52
[8] Moore T J, Miller R L, Lesh R, A. Stohlmann M S and Kim Y R 2013 Modeling in Engineering: The role of representational fluency in students’conceptual understanding Journal of Engineering Education 102 1 141-178
[9] Richey R C and Klein J D 2007 Design and development research Mahwah NJ: Lawrence Erlbaum Associates Publisher
[10] Arifin Z 2009 Evaluasi pembelajaran Bandung: PT Remaja Rosdakarya Publisher
[11] Taber K S 2017 The use of cronbach’s alpha when developing and reporting research Instrument in Science Education Res Sci Educ 48 1273-1296

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