Research Article

Profile of Pre-service Physics Teachers' Representational Fluency on Electrostatic Concept

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Abstract.
Science teachers have to master representational to communicate and be aware of the students’ difficulties in understanding science concepts. This study aims to determine representational fluency as part of science communication skills in pre-service physics teachers. This study uses descriptive analysis techniques based on the percentage. The research subjects are 50 pre-service physics teachers aged between 19 and 22 years. This study was conducted at the Study Program of Physics Education of a college in Maluku. How fluent is a pre-service physics teacher in representing the concept of electrostatic was measured using 15 valid and reliable representational fluency multiple choice test that includes four component of representational fluency: constructing single representation, constructing multiple representation, translating between representation and reviewing single representation. The findings of the present study indicate that although students had started to learn concepts of electrostatic their representational fluency is still low. The preservice teachers’ rate of giving correct answers to the test items varies between 8% and 48%. The mean score of the pre-service teachers was found to be 4.06.

Keywords: representational fluency, electrostatic

1. INTRODUCTION

The abstract and complex nature of science and the multimodal nature of scientific language (i.e, linguistic, visual, audio, gestural, spatial) place pedagogical and content demands on teachers. Therefore, to make abstract and complex science content more accessible to students, teachers need to have skills in using various forms of representation. The concept of pedagogical content knowledge [1], which later developed by linking content knowledge and explanations and representations generated during teaching [2], implies that teachers’ use of various modes of representation in science classrooms as the basis of today’s global communication through representation considered a multi-representational pedagogy [3]. To facilitate the teaching of science concepts, teachers should be able to effectively select and use multiple representations of appropriate content including text, pictures, diagrams, graphs, tables, images and sounds in animation to communicate, promote student interpretation, understanding, explanation, and even creation of representations [4].

The ability to use various types of scientific representations coherently, efficiently, and effectively is known as representational fluency [5–7]. Representation is the language of physics, the teacher must be a representative agent who is fluent in communicating and aware of students' difficulties in understanding science concepts. Teachers who are fluent in representation will be able to understand representations and use them easily. They will be able to process information in various representations (or combinations of representations) and be able to choose the best representation for a particular purpose.

Aspects of representational fluency emerged in the literature through the integration of three perspectives namely visualization competence, metarepresentational competence and representation competence [6]. Visualization competence is defined as the process of making meaning from representations [8]. This representational fluency perspective focuses on the criteria for understanding all dimensions of representation (1D like equations, 2D like graphics, 3D like physical objects) and three levels (macro, submicro and symbolic). Metarepresentational competence (MRC) is another perspective of representational fluency. The main focus of MRC is a metacognitive approach to representation in which individuals can understand the rationale and design strategies for creating certain representations. The MRC view includes the ability to create or discover new representations, understand, explain, and critique representations for adequacy of use and learn new representations quickly [9]. Representational Competencies take a closer look at a specific constellation of representational domains, working exclusively in physics, chemistry or biology [10]. The term representation competence is also used for abilities in certain representations. Representational fluency, described in this paper, is an integration of these three perspectives. Each perspective has certain elements, such as the importance of translating between representation and making meaning in metavisualization, metacognitive skills required for meta-representation competence, and recognition of domain-specific representation competencies.

Referring to the integration of the three perspectives that have been described, we developed and validated an assessment consisting of 15 constructed response items which were multiple choice questions to engage pre-service physics teachers (PPT) in three components of representational fluency to evaluate their representational fluency on the topic of static electricity consisting of from 1) the ability to construct single representations, 2) translating between representations, 3) multiple representations and

4) reviewing representations that must be mastered by prospective physics teacher students. We then used the assessment instrument to survey how well the student physics teacher candidates performed on fluency in the representation of static electricity after they received textbook-based instruction and problem solving. Representation is very important in the study of static electricity, because research shows that the concept of static electricity is problematic because of its invisible and complex physics concept [11]. Representing static electricity concepts and interpreting static electricity visualizations to relate observable phenomena are important for students to develop an integrated understanding [12, 13]. The purpose of this study is to determine the profile of PPT representational fluency on the topic of static electricity. The question to be answered is what is the profile of PPT representational fluency on the topic of static electricity. The results of this study provide insight into what challenges arise for prospective physics teacher students to be representationally fluent when teaching. The results of this study can also be used as a reference in developing learning strategies that can train representational fluency.

2. RESEARCH METHOD

This study uses a descriptive method, which is to explore the facts on the field and present the actual conditions. This descriptive method is used to describe pre-service teachers' skills in representational fluency after having received regular textbook-based and problem-solving instruction. The target population in this study is the fourth-semester students. The participants of the study were 50 pre-service physics teachers (PPT) ranging in age from 19 to 22 years. This study was conducted at Study Program of Physics Education of a college in Maluku Indonesia in the even semester of 2021-2022 academic year.

Pre-service physics teachers' representational fluency was identified using 15 items valid and reliable multiple- choice test questions on the concept of electrostatic [14]. We used a multiple-choice test because it refers to previous studies [6, 15, 16], where they used a multiple-choice test to measure representational fluency. The representational fluency test includes four components: constructing single representation (CSR), constructing multiple representation (CMR), translating between representation (TBR) and reviewing single representation (RSR). Some sample items used in the study are presented in Figure 1. The data that has been collected is then processed and analyzed using descriptive analysis techniques based on the percentage of students who answered correctly and incorrectly from the given representational fluency test. The percentage interpretation is based on the interpretation of proposed by Arikunto [17] is presented in Table 1.

TABLE 1: Interpretation of pre-service physics teachers' representational fluency.

No.	Percentage (%)	Interpretation
1	0	None
2	1-25	A small portion
3	26-49	Almost half
4	50	Half
5	51-75	Mostly
6	76-99	Almost entirely
7	100	All

3. RESULTS AND DISCUSSION

The scores that can be taken from the multiple-choice test used in the study ranged from 0 to 15, the lowest score to be obtained from the test was 1 and the highest score was 8. Frequencies and percentages of the correct responses of the PPT to 15 multiple-choice items related to the type of representational fluency are presented in Table 2.

TABLE 2: Frequencies and percentages of the correct responses items related to the type of representational fluency.

Item	Frequency	%	Type of Representational Fluency	Item	Frequency	%	Type of Representational Fluency
1	10	20	TBR	9	18	36	CSR
2	10	20	TBR	10	20	40	CSR
3	12	24	CSR	11	15	30	RSR
4	16	32	TBR	12	15	30	CMR
5	4	8	CSR	13	15	30	CSR
6	8	16	CSR	14	17	34	CSR
7	24	48	TBR	15	9	18	CMR
8	11	22	CMR				

Description: CSR: constructing single representation; CMR: constructing multiple representation; TBR: translating between representation;
RSR: reviewing single representation

The highest rates of correct answers were obtained for the items 7. This item is to test the representational fluency in the aspect of translating between representation. In this aspect, PPT is asked to translate the mode of representation text into the mode of mathematical equations of the electric fields. There are 48% (almost half) PPT gave the correct answer by choosing option A. Representations in the mode of mathematical equations in representing electric fields are well known to PPT because mode of mathematical equations is generally used by PPT in solving physics problems. This result provides evidence that learning experience of the content plays an important role in representational fluency in the case of electrostatic. Mathematics is understood as a method of problem solving but not as a constructive thinking tool with a physical interpretation [18]. Question item 7 is shown in Figure 1 (b).

5.Two electrically charged objects, namely +Q and +2Q, are initially separated by a distance r, then the two charges are moved so that the distance between the two charges becomes 2r. The electric force of the two charges obeys Newton's third law. The correct table representation is shown by…

Charge I	Charge II	Distance	Force F_{12}	Force F_{21}
+Q	+2Q	r	F	2F
+Q	+2Q	2r	F/2	2F/4

a.

Charge I	Charge II	Distance	Force F_{12}	Force F_{21}
+Q	+2Q	r	F	2F
+Q	+2Q	2r	2F	4F

b.

c.

Charge I	Charge II	Distance	Force F_{12}	Force F_{21}
+Q	+2Q	r	F	F
+Q	+2Q	2r	F/4	F/4

c

Charge I	Charge II	Distance	Force F_{12}	Force F_{21}
+Q	+2Q	r	2F	4F
+Q	+2Q	2r	F	2F

d.

(a) Item 5

7. The electric field strength at a certain distance from a source charge is directly proportional to the magnitude of the charge and inversely proportional to the square of the distance. The statement when expressed in a mathematical equation representation, is...

$E = k\frac{Q}{r^2}$ a.

$E = k\frac{Q}{r}$ c.

$E = \frac{Q}{r^2}$ b.

$E = \frac{F}{Q}$ d.

(b) Item 7

Figure 1: Example of representational fluency test.

As can be seen from Table 1, the preservice teachers' lowest rate of giving correct answers were obtain for the items 5. Item 5 relates to the PPT representational fluency test in constructing a single representation. The single representation that the PPT must construct is a representation of the Coulomb force acting on two charges in different magnitude with varying distances expressed in tabular representation mode. Question item 5 is shown in Fig. 1(a), where the correct answer is option C.

In order for PPT to be able to construct representation in the modus table, there are at least three steps they have to do. The first step is to determine the magnitude of the Coulomb force on each of the two charges. Then determine how the Coulomb force changes on each of the two charges if the distance between the two charges changes. Furthermore, the PPT must fill in the table each component involved in Coulomb's law. Based on the selected answers by PPT, where 42% of PPT chose option A and 38% of PPT chose option B, the analysis we can propose is that students assume that the Coulomb force acting on the two charges is different in magnitude on each charge (F_{21}>F_{12}, because Q_2>Q_1). The next analysis is why the majority of students are wrong in answering representations in tabular form, because Coulomb's law in tabular representation mode is rarely found in physics textbooks used in Indonesia, generally in textbooks Coulomb's law is expressed in text representation mode and mathematical equation representation mode. This condition is in line with research which states that based on a survey that, on average, the students indicated that 44.3% of the time the idea expressed in their representation came from their textbooks [19]. Students' fluency in constructing the table representation mode needs to be improved and the teacher needs to master it well because students preferred tables, because they were more understandable than other representations [20].

The preservice teachers' rate of giving correct answers to the test items varies between 8% and 48%. The mean score of the pre-service teachers was found to be 4.06. This mean score showed that the test scores of the most pre-service teachers were low. For teachers, translation among modes of representation skills have to be mastered and they should move smoothly between various representations because he/she will teach a new concept to his/her students. Lemke has noticed that to understand and use a scientific concept, someone has to be able to translate back and forth among representation of the concept [21]. This implies that all attempts by teacher to understand concepts in science entail representational work [22]. Generally speaking, the concept of representational fluency is an important aspect, it is at the core of medium and higher levels of abilities which constitute representational fluency [23].

4. CONCLUSION

Representation is the language of physics, therefore the teacher must be fluent in the representation of physics concepts in order to be able to use it easily when realizing students' difficulties in understanding science concepts. Representational fluency needs to be provided to pre-service physics teacher. To ensure that the pre-service physics teacher developing adequate representational fluency during their undergraduate studies is the responsibility from the physics department. Various possible strategies need to be developed to overcome student deficiencies representational fluency and how these strategies are put into practice in facilitating the efforts of physics lecturers to change the teaching of physics in a way that is more suited to the needs of today's students.

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