The use of classroom assessment based on multi-representation ability in Mechanics concept

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Abstract. This study aimed to describe the use of classroom assessment based on multi-representation ability. This research used descriptive research method. Research participants were 20 prospective physics teacher at one university in Indonesia, who attended basic physics course. Research instruments used questionnaires and essays test based on multi-representations. The results showed that the learning process only use summative assessment which focuses at the end of material and learning units. Learning process and assessment in Basic Physics Course used one or two representational modes, so those did not facilitate simultaneous representation modes. The result described that only 42\% prospective physics teachers representation ability was good category (75-84 attainment) on mathematical representation. The recommendation of this study is to develope learning program, formative, and diagnostic assessment based multi-representation in Basics Physics Course.

1. Introduction
Physics is a part of natural science that aims to study various phenomena or processes of nature, nature of matter, and its application. Nature phenomena is formed by one or more physical quantity that are interconnecting and interacting. Analysed and explained process of natural phenomena requires application of representation form. Representation ability is an ability to interpret concept in certain formats or modes to solve problem appropriately [1]. Cognitive taxonomy study divides representation into internal and external representation [2]. Mental representation is built into mind or individual mental. Individual heard, seen, perceived was represented mentally in individual minds. External representation is an observable physical form such as verbal, graph, diagram, and mathematic [3]. Knowledge coherent structure is composed of development internal and external representations [4]. External representation is another name of multi-representation, both name are applied alternately in various journals. Alternative multi-representation physics abilities are verbal, diagram, graph, and mathematic representation [5,6].

Learning process and assessment are closely related to each other. Implementation of learning process and assessment based on physics characteristics [7]. Learning and assessment will be effective if the students are able to explain physics concept with different representation. Multi-representation ability are key to physics learning [8]. Learning process focuses on how to describe a concept with multi-representation, will increase learning effectiveness and student physics concept understanding. Some
studies explained benefits multi-representations strategy in learning process, a) use of simultaneous representation enable students to visualize relationships between concepts and enhance students’ deep understanding of scientific phenomena, b) multi-representation provided information level affect content explanation and student concept understanding, c) multiple representations allowed student to use different ability in exploring phenomena, this supported students’ knowledge integration [9].

Assessment is collecting process and interpreting information to make decisions student, teaching, curriculum, program, and education policy [10]. Physics has different characteristic with other scientific studies. Assessment strategies selection is based on the nature of physics concept. Multi-representation based assessment facilitate ability to translate physics concept with different representations. Physics concept is closely related to representation ability. Students have good understanding of concepts if they have good multi-representation understanding [11].

Assessment strategies that develop multi-representation ability in physics learning. There are summative assessment, formative assessment, and diagnostic assessment [12]. Summative assessment are conducted periodically at the end of one unit, one semester, or one year. The result of assessment information is used to decision making how well student achievement and its conclusion is reported at the end of semester [13]. Formative assessment are conducted throughout the classroom. Assessment information is used for feedback teaching and learning process in the sort-term future [14]. Diagnostic assessment identified characteristics, strengths, weaknesses students’ knowledge, skills, abilities, learning difficulties, and its aim provided advice and guidance for students and teachers on particular learning [15].

This study aimed to describe of the use of classroom assessment based on multi-representation ability in Basic Physics Course. The result of this study are expected as foundation to develop learning and assessment based multi-representation.

2. Research method
This research used descriptive research methods. This study was a preliminary study as foundation for development of subsequent research. Research stages included field observation, problem identification, data collection using multi-representation essay test and questionnaire, data analysis, and report preparation. Research participants were 20 prospective physics teachers, who attended basic physics course at one University in Bandung.

Questionnaire was used to obtain data implementation of learning process and assessment in Basic Physics Course. The questionnaire was composed of 11 items yes and no questions, and 4 items open-ended questions. Open-ended question dug in-depth information from previous questionnaire items. Components questionnaire gathered information: learning process, student learning difficulties of mechanics concepts, and assessment use. Quantitative of questionnaire responses were analysed in percentages. Qualitative of questionnaire responses analysed tendencies for open-ended question items.

The data of multi-representation ability were obtained using multi-representation essay test (verbal, diagram, graph, and mathematics) on mechanics concept, including kinematics, circular motion, dynamics, equilibrium, work and energy. Scoring test response used a rubric with 0-5 scale. Multi-representation ability were categorized into five categories very good, good, sufficient, poor, very poor [16]. Score ranges of each category were described 100-85 as very good category, 84-75 as good category, 74-65 as sufficient category, 55-64 as less category, and 0-54 as very less category.

3. Result and discussion

3.1. Multi-representation implementation on learning process and assessment
Questionnaire used to uncover implementation multi-representation on learning process and assessment, students’ difficulties in learning mechanics concept. Two types of questionnaire were used to data collection research, which these were closed and open response. The aspects of closed statement questionnaire were described in table 1.
Table 1. The aspects of closed statement questionnaire.

| Aspects                                      | Statements                                      | Codes |
|----------------------------------------------|-------------------------------------------------|-------|
| Multi-representation application on learning process | Know the purpose of basic physics course         | L1    |
|                                               | Know the description of basics physics course    | L2    |
|                                               | The teaching material used in basic physics course based multi-representation | L3    |
|                                               | The courses material were presented in multi-representation design | L4    |
| Student difficulties learn mechanics concept | Learn mechanics concept                          | D1    |
|                                               | Using diagram representation when learning mechanics concept | D2    |
|                                               | Using mathematical representation when learning mechanics concept | D3    |
|                                               | Using verbal representation when learning mechanics concept | D4    |
|                                               | Using graph representation when learning mechanics concept | D5    |
| Multi-representation application in the assessment | The task facilitated multi-representation application | A1    |
|                                               | Assessment was done during the learning process  | A2    |
|                                               | The exam question facilitated multi-representations application | A3    |

Table 2 illustrated the learning process did not facilitate multi-representation. Students had difficulties understanding mechanics concept. Statement of D2 described mathematics representation more dominant applied during the learning. Statements of student indicated students’ major difficulty when applying multi-representation ability in learning mechanics was verbal representation (D2, D3, D4, and D5). Students’ statements indicated that assessment did not facilitated multi-representation student (A1, A2, and A3). Assessment strategies tended to summative by organizing assessment on each unit of matter, middle and the end of semester.

Table 2. Responses percentage of students to learning process and assessment implementation.

| Codes | Yes (%) | No (%) |
|-------|---------|--------|
| L1    | 84      | 16     |
| L2    | 74      | 26     |
| L3    | 11      | 89     |
| L4    | 21      | 79     |
| A1    | 37      | 63     |
| A2    | 32      | 68     |
| A3    | 32      | 68     |

| Difficult (%) | Easy (%) |
|----------------|----------|
| D1             | 84       | 16      |
| D2             | 74       | 26      |
| D3             | 11       | 89      |
| D4             | 21       | 79      |
| D5             | 37       | 63      |

Table 3 described open responses questionnaire, as closed response questionnaire support. The analyzed of students answer result involved Q1: a) difficult topics mechanics include rotational motion, rigid bodies rotation, centre of mass, b) some student reasons were difficulties to relate physics variables in rotation motion, force types acting in topics dynamics were abstract so difficult to visualize in problem solving. Students response Q2 statement were a) multi-representation were a technique to describe a concept, multi-representation were multi-stage as a means to facilitate understanding physics concept. Students’ responses statement Q3 were a) Microsoft PowerPoint media was used in lecturing process, b) the use of representation verbal and diagram in explaining mechanics concepts. Some response of
students to Q4 statement were a) reference textbook assignment, b) quiz each completed a material unit, c) written test conducted every mid and the end of semester, d) task, quiz, and examination format tended to facilitate mathematics representation ability.

Table 3. Free response questionnaire statements.

| Statements                                | Codes |
|-------------------------------------------|-------|
| Mechanics concept topics were difficult and the reason | Q1    |
| Understanding multi-representation ability | Q2    |
| Lecturing process on basic physics         | Q3    |
| Assessment during Basic Physics lecture process | Q4    |

The result of open response questionnaire analysis showed: some mechanics topics were still considered difficult, lecturing process using instructional media variation, and tendency to use one of representation mode not yet facilitated some simultaneous representation modes. Assessment characteristics were summative assessment, with tasks format and exam question focused on facilitating mathematics ability. Learning and assessment facilitated students in learning physics concepts, but less than maximum because students’ physics concepts understanding were still partial. Student tended to excel only one representation ability. According to expert students’ understanding of concept physics increased when representational modes were applied simultaneously to the learning process and assessment [17,18].

3.2. Multi-representation profile of prospective physics teachers

Table 4 shows that verbal representation ability is entirely in very poor category (100%), student’s mathematical representation is small in the good category (42%), diagram representation is mostly in very poor category (89%), graph representation is entirely in very poor categories (100%). Based on multi-representation ability categorization, most students were good category on mathematical representation (42%). Prospective physics teacher perception mechanics concepts were a collection of mathematical representation and mathematical representation most often use in solving problem. Students were expert mathematical representation without understanding the physical meaning of mathematical representation and mechanics concept application to everyday life. Students may have requisite mathematicial knowledge that needs applied to a physical situation, but they fail used it to solved problem because they are unaware of its usefulness [19]. Students are belief that learning consists of memorizing facts and mathematics formulas provided by teacher [20].

Table 4. Profile of multi-representation ability prospective physics teacher.

| Ability Categories | Percentage of Multi-representation Ability |
|--------------------|-------------------------------------------|
|                    | Verbal | Mathematics | Diagram | Graph   |
| Very Good          | 0      | 5           | 0       | 0       |
| Good               | 0      | 42          | 0       | 0       |
| Sufficient         | 0      | 21          | 5       | 0       |
| Poor               | 0      | 16          | 5       | 0       |
| Very poor          | 100    | 16          | 90      | 100     |

Verbal representation ability was entirely in very poor category (100%). Several stage of the students solve problem: write physicals quantities and units, write mathematical equations related to physics concepts in question, and solve mathematical equation calculation by applying discoverer quantities physics in question. The findings show that students focus on solving mathematics question relate to physics concept and their solving without verbally defining mathematical question. According [21] student rarely use verbal (qualitative) representation in solving problem, although they understood integrating verbal representation to help understand physics concept.
Other representation very poorly was graph representation. Some student errors apply graph representation, a) forming variable types on x and y-axis, b) determining whether the variable is on the x or y-axis, c) interpreting data pattern in the graph. Another mistake in applying graph representation students have difficulty interpreting the graph slope and determining x and y-axis scale [22]. Students difficulties applied graphical representations a) more difficult to interpret curve graphs than the straight graph, b) focus more on data interpretation in x and y-axis than graph slope, c) area interpretation below graph [23]. Graph interpretation was an important part of physics this ability integrated when students perform physics experiment [24].

4. Conclusion
Assessment characteristic tends summative assessment which focuses at the end of material and lecture units. The learning process used one or two representation modes which did not use multiple representations simultaneously. Task, quizzes, and exam question formats focus on mathematical representation application. Profile of prospective physics teacher representation ability was categorized well on mathematical representation. Findings of the research need to follow of developing lecture program, formative, and diagnostic assessment based multi-representation.

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