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# Exploring Multiple Representation Preference to Develop Students Misconception Inventory in Measuring of Students Science Conception Awareness

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**Abstract:** Representation is a form that can describe a certain material concept. In physics learning, students are required to be able to present a concept of physical matter into various possible forms of representation. The ability of students to use multiple representation indicates that the students have fully understood the concept of physics (no misconception occur). Facts that occur in the field is still limited form of representation used by teachers when teaching physics, so it is still possible to students misconception. This study aims to explore Multiple representation preference used in the process of physical learning to develop SMI in measuring students science conception. Method used is qualitative method through semi-structured interviews to teacher and students. It uses simple random sampling technique. Exploration results based on deeply structured interviews to teacher and students have shown that there are several aspects of sources and causes students' misconception. The results of analysis also obtained a number of qualitative information which supports the development and validation of the instrument to measure the degree of students science conception. This instrument can be used to identify misconception and level awareness of students conception.

**Keywords:** Multiple representation; Students Misconception Inventory; Science conception.

## 1. Introduction

Nowadays for most students, physics is still a difficult subject to be understood. So most of them are not interested in studying physics seriously and deeply. This condition happens as a result of their experience after following physics learning process in the class. Learning experience they got in the class less accommodate prior learning experience (prior knowledge). This phenomenon can be easily observed, it is because some teachers only teach physics concepts by explaining its definition and formula only. The perceived impact is the lack of students' ability in using the concepts, so students only tend to memorize the concept by themselves. Actually this condition can be avoided by a meaningful learning process through teacher expertise in connecting between the concepts that have been studied and what is being studied (Learning object). So, students have an empirical experience with the learning object. Students' involvement in interacting with learning object can provide an opportunity for students to build their knowledge.

Not all learning objects used to study physics phenomena can be observed directly. Therefore, teachers should be able to mix all learning components and present them in learning process to help students understand material which is going to be learned. To simplify process of analysis and explanation of physics natural phenomena teachers usually use a variety of representations.



Representation is a configuration (form or arrangement) that can describe or represent something in a way [1]. Students's ability using representation in physics learning process is very important for students' science knowledge understanding process. Representation helps students to form knowledge and problem solving [2].

Certain physical materials can be presented using multiple representations, in other words can be called mutirepresentation. Multiple representation also means re-representation of same concept with different formats, including verbal, images, graphics, and mathematics [3]. Different formats or modes of representation in a learning process will provide a good opportunity for students to understand concepts and communicate them [4], [5].

A learning process that uses mutirepresentation in presenting physics material in a classroom will increase opportunity for teachers to see students' ability in understanding concept of the taught physics material. Students will have difficulty to solve the problems, if they are unable to represent the concepts into various forms [6]. However, there are still limited forms of representation used by teachers during physics learning process in the classroom. The limitation of representational format used will prevent students from having ability to solve physics problem [7]. For example teachers tend to use more verbal explanations, and students are not challenged to explain the same physics concept by using other representations such as graphics, images, or diagrams [8]. Other representations, such as graphic should be used in learning process because graphics can play an important role in helping students deepen their understanding in physics concepts [9].

The use of multiple representation also needs to be applied in the learning process because students' ability in examining a particular representation will be different each other [10]. In addition, the use of multiple representation also helps students to understand abstract physics concepts such as concepts of quantum physics, which involves very small physics systems. Through multiple representation learning process, students will be able to master the concept comprehensively [5].

Multiple representation should be the main strategy in physics learning process. It is based on two arguments. The first argument is the study of physics at school should reflect learning model that leads to process of knowledge search and knowledge products introduction. The second argument is that varied approaches must always implement in every physics learning [11]. In addition, there are three main functions of multiple representation; as a complement in cognitive process, helping to limit the possibility of other misinterpretations, and building a deeper understanding of concepts [12].

Based on the results of preliminary observations made using questionnaires with teachers and students, it is known that teachers tend to always use mathematical equations and verbal representations to teach physics in the class. Whereas other representations, such as images, diagrams and graphical representations are rarely used. In physics learning process, students still get difficulties in understanding representations used during the learning process. The use of mathematical equation representations: (i) students find it difficult to understand the mathematical equations associated with concept of certain physics material; (ii) students find it difficult to process data based on mathematical equations used (low mathematical ability of students); (iii) students find it difficult to explain relationship between physics quantities contained in certain mathematical equations. The use of verbal representation: (i) students tend to memorize certain physics concepts; (ii) students find it difficult to re-explain it using their own language related to certain physics concepts.

Learning process presented by teachers using a limited representation format (limitation of representation) cannot be separated from misconception possibility in students related to physics material delivered during learning process in the classroom. Based on data that has been obtained, there are 20% of students who often experience misconception of physics material, while the rest have experienced it. Misconception on certain physical materials will certainly have an impact on students' understanding of next physics materials. Therefore, teachers need to actively criticize causes of misconceptions that occur in students who are thought by them. It is necessary, so that teachers can prepare appropriate learning strategies to correct student misconceptions [13].

In order to obtain a formulation of a multiple representation based learning strategy, a diagnostic scale instrument of SMI instrument is required. SMI instrument is used to determine caused factors

and solution of misconceptions experienced by students in understanding physics material concept. To obtain appropriate SMI instrument, an explorative research involving teachers and students is needed as a source of information for emergence of SMI instrument components, ideas, and structures.

The rest of this paper is organized as follow: Section 2 describes the proposed research method. Section 3 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

## 2. Research Method

This section describes the proposed research method.

### 2.1 Participants

This research involves 38 students and 2 teachers in YP Unila Senior High School. It uses simple random sampling technique. Students involved in this research is based on students' volunteering to be interviewed related to the use of representations in physics learning process.

### 2.2 Procedures

The method used is qualitative method using semi structured interview to teachers and students. Interviews were conducted using interview protocols to determine type of representation used and possibility of misconceptions during physics learning process in the class. Firstly, before semi structured interviews to teachers and students were conducted, observations have been made using questionnaires first. It was done to determine teachers and students' views about research topic objectively/ without any intervention from the researcher. Next, semi structured interviews to teachers and students individually were conducted. These interviews were conducted to discuss how learning process presented by eachers, related to representation format and students' misconception.

The interview questions include: (1) what representations are often presented by your teacher?; (2) do you have a difficulty in using some physical representations? Explain it; (3) have you ever experienced any misconceptions with certain physical materials?; (4) if yes, where did the concept go wrong (student, teacher, textbook, or teaching)? Explain it; And (5) if yes, what do you do to improve your physics concept. Secondly, the interview data will be checked for compliance with initial observation result data. Then the data will be analyzed and classified to compile SMI instrument.

### 2.3 Data Analysis

Interview results were analyzed using a combination of induction, deduction, and verification techniques [14]. Data analysis techniques are showed in the following: (1) data encoding, (2) grouping based on classification that has been made, (3) synthesize and find qualitative information that is considered important. Qualitative information on interviews with teachers and students is used to develop a SMI instrument to measure students' science conceptions which will be re-tested to students in order to know validity of the instruments that have been made.

## 3. Results and Discussion

A SMI instrument has been created based on suitability analysis data of semi-structured interviews and preliminary observation data presented in Table 1. Previously this instrument has been tested to students. The students involved are 38 students who will answer this instrument with 5 answer choices, namely always, often, sometimes, rarely, and never.

**Table 1.** Instrument of Students Misconception Inventory (SMI).

No	Statement
<b>A. Misconception Sources</b>	
1	I have experienced misconceptions because of my teacher
2	I have experienced misconceptions because of my own personal
3	I have experienced misconceptions because of physics textbooks

No	Statement
<b>B. Misconception Causes</b>	
<b>Teacher</b>	
1	I find it difficult to understand representation used by my teacher in learning process.
2	I have ever experienced a miscommunication with my teacher.
3	I am sometimes confused with learning media used by my teacher.
4	I am sometimes confused with language used by my teacher.
5	I have got a wrong learning material from my teacher (misconception on the teacher).
<b>Student's Personality</b>	
1	I do not like physics
2	I am not interested in studying physics
3	I find it difficult to concentrate when learning physics
4	I do not pay attention to my teacher's explanation
5	I find it difficult to understand physics material by self-study
6	I find it difficult to understand physics story
7	I find it difficult to distinguish physics formula that will be used
8	I often forget physics formula
9	I have trouble in completing mathematical operations while working on physics questions
10	I find it difficult to explain relationship between physical quantities contained in certain mathematical equations
11	I tend to memorize certain physics concepts
12	I find it difficult to re-explain using my own language related to certain physics concepts
13	I have trouble in making graphics about a particular physics material
14	I have trouble in analyzing graphics of a particular physics material
15	I find it difficult to draw a certain physics material
16	I have trouble in analyzing image of a particular physics material
17	I have trouble in creating other representations of an available representation
<b>Textbook</b>	
1	I rarely read my physics textbooks
2	I have trouble in understanding the language used (confusing)
3	I sometimes get confused about images presented in textbooks
4	I have difficulty in answering the questions in textbooks.
5	I have found a different material concept between one textbook and another.
<b>C. How to Correct the Misconceptions</b>	
1	I ask my friend who understands it better than me
2	I always ask to teacher about physics material that I have not understood
3	I use other learning resources, such as internet (pHet Simulations).

The instruments above can already be used to collect data on student misconceptions because these SMI instruments are valid and reliable. The scale for each point has a good coefficient of reliability that is greater than 0.6 were shown in Table 2.

**Table 2.** Descriptive reliability of items of SMI.

	Misconception sources	Misconception causes	How to correct the misconceptions	Full scale
Cronbach coefficient	0,615	0,655	0,616	0,679

There are three important points about misconceptions that will be discussed, they are sources, causes, and ways to correct misconceptions. This is necessary to be noted because misconception can hamper students' next learning process [15], [16]. The first point which will be research focus is the source of misconception. For more details see on the instrument. This is in line with previous research which states that the main causes of misconception come from (1) students, (2) teachers, (3) textbooks, (4) contexts, and (5) how to teach teachers [17].

The second point is the cause of misconception. This needs to be discussed, so that teachers can anticipate what kind of contextual learning activities will be presented in the classroom to minimize possibility of misconceptions [18]. The first cause of misconception is teachers [19]. The cause of misconception from interview result can be seen in the above table.

In learning process in the classroom, teachers are required to be able to deliver learning materials to students properly and correctly (not causing misconceptions). This needs to be done because teachers are the spearhead of education in learning process in the classroom. However, in fact is that teachers contribute to misconceptions in students who would certainly be a source of misconceptions in students, as well as delivering the wrong learning materials [17].

This is because of some factors such as; teacher presents ineffective learning or teacher fails to convey precisely the material being taught [19]. It can have an impact on students' interest to research physics harder. Similarly, students find physics is difficult and tedious, then there is a view which assumes that studying physics for women is irrelevant [20]. Secondly, teachers often fail to explain abstract material concept appropriately either by visualizing or analyzing learning materials to help students understanding learning materials [21].

The second cause of misconception is students' personality. Students' misconceptions are certainly influenced by students' own personal abilities. Student physics misconception can be a misconception on the concept of physics material or when students answer physics questions. Like students' limited ability when think abstractly [22], or low student math skills [23], and students' ability to solve physics problems using specific representations [24], [25].

The third cause of misconception is textbook used. Misconceptions in students may also be caused by the use of textbooks [26], [27], [19]. This can be caused by some things and factors. The first, language used in textbooks is unclear or confusing students to understand material concept [27], [28]. For certain students, they can learn independently using textbooks. However, they have difficulty in constructing their knowledge, because language used in textbooks is not clear or contains misconceptions [29]. Like there are incomplete material concepts presented or even there are misconceptions [30]. In addition, textbooks do not always provide complete and correct information and explanation [27], [19]. Like the use of symbols and images is difficult to interpret or understand [31].

The third point is how to correct the misconception. Based on the above explanation, it is known that learning process provided by teacher still allows the occurrence of misconception, whether the misconception comes from teachers or other factors. To avoid the misconceptions, teachers' ability and willingness to improve the way of teaching is needed. Teachers need to first identify students' preconceptions before presenting a learning process that can provide opportunities for students to construct their knowledge first [18].

Teachers have some important roles to reduce students' misconceptions. The things that can be done are identifying students' misconceptions and finding the best solution to reduce the misconception by considering students' ability [32], presenting an attractive learning, for example with a direct practicum [18]. Then teachers can practice a learning that will train students' analytical and synthetical skills [33]. In addition, to help students constructing their knowledge deeper, teachers can also use learning with multi-representation approaches [34]. There are several benefits of applying multiple representation learning to reduce misconceptions in students, which have high effectiveness in instilling physics concepts [10], assisting students in problem solving and concept development

[35], as well as limiting the likelihood of student misconceptions in interpreting a particular concept [12].

#### 4. Conclusion

This paper has explored multiple representation preference to develop students misconception inventory in measuring of students science conception awareness. Based on the explorative research that involves teachers and students, a valid and reliable SMI instrument with a cronbach alpha value of 0.679 was generated. This SMI instrument can be used to measure students' conceptions of science including the sources, causes and how to correct the misconceptions based on the multiple representation preference which are available. The findings of these qualitative analyzes reflect the extent to which the role of learning resources (teachers, textbooks, the Internet, etc.) whose contents contain multiple representational modes will contribute to the change in concepts students acquire. Hopefully in the next research, there will be develop this instrument in a wider scope.

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