Profile of senior high school students’ misconception in physics using need-based analysis

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Abstract. This study obtained the current situation of physics teaching, learning, and assessment at the senior high school in Surakarta, Indonesia based on various skills in 21st century. A need-based analysis was conducted to explore students’ current situation that lead to misconception in understanding concept of physics as learning objectives. Through random sampling, students’ questionnaires and teachers questionnaires to over 120 students and 12 teachers were held respectively. The implications showed that generic science skill and interpersonal skills had influenced students’ understanding of physics as the two affecting factors could be the reasons for misconception. From the questionnaires result, it showed that teachers and students of senior high school in Surakarta need a proper diagnostic test to investigate and map students’ misconception in physics classroom especially in difficult learning object such as kinetic gas theory. The four-tier diagnostic test with five possible answers was developed based on the result of need-based analysis and factors affecting students’ misconception which were students’ generic science and interpersonal skills.

1. Introduction

The emergence of collaboration between of physics teaching at school and 21st century skills, some of cases will be related to misconception and so that teacher need to understand how to diagnose that properly when the class taking apart [1]. However, proper and fit test with high reliability and validity will enable teachers to diagnose the strengths and weaknesses of students’ in each class session so that they can evaluate the method to make physics more understandable for student [2]. There are several abilities which can help them to determine appropriate test to diagnose types and levels of teaching and learning as teachers need to improve the quality of teaching and learning efficiency [3]. Science education is often challenged by students’ misconceptions about various phenomena [4]. As the parameters written, a need-based analysis is needed to perform so that teachers are able to determine what kind of factors affecting the misconception happened in students [5]. So, it can be decided the use of proper test related to the misconceptions’ factors affecting [6].

Based on the interview and questionnaires held in six senior high school in Surakarta, the test done by teachers are more likely to measure students’ cognitive understanding. There are no borderline and concern to map misconception happened in students where they learn physics as students made mistake in answering the tests given. The interview also has taken the result that 12 teachers who have been aimed to answer some questions stated that they did not know what factors affecting the case of misconception in physics.
Nowadays, most concepts about students’ misconception diagnosis are based on attributes for each lesson [7]. Diagnostic test could investigate students’ misconception [8]. There are several former studies related to the development of diagnostic test using tier including: one-tier diagnostic test, two-tier diagnostic test, three-tier diagnostic test, and four-tier diagnostic test [9]. Four-tier test is used in this study whether students are surely answering the correct answer or not based on test created from need-based analysis since it can investigate students’ misconceptions as a framework [10]. The ease of misconception can be carried out so that the gain of 21st century skills in science are performed well to build students’ science conception [11].

Other research also stated that diagnostic is apparently related to know precisely, to decide, and to agree upon so that students’ understanding, and teachers’ imagery are tied in the same way [12]. To be able to ease misconception in physics using diagnostic test, a researcher has done a study that diagnostic test could diagnose students’ conceptual understanding in both weakness and strength during the physics classroom [13]. Yet, it is so important to know what kind of needs to perform the diagnostic test held by the teachers in classroom [14].

Since textbooks are the dominant resource for science instruction in most classrooms, text-based methods of facilitating conceptual change need to be examined [15]. In this study, a need-based analysis is first to be carried out in the first interviews and questionnaires with 12 physics teachers in senior high school in Surakarta to investigate the current situation. Then, the factors affecting found during the interviews will be able to be parameters to provoke a development of test determining students’ misconception during the physics classroom [16]. Test-takers and methods of providing the feedback will also be explored so that it can be a proper test to map students’ misconception in kinetic gas theory as learning objectives.

2. Methods

This study was located in Surakarta, Central Java. Sampling techniques is using quota sampling due to the amount of school in Surakarta. Data samples consist of six senior high school in Surakarta. Study was held during April to December 2018. Data collection was done by questionnaires, interviews, and documents.

The interviews were done by the consent of teachers and students joining this study. All answers in the interviews process were recorded by the permission of respondents so as the questionnaires. Data collection were done to know and map what needs teacher proposed to investigate students’ misconception during physics class and what factor affecting that lead to misconception itself. Triangulation method in this study has been done to get valid and reliable data as the qualitative study is included [17].

There are two design of questionnaire and interviews framework. The questionnaires were using Likert scale, including: ‘1=Strongly Disagree, 2=Disagree, 3=Fairly Agree, 4=Agree, 5=Strongly Agree’ [17]. First, student questionnaire (SQ hereafter) has been spread to 120 students as respondents from 6 senior high schools in Surakarta and teacher questionnaire (TQ hereafter) has been spread to 12 teachers as respondents from 6 senior high school in Surakarta. The SQ and TQ are described in this section.

2.1. Design of the questionnaires

The design of questionnaires (SQ and TQ) was created and synthesized through deep review based on recent study of Brotoisiswoyo [18]. The indicators of first parameter as need-based analysis main focus which is generic science skill is including: (1) direct observation, (2) indirect observation, (3) awareness of scale, (4) symbolic language, (5) basic obedience logic framework, (6) inference logic, (7) the law of cause and effect, (8) mathematical modeling, and (9) building concepts. While the second point to observe as parameter is interpersonal skills while learning physics.

The indicators breakdown related to recent study are skills possessed by a person to understand various social situations wherever they are and how they display behavior that is in accordance with the expectations of others which are interactions between individuals and other individuals.
Indicators of interpersonal skill breakdown in this study are capacity of initiative, ability to be open, assertiveness skills, the ability to provide emotional support, and the ability to resolve conflicts according to [20]. Questionnaires were held to find out teachers’ attitude to the parameter and their needs to perform test that is able to investigate misconception in physics among students in senior high school [21].

2.2. Participant of the questionnaires
A total of 120 students from six senior high school in Surakarta took part in the SQ survey. Among them, 55 students were from a top level of national exam in the previous school state and 30 were from Olympiad participants. As for the students’ majors, all were taking physics classroom. All the remaining 120 students produced valid questionnaire data in the survey.

As for the TQ survey, a total of 12 teachers from the same six senior high school as the student respondents participated in the survey. Altogether, the raw data collected in the present study. To facilitate the data analysis, the researcher sorted out the quantitative data using Microsoft Excel to carry out the descriptive analysis [22].

3. Results and Discussion
The demographic data has indicated that the students have been learning physics for 6 to 9 years. The data collected were taken as teachers stated that students could get misconception in physics concept since they are not able to maintain their generic science skills and interpersonal skills properly as the physics classroom started. It was genuinely investigated that teachers also were not familiar to their needs in order to map students’ misconception in physics. The brief and clear results of questionnaires from both SQ and TQ were reported in detail in this section.

3.1. The attitude of physics teachers of their needs related to generic science skills
One of the needs to perform diagnostic in misconception of learning physics is generic science skills. Generic science skills are skills that can be used to learn various concepts and solve various scientific problems. This study used nine indicators by Brotosiswoyo which are: (1) direct observation, (2) indirect observation, (3) awareness of scale, (4) symbolic language, (5) basic obedience logic framework, (6) inference logic, (7) the law of cause and effect, (8) mathematical modeling, and (9) building concepts.

The interpretation of percentage index consists of five categories which are: strongly disagree (0% < score ≤ 36%), disagree (36% < score ≤ 52%), fairly agree (52% < score ≤ 68%), agree (68% < score ≤ 84%), and strongly agree (84% < score ≤ 100%). The interpretation to percentage state are more likely to be done based on the study of Gusmida and Islami [23]. The attitude of physics teacher of their needs related to generic science skills can be seen in Table 1.

| Items of questionnaires                                                | Index (%) | Interpretation       |
|----------------------------------------------------------------------|-----------|----------------------|
| My students are able to do direct observation during the physics class| 91.67%    | Strongly agree       |
| My students are able to do indirect observation during the physics class | 91.67%    | Strongly agree       |
| My students are able to understand awareness of scale and how to use it in learning physics | 83.33%    | Agree                |
| My students are able to understand symbolic language in learning physics | 66.67%    | Fairly agree         |
| My students are able to understand the frame-work logic in physics    | 58.33%    | Fairly agree         |
| My students are able to understand inference logic in physics         | 83.33%    | Agree                |
| My students are able to understand the law of cause and effect that is related to a physics concept | 91.67%    | Strongly agree       |
| My students are able to understand mathematical modeling used in physics | 66.67%    | Fairly agree         |
| My students are able to understand how to build a concept in physics  | 66.67%    | Fairly agree         |
From Table 1, it can be seen that teachers are more likely to know that their students have good performance in direct and indirect observation, the use of scale, the natural causality, and inference logic. Besides, teachers also stated that their students were still not good enough to build concepts in physics, perform mathematical modelling used in physics, and use symbolic order and framework logic in physics. Based on the need-based analysis through TQ result, it has been shown that teachers need a test to map and investigate students’ misconception related to generic science skills parameter.

3.2. The perceptions of physics teachers of their needs related to interpersonal skills

The needs to perform diagnostic in misconception of learning physics is related to interpersonal skills as interpersonal skills could show skills possessed by a student to understand various social situations wherever they are and how they display behavior that is in accordance with the expectations of others which are interactions between individuals in physics classroom skills [24].

The interpretation of percentage index consists of five categories which are: strongly disagree (0% < score ≤ 36%), disagree (36% < score ≤ 52%), fairly agree (52% < score ≤ 68%), agree (68% < score ≤ 84%), and strongly agree (84% < score ≤ 100%). The interpretation to percentage state are more likely to be done based on the study of Gusmida and Islami. The attitude of physics teacher of their needs related to interpersonal skills can be seen in Table 2.

Table 2. The attitude of physics teachers of their needs related to interpersonal skills

| Items of questionnaires                                                                 | Index (%) | Interpretation |
|----------------------------------------------------------------------------------------|-----------|----------------|
| My students are able to do direct observation during the physics class                  | 91.67%    | Strongly agree |
| My students are able to do indirect observation during the physics class                | 91.67%    | Strongly agree |
| My students are able to understand awareness of scale and how to use it in learning physics | 83.33%  | Agree          |
| My students are able to understand symbolic language in learning physics               | 66.67%    | Fairly agree   |
| My students are able to understand the frame-work logic in physics                     | 58.33%    | Fairly agree   |
| My students are able to understand inference logic in physics                          | 83.33%    | Agree          |
| My students are able to understand the law of cause and effect that is related to a physics concept | 91.67%    | Strongly agree |
| My students are able to understand mathematical modeling used in physics               | 66.67%    | Fairly agree   |
| My students are able to understand how to build a concept in physics                   | 66.67%    | Fairly agree   |

From Table 2, it can be seen that teachers are more likely to know that their students have good indicator skills to initiate the answer when teachers were asking for something, open when asking about physics concept, and compete to solve the problems given. Besides, students were still being a little bit ignorant when they knew their friend of them did not understand the concept which means there was self-centered to understand at the top. This become a huge reason why students who have misconception tend to stay in the same state. It is because they were shy to be lower than their friends.
Based on this result of need-based analysis through TQ result, it has been shown that teachers need a test to map and investigate students’ misconception related to interpersonal skills parameter. Students need to be bonding well so that they can help each other when one of their friends has misconception when learning physics in the classroom. It is related with study that has been done by Foisy that stated interpersonal skills affected high school students’ conception to understand the learning objects [25].

3.3. Interviews with physics teachers related to generic science and interpersonal skills

The interviews done with 12 physics teachers in senior high school in Surakarta. The interviews focused on what teachers need to perform action to diagnose students’ misconception in physics classroom. The interviews also found out what kind of factors affecting the misconception case and what learning objects or physics concept that bring the case of misconception up most.

Based on the interviews, teachers were more likely to mention that their students were unable to differ symbolic language and define the proper scale in learning physics, yet they were able to do direct observation and indirect observation. Teachers also stated that their students were still quite below understanding to use basic obedience logic framework when they were given some sort of higher order thinking test. Students tend to answer in a complicated way instead of making their own statement. The inference logic also become one parameter that has not been passed since students depend on internet source to solve the problem and not a physics text-book.

As the problem rise, the law of cause and effect also become a focus to be solved because students still did not understand the simplest meaning of a concept. Kinetic gas theory is one of the hardest learning objects in physics since students were unable to perform proper mathematical modeling and concepts building. Kinetic gas theory was mentioned several times by teachers as they were mapping the most difficult learning objects that lead to any case of misconception. The result was related to Phonapi chat study that stated that teachers need to perform diagnostic test based on teachers and students need using hierarchy method [26].

Some of teachers mentioned that students had already have a good intention in asking and answering the problems given in physics classroom, but they were a little bit ambitious when it was coming to a friend. If one of their friends did not understand the concept of physics taught in classroom, they tend to stay in silence. It was related to the study done by Rampullo [27]. the result of the study stated that students were still being in cooperative and competitive learning instead of collaborative learning environment. As they started to get some problems in classroom, they will put themselves first instead of anyone. So, students who experienced misconception and did not have guts to ask for explanation to the teachers will remain in the same state in the classroom.

3.4. Interviews with physics students related to generic science and interpersonal skills

The interviews done with 12 physics students in senior high school in Surakarta. The interviews focused on what students need to map their misconception in physics classroom. The interviews also found out what kind of factors affecting the misconception case and what learning objects or physics concept that bring the case of misconception up most in classroom.

Based on the interviews, students stated that they were able to perform direct and indirect observation which were usually happening in practical session of physics classroom. Yet, they were still unable to use proper symbolic order and scale so that they would be confused when they were given problems that were not related to the casual explanation from the teachers. Also, students were depending on internet to solve the problem as they were lazy to find textbook in the library to overcome their misconception in understanding physics concept. It was related to the study held by Arslan that stated students were feeling lack of references because they depend on one source as the misconception rise in physics classroom [28].

Some of students mentioned that they were brave to ask for explanation when there were misunderstanding. Some of them were happy when teachers gave a problem to solve but some others were not. They also learned in competitive environment since they were kids so that they tend to not
helping their friends who have misconception during physics classroom. It was not what they demand, but they also did not understand enough the physics concept given by the teachers in the classroom. Vongkrahchang also found the same result that students in high school were still trying to determine themselves so that they would have misunderstanding and misconception in learning science because students also dealt with personal problem in puberty [29].

4. Conclusion
Through SQ and TQ, this study performed a need-based analysis on what teachers and students need to investigate and map students’ misconception in physics classroom. Data samples were 120 students and 12 teachers. Samples were interviewed and asked through questionnaires that were held respectively. Based on the results, it was shown that factors affecting in students’ misconception in learning physics were generic science and interpersonal skills. So, teachers and students need an instrument test as assessment to diagnose the case of misconception. This study was using multiple choice type of test since teachers were more likely used this kind of test during the physics classroom.

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