The analysis of hypothesis-deductive reasoning ability in learning particle dynamics

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Abstract. Hypothesis-deductive reasoning ability refers to the ability to think logically to formulate hypotheses based on existing scientific theories. This study aims to describe the hypothesis-deductive reasoning ability of Grade X students at Integrated Models Madani Senior High School Palu in learning physics, specifically on the topic of particle dynamics. This type of study is a qualitative research using a qualitative descriptive approach. The subjects in this study consisted of 26 students of Grade X Science 5 Integrated Models of Madani Senior High School Palu who had participated in studying the topic of particle dynamics. The instruments used include a hypothesis-deductive reasoning ability test and interview guidelines. The data obtained were then analyzed using descriptive analysis. The results of the analysis showed that the students' hypothesis-deductive reasoning ability was 58.2%. This indicates that the students' hypothesis-deductive reasoning ability is categorized as sufficient. The factor that affects the hypothesized-deductive reasoning ability is the learning process in the classroom as several students received the same form of questions, and the teacher provides direction as well as motivation, so that the classroom conditions are conducive.

1. Introduction

Physics refers to a branch of science, namely the study of natural phenomena in terms of matter and energy. It is a basic science that includes a scientific structure consisting of facts, concepts, principles, laws, postulates, scientific theory and methodology [1,2]. In other words, physics is a science that is formed through standard procedures or also known as scientific methods.

In physics, the scientific method ensures that a conclusion reached is supported by evidence and is systematically organized. The scientific method according to Amien (1987:103) includes: understanding problems, formulating hypotheses, collecting evidence or data, reaching conclusions, and finding concepts [3]. To be able to carry out the scientific method, students must have scientific reasoning abilities.

Scientific reasoning ability is the ability to draw conclusions based on existing evidence [4]. One of the scientific reasoning abilities that must be possessed by students is the hypothesis-deductive reasoning ability. Hypothesis-deductive reasoning ability is the highest level of human thinking ability used by scientists [5]. Piaget's theory of student cognitive development occurs in four stages. One of the stages is the formal operational stage, in which once the age of the students is 12 years and over, the child is able to use concrete operations to form more complex operations. The main characteristics of development during this stage are hypothesis, abstract, deductive and inductive as well as logical and probability [6].
Piaget's hypothetical-deductive reasoning according to John W. Santrock (2009: 58) is a concept that adolescents can develop hypotheses (best guesses) about various ways to solve problems and reach a conclusion systematically [7]. This ability allows students to think of a hypothetical solution to a problem and formulate a logical and systematic plan to conclude which possible solution is correct. As a result, students who have the ability to reason hypotheses-deductively can solve problems based on problem solving.

Students' scientific reasoning abilities and students' synthesis problem solving abilities in physics learning have a positive relationship, which explains that the higher the students' scientific reasoning abilities, the higher the students' ability in solving physics synthesis problems [8]. In addition to this, there is also a positive relationship between students' hypothetical-deductive thinking skills and students' conceptual understanding, so that if students have high-order thinking skills it will affect students' conceptual understanding [9]. This is in accordance with the research conducted by Rahayu [10] explaining that the physics reasoning abilities or high-level thinking abilities of students of SMAN 1 Torue are still in the poor category, the things that affect are not understanding the concepts of physics, not being careful in answering questions and students' lack of interest in answering these questions.

The students' hypothesis-deductive reasoning ability will develop, in which the things that may affect the process include the learning model applied, experience in constructing the physics learning tools, experience in creating worksheets, and also the teacher's motivation [5]. By using a particular learning model such as a learning model with an inquiry approach to research practice, which provides wider opportunities for students to hypothesize, identify and plan experiments, and draw conclusions from experimental results, it is able to foster the ability to think hypothesis-deductive in students [11]. In addition to the learning model by forming learning groups with a problem solving approach, it can develop students' reasoning abilities to be better than conventional learning groups, this can occur because it is caused by the use of problem-solving approaches that emphasize problem finding and how to solve them [12].

Based on the observations conducted at Integrated Models of Madani Senior High School Palu, especially on Grade X, the physics learning process that was applied was group learning. With group learning, students are able to exchange ideas in completing assignments or problems given by the teacher. Moreover, they can better understand the materials presented. In addition to this, the students of Integrated Models of Madani Senior High School Palu have also produced various scientific works through extracurricular activities and have participated in competitions both at regional and national levels. One of the determining factors for the success of writing editorial texts or writing scientific papers is that students must have high critical thinking skills [13]. The results of observations and studies in previous studies explained that the students in the Integrated Models of Madani Senior High School Palu were identified as having the ability to reason hypothesis-deductive. However, the teachers and students do not know about the hypothesis-deductive reasoning ability. Also, they do not know about how to cultivate this ability both in terms of learning models, approaches and teaching materials.

Based on the description above, the purpose of this study was to describe the hypothetical-deductive reasoning ability of Grade X students in the Integrated Models of Madani Senior High School Palu in learning physics, specifically on the topic of particle dynamics. The expected benefits of this research are that in the future, this research can be used as an additional source of research literature in the learning process, where the relationship lies between students' hypothesis-deductive reasoning abilities on particle dynamics.

2. Method
The type of research used in this research is qualitative research using a qualitative descriptive approach, and the final data collected is in the form of qualitative data. This research was conducted at Integrated Models of Madani Senior High School Palu. There are two types of instruments in this study, namely a written test of hypothesis-deductive reasoning abilities and an interview guide. This instruments have been validated by one of the lecturers of physics education at the Teaching and Education Faculty of Tadulako University. From the results of the expert's validation, it was concluded that the instrument
could be used in this study. The subjects in this study consisted of 26 students of Grade X Science 5 who took a written test of 5 question items revolving around the topic of hypothesis-deductive reasoning. Then, the researcher analyzed each answer and categorized them as high, medium and low using the results of the calculation of the average value and standard deviation. After categorizing the answers, 6 respondents were selected to take the interview test using the interview guidelines prepared by the researcher. At last, the interview process is analyzed through a qualitative descriptive approach in order to obtain deeper knowledge regarding the students' hypothesis-deductive reasoning ability.

After a descriptive analysis is carried out on the data obtained, the students' hypothesis-deductive reasoning ability are categorized based on the category reference of the level of scientific reasoning ability [4].

| Table 1. Levels of scientific reasoning abilities category |
|----------------------------------------------------------|
| Percentage      | Category       |
|-----------------|----------------|
| 81%-100%        | Very Good      |
| 61%-80%         | Good           |
| 41%-60%         | Moderate       |
| 21%-40%         | Poor           |
| 0%-20%          | Very Poor      |

3. Findings and Discussion
Hypothesis-deductive reasoning is an essential ability that must be possessed by students. Indicators of hypothesis-deductive reasoning ability in this study are (1) Formulating hypotheses, (2) Making plans to test hypotheses, (3) Writing theoretical results, (4) Concluding conclusions from the proposed hypothesis (accepted/ rejected) [14]. The data on the results of students' hypothesis-deductive reasoning abilities are presented in the form of images of the data on the hypothesis-deductive reasoning abilities of indicator students.

![Figure 1](image)

**Figure 1.** The data of the indicators of hypothesis-deductive reasoning abilities in percentages

Based on the research results, each indicator showed that the formulating hypotheses indicator obtained a score of 76.7%. This indicated that students were able to hypothesize correctly and were categorized in good category. In addition, it also implied that most students had been able to answer correctly in terms of proposing hypotheses on each given problem. This was supported by the results of data collected on students' answers as well as the research subjects and interviews towards the respondent. The results indicated that students did understand the sample questions given by reading repeatedly to understand them better. Moreover, the students claimed that they repeatedly read the questions in order to understand the meaning of the questions. This helped the students to hypothesize correctly.
As of the designing plans indicator to test the hypothesis, a score of 62.0% was obtained. This showed that students had been able to design plans to test the hypothesis correctly and were categorized as good. This suggested that most students had been able to plan correctly to test the proposed hypothesis to prove whether the hypothesis was true or not. This was supported by the results of student answers data or research subjects and interviews with respondents. The results indicated that students could really understand the sample questions by reading them repeatedly in order to understand more thoroughly. Additionally, the students also repeatedly read the questions in order to understand the meaning. However, there were a number of respondents who had difficulty with this indicator as each hypothesis of the problem given had a different plan to prove this hypothesis.

For the indicator of writing the results according to the theory, the score obtained was 49.7%. This showed that students were able to write the results according to the theory correctly and the results were categorized as moderate. This also indicated that some students had been able to answer correctly in terms of explaining the results related to the theory, but there were some students who did not understand the theory nor the concept that could explain the results related to the proposed hypothesis. This was supported by the results of students' answers data or research subjects and interviews with respondents, in which the data collected implied that students experience serious difficulties in terms of theories and concepts related to the proposed hypothesis.

Last but not least, the drawing conclusion indicator obtained a score of 44.4%. This showed that students were able to conclude correctly and it was categorized as moderate. Additionally, it suggested that some students had been able to answer correctly in terms of pulling conclusions and supporting theories related to the problems given. However, there were some students who did not understand the theory underlying these conclusions and did not write down the conclusions (accepted/rejected). This was backed up by the results of data on student answers or research subjects and interviews with respondents. The results showed that students experienced serious difficulties in terms of theories or concepts which underlie conclusions on these problems. In this case, the indicator of formulating a hypothesis was the best indicator achieved by students, which meant that it could be determined that students' ability to hypothesize was categorized as good. Meanwhile, the drawing conclusion indicator was the lowest indicator for student achievement. Students' ability is categorized as moderate.

Based on the results of the tests and interviews, it indicated that the ability of students in proposing hypotheses is categorized as good, the ability in designing plans to test hypotheses are categorized as good, the ability in terms of writing theoretical explanations or results according to theory are categorized as moderate, and the ability to draw conclusions is also categorized as moderate. All in all, out of the 26 students who took the hypothesis-deductive reasoning ability test, 5 students were categorized in the high category, 17 students were placed in the medium category, and the remaining 4 students were categorized in the low category.

The factors which affect students' hypothetical-deductive reasoning abilities include the learning process carried out during the implementation of the particle dynamics learning and teaching. The classroom activities are always conducted in groups. In this case, the teacher elaborates a problem and students are expected to discuss to solve the problem in groups. After that, the representatives from each group explain the result of their discussion in front of the class. This can lead to promoting hypothesis-deductive reasoning abilities. This is relevant to research conducted by Lestari [11] by forming learning groups with a problem solving approach, this can develop students' reasoning abilities to be better than conventional learning groups, this can occur because of the use of problem-solving approaches that emphasize problem-finding and how to solve them. When discussing students try to find the problem then pay attention to the problem in order to find the most appropriate solution to solve the problem. With lots of input, students can make their best decision or solution.

However, the disadvantages in the learning process is that the classroom has never carried out any practicums in the laboratory to explore further regarding the theory, so that it can further improve students' reasoning abilities. However, the learning process which occurred at the time had already been able to enhance students' reasoning abilities. In addition, there were several students who received similar forms of questions, such as the same picture on each question, even though the question being
asked is different. This helped students to remember better and finish these exercises. Additionally, it can also nurture students' reasoning abilities. This is relevant to research conducted by Rosita [15], it is explained that experience is very decisive in the development of the process of forming student knowledge, the more experiences about problems, environments or objects faced by students and problems they have faced, the more they will develop their thinking and knowledge.

During the implementation of the hypothesis-deductive reasoning ability test, the teacher participated in providing instructions, motivation and accompanying the implementation of the test. As a result, most of the students were extremely enthusiastic. Even if some students were not enthusiastic and did not engage in the activities, but the atmosphere of the classroom is conducive. This affects the classroom conditions as well as the results of these tests. All in all, the students were able to complete and apply their reasoning skills to answer the questions given. This is relevant to the research conducted by Andani [5], elaborated that the hypothesis-deductive reasoning ability in the students of Senior High School 1 Jember is influenced by the learning model applied and the experiments they had of making Newton's law learning tools. Hypothesis-deductive reasoning ability in students of Senior High School 2 Jember, on the other hand, is impacted by the experiments of creating worksheets and the teacher's explanations related to the hypotheses. Additionally, the hypothesis-deductive reasoning ability in students of Senior High School 3 Jember is affected by the teacher's motivation before the test is carried out, which as a result encouraged the students and the rest of them became enthusiastic in reading the sample questions and working on the solutions. Learning media is one of the factors that support the implementation of learning in the classroom so that it affects the development of students' hypothesis-deductive reasoning abilities. One that can support the success of the learning process is a textbook that is accompanied by inquiry, an inquiry-based textbook accompanied by multiple representations containing descriptions of physics subjects to seek information and knowledge where students are encouraged to be directly involved in inquiry to practice their hypothesis-deductive reasoning skills [16]. Based on the constructivist learning theory, it explains that in learning ideas or ideas found by students are then observed and transformed and interpreted themselves into more complex information [17]. This is in accordance with one of the factors in the development of students' hypothesis-deductive reasoning abilities, namely in the learning process carried out. In this school, the students' hypothesis-deductive reasoning ability level was 58.2%. This indicated that the hypothesis-deductive reasoning ability of the school is categorized as moderate.

4. Conclusion

Based on the results of the research data analysis, it was concluded that the hypothesis-deductive reasoning ability of Grade X Science Integrated Models Madani Senior High School was 58.2%. This suggests that the students' hypothesis-deductive reasoning ability is categorized as moderate. For indicators of proposing hypotheses and designing plans to test the hypothesis, the scores obtained are categorized as good. As of the Indicators of writing the results in accordance to the theory and drawing conclusions, the scores obtained are categorized as moderate. The factor which affects this study on the students' hypothesized-deductive reasoning ability is the learning process in the classroom. Several students received similar forms of questions and the teacher provided instructions, as well as motivation, so that the classroom atmosphere becomes conducive. This research can be used as reference data in order to develop hypothesis-deductive reasoning abilities, but this research only focuses on examining students' hypothetical-constructive reasoning abilities. For future researchers: future researchers are suggested to carry out experimental studies with the treatments that can help enhance motivation to study, students' motivation to enhance their hypothesis-deductive reasoning ability in Physics subject.

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