Inquiry-based physics textbooks with multi representation to practice hypothetico deductive reasoning for senior high school students

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Abstract. Physics learning consists of theories, concepts, and laws that study phenomena in the universe that must emphasize students to use higher-order thinking skills. Scientific reasoning is a thought process that is used to solve problems based on scientific evidence. When students can reason well, these students can understand the concepts of the material that has been learned. Hypothetico deductive reasoning is one of scientific reasoning that can foster higher order thinking skills. One that can support the success of the learning process is a textbook accompanied by an inquiry. This inquiry-based textbook accompanied by multirepresentations contains a description of physics subjects to find information and knowledge where students are encouraged to be directly involved in inquiry to practice hypotethico deductive reasoning skills. This book is equipped with multi representations to facilitate students in processing concepts and solving problems. Inquiry-based student textbooks accompanied by multiple representations can improve students to gain experience, investigate problems and draw conclusions according to scientific methods.

1. Introduction

Physics studies about objects and natural phenomena through scientific methods that include the preparation of hypotheses, the design of experiments, evaluation, evaluation, and taking conclusions [22]. Physics does not only study about the basis of knowledge but the process of finding phenomena for events. According to [24], physics is a term that describes two main things, namely the basis of knowledge and the knowledge process . The nature of physics includes curiosity about objects and phenomena in nature that cause new problems that can be solved using scientific methods. [2], states that physics as part of science is essentially 1) a body of knowledge, 2) a way of thinkink, 3) a way of investigating, 4) it's interaction with technology and society.

Learning physics which consists of theories, concepts, and legal study nor any events in the universe should give students the opportunity to construct their own concept of me going through the scientific method in accordance with scientific procedure . According to [7], scientific procedures in learning physics indirectly require students to use their reasoning ability to answer problems that given

by teacher, students' knowledge is formed based on rational and logical arguments. Thinking skills are very necessary when studying physics. According to [1], [11], and [19] when students can understand a concept, then the student will be easier to explain the concept with his own language, and that requires reasoning in thinking too . One of the individual skills that needs to be improved is reasoning skills. According to [12], reasoning is the process of drawing conclusions by connecting evidence, facts, instructions, and principles to make new conclusions. One type of reasoning that must exist in learning physics is scientific reasoning. According to [8], Scientific reasoning is divided into two types namely empirical-inductive and hypothesis-deductive. Empirical-inductive type reasoning only studies one visible event while the deductive-hypothesis examines three thoughts namely clarification, observing and sorting data. According to [10], scientists often use hypothesis-deductive type reasoning patterns. Students in studying science must have the ability to think hypothetically-deductive.

Although the ability to reason is very important in learning physics. Students' scientific reasoning abilities are currently considered low. Based on the results of the 2015 PISA (Program for International Students Assessment) study, Indonesian students on science competencies scored 403 points and an average international score of 500, which means that Indonesian students' ability in science is still relatively low. Indonesian students are still at level 2, which means that students' abilities are still limited to daily content knowledge, basic procedural knowledge, scientific explanations, interpreting data, and identifying questions that are being handled in simple experimental designs. [17] The lack of scientific reasoning due to low level of training in reasoning to solve problems in the learning process. Students need to be involved in a variety of appropriate activities and need to find the right way to build understanding of scientific concepts to develop thinking, reasoning, discussion, and scientific skills that can support students in problem solving [16]. Teachers as facilitators have not developed much teaching material as innovative learning media to practice the ability of scientific reasoning, especially on hypothetico deductive reasoning students.

Teaching material is a set of material that refers to the curriculum in achieving competency standards and basic competencies that have been determined. The use of teaching materials and the selection of teaching materials have a direct effect on learning compared to the influence of teacher teaching methods [3]. Teaching materials will continue to be needed by the teacher for the learning process. The success of the school curriculum depends on the quality and quantity of teaching materials available to teachers and students. Text books teaching is a form of teaching materials that will help guide students and teachers in the success of the learning process. According to a World Bank report [18] ownership of textbooks is positively correlated with student achievement in class. Textbooks are books intended for students as a learning tool that is very important. A good textbook is a book that is easily understood by students. Learning physics will be easier and more interesting if in the book there are multi forms of representation, such as multi-representation of images, mathematical, verbal, and diagrams. According to [21], multi-representation as a reference in repeating the presentation of the same concept in various forms such as pictures, verbal, numerical, and graphic. Through multi-representation students can easily process the knowledge obtained in various forms. Representation indirectly creates reasoning, habitual thoughts, and reasons to support the learning process [15].

Meaningful learning is very effective learning to improve hypothetico deductive reasoning. One example of meaningful learning is inquiry-based learning. According to the National Science Education Standards [14] professional development of science teachers needs to integrate learning, pedagogic, and student knowledge. In addition, the development of science teachers also needs to apply science teaching through inquiry and inquiry. For this reason inquiry should be used effectively in the learning process of science in the classroom. According to [13], inquiry-based science learning is a learning approach based on the characteristics of science learning because it is based on the stages of scientific work that can develop students' attitudes and scientific skills. Inquiry based learning can direct students to find something and solve problems in scientific research. In accordance with the research of [5], that inquiry learning can improve students' scientific reasoning ability, one of which is

hypothetical deductive reasoning. Therefore this study examine the textbook-based inquiry with multirepresentation to practice hypothetico deductive reasoning for students.

2. Research Method

This type of research is development research, to produce development products in the form of textbooks. This research development intend to develop inquiry-based student teaching materials accompanied by multirepresentation to improve hypothetico deductive reasoning in high school students. The procedure of this study refers to the model developed by Niveen which includes the preliminary research stage, prototyping stage, and systematic reflection and documentation. The textbook contains scoring used by experts using validation sheets. Validation sheets contain scoring used by experts to assess the quality of textbooks. The range of scores used on the validation sheet is 1-4 with criteria 1 = not good, 2 = not good, 3 = good, and 4 = very good. A valid textbook is then continued at the assessment stage . In addition to being validated by experts, the hypothetico deductive reasoning problem in the book was tested on students to see the level of difficulty, and the validity of the questions. In addition, the textbook feasibility test includes a textbook quality test adapted from [20] namely 1) presentation component, 2) Skill component, 3) conformity with KI and KD, 4) truth of concept, 5) completion of practice questions, 6) the contents of the material, 7) the rules of writing textbooks, 8) the effect of textbooks. Data obtained from the scoring rubric questionnaire and the percentage were adapted from the journal [20].

Table 1. Percentage of quality of teaching materials

Percentage	Criteria
0.00-0.25	Very less
0.26-0.50	Less
0.51-0.75	Good
0.76-1	Very good

After knowing the influence of textbooks, then doing N-Gain calculations to find out the increase in students' hypothetical deductive reasoning skills due to the use of textbooks. Improvement of students' cognitive and hypothetico deductive reasoning that occurs before and after learning is calculated by the gain that is normalized by the formula (1)

$$\langle g \rangle = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{\langle S_{max} \rangle - \langle S_{pre} \rangle} \quad [6] \tag{1}$$

With information :
$\langle S_{post} \rangle$ = average post test score
$\langle S_{pre} \rangle$ = average pre test score
$\langle S_{max} \rangle$ = maximum score
After knowing the results of the gain, it is included in the category according to table 2.

Table 2. Gain level categories

Limitation	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Average
$g < 0.3$	Low

To test the effectiveness of textbooks using an impact test with measurement of effect size. Effect size Giving the possibility of increasing students who can be expressed with a standard scale [4] this calculation is used to determine the effect of the use of student textbooks to increase students'

hypothetical deductive reasoning . The calculated Effect size value is obtained from the difference in post test mean between the experimental group and the control group. Effect size formula (2)

$$D = \frac{(M_E - M_K)}{SD_{pooled}} \tag{2}$$

$$SD_{pooled} = \sqrt{\frac{(n_E - 1)S_E^2 + (n_K - 1)S_K^2}{n_E + n_K - 2}} \tag{3}$$

With information :
D = effect size
M_E = mean experinment
M_K = mean control
SD_{pooled} = standard deviation
S_E = standard deviation of the experimental class
S_K = standard deviation of the control class
n_E = the number of student in the experimental class
n_K = the number of student in the control class
Impact coefficients are classified by criteria of [4] as in table 3.

Table 3. The effectiveness of textbooks

Effect size	Information
$D < 0.1$	No effect
$0.1 < D < 0.4$	Small
$0.4 \leq D < 0.8$	Average
$D > 0.8$	Big

After the effectiveness test is to test student' responses regarding the quality of textbooks using the student questionnaire response rubric . Student' responses are needed in order to find out how much students interest in this textbook. The data obtained is qualitative data that is converted to a qualitative scale.

3. Results and Discussion

The result of this study are student teaching material on Newton's motion material. Inquiry-based student textbooks accompanied by multi-representations on the subject of Newton's motion are alternatives to learning media to increase students' hypothetical deductive reasoning in physics learning that can instill knowledge of concepts and understanding of students' scientific processes. This textbook provides an understanding of the concept of improve students' hypothetico deductive reasoning using inquiry models. [23] argues that the material in learning will be easily accepted by students if the material is delivered through direct experience because it is easier to remember and meaningful. One learning that emphasizes students in being able to develop their experiences directly is inquiry.

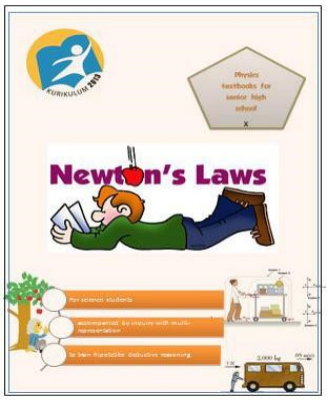

Figure 1. Cover of books

With inquiry can provide opportunities for students to learn to find something, not just to accept. In inquiry learning students with their own mental processes can find a concept, so students construct their own knowledge through their questions about a matter, then plan and conduct investigations to answer these questions, conduct analysis and communicate their findings. This textbook is a book that contains material about the Newtons law chapter in which presents a process of inquiry to find truth, information, and knowledge in which students are encouraged to be directly involved in conducting inquiry, namely asking questions, formulating problems, conducting experiments, collecting and analyzing data, draw conclusions, discuss and communicate with accompanied by multi-representation methods to facilitate students in learning. It is expected that students can find a concept. So, students can find a concept from the result of compiling the design of experiments conducted on their own abilities.

Book-based teaching is aimed at providing the opportunity for students to gain experience, to investigate its own problems with using those skills in accordance with the scientific method. Based on inquiry learning, concepts in learning are discovered by students. Components textbook i nkuiri covering the steps to formulate the problem, formulate hypotheses, collect data, testing hypotheses, formulating conclusions. While multi-representation is used to facilitate students in understanding the contents of the material available in textbooks. At the end of the material the book is presented enrichment to test the hypothetico deductive reasoning of students according to Lawson's scientific mindset *if*..., *and*..., *then*..., *and* / *but*..., *therefore*... as in Figure 2.

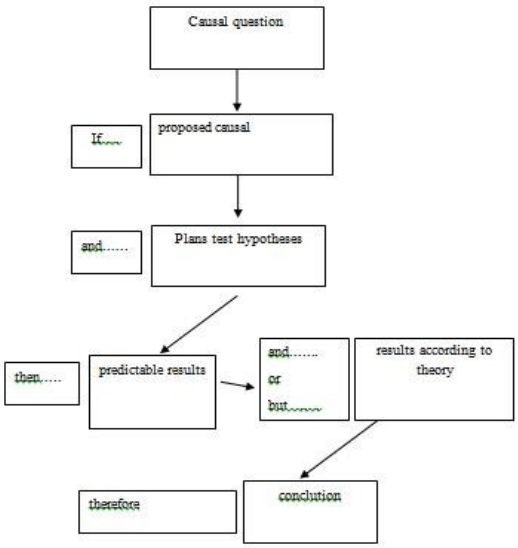

Figure 2. Box for answering hypothetico-deductive reasoning questions [9].

The textbook components is in accordance with the stages of inquiry learning which include,

3.1. Formulate the problem

At the stage of formulating the problem presented several problems that can lead students to a problem that contains a puzzle and encourage students to find the right answer. Problems at this stage contain representations to make it easier for students to guess puzzles. For example, at one stage Newton's textbook 3 presented the problem in Figure 3. as follows

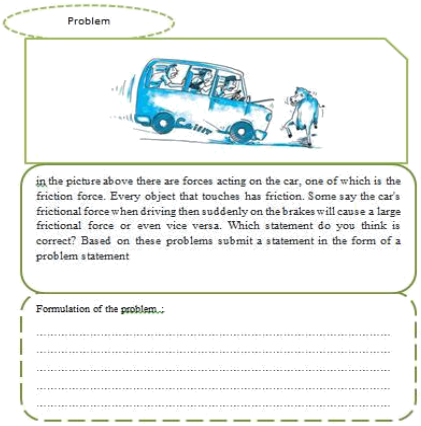

Figure 3. Problem formulation of an incident

In picture 3. Presented an image of a car that suddenly brakes when there is interference in front of him. Students are asked to give initial problems that occur in the picture in accordance with the style caused. If students have been able to formulate the problem of events in the picture, the student has an initial understanding of Newton's laws to be studied.

3.2. Formulate a hypothesis

At this stage a hypothetical assistance to students is presented in formulating temporary answers to a problem being studied by asking questions that can encourage students to be able to formulate temporary answers . An example at the stage of formulating a hypothesis is seen in Figure 4 .

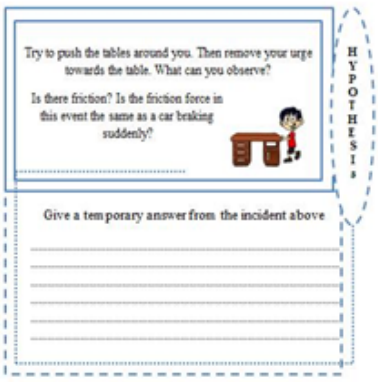

Figure 4. Hypothesis formulation

3.3. Collecting data

At this stage students are presented with questions that can encourage students to think in search of the information needed. An example of collecting data is seen in Figure 5.

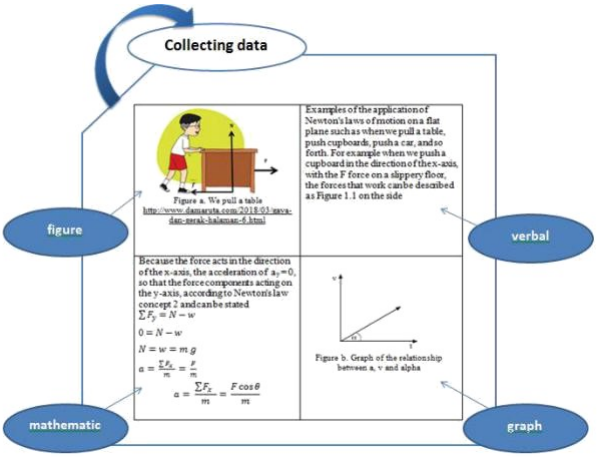

Figure 5. Collecting data

3.4. Test the hypothesis

At this stage, it is presented how to determine the answers deemed accepted according to information obtained based on data collection. Data from the results of hypothesis testing can be verbal or mathematical answers that are explained in a coherent and detailed manner.

3.5. Formulate conclusions

At this stage, students can provide feedback on their work. Students are asked to formulate conclusions by describing the findings obtained based on the results of hypothesis testing.

The inquiry-based textbook presents the stages of inquiry on each subject. The presentation is equipped with multiple representations to facilitate students. Textbook based on inquiry-emphasize to the students to be actively involved directly in the learning process so that students can discover and construct new knowledge from prior knowledge of the students. by using inquiry-based textbooks accompanied by multiple presentations will provide the widest opportunity for students in classroom learning activities especially to improve hypothetico deductive reasoning and can improve students in creative thinking in problem solving, and can provide opportunities for students to find and develop their own concepts that has been learned. Besides that by practicing deductive hypothetical reasoning it can improve students to think at a higher level. Examples of reasoning problems can be seen in Figure 6.

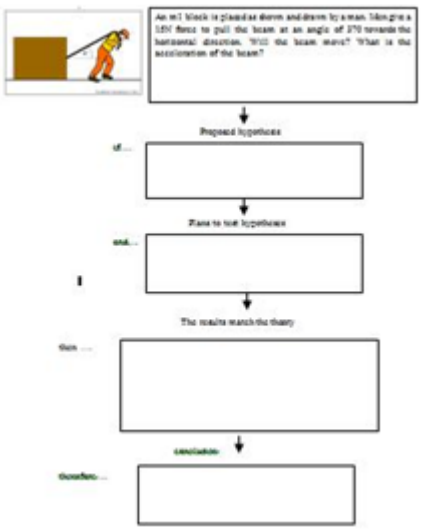

Figure 6. Problem practice hypothetico deductive reasoning

4. Conclusion

Inquiry-based student text-books accompanied by multi-representations to practice hypothetico deductive reasoning are textbooks consisting of the stages of formulating problems, formulating hypotheses, collecting data, collecting data, testing hypotheses, and formulating conclusions. Textbooks of inquiry with multiple representations in order to attract and facilitate students in the reading of the material as well as problem solving. This textbook uses hypothetico deductive reasoning skill patterns in answering practice questions. The result of this study are student textbooks on Newton's laws of motion class X.

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