The effect of using newton's law worksheets to improve critical thinking skills

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Abstract

The research aims to produce Newton's law worksheets that can empirically train students' critical thinking skills. The method used in this research is R&D (Research and Development). The model used is the ADDIE model (Analysis, Design, Development, Implementation & Evaluation). The sample of this research was 75 students of SMA class XI semester 1 which were taken through purposive sampling technique. The instruments used were pre-test & post-test. The data in this study were analyzed using the Rasch model and the N-Gain test. The results of the field trials showed an increase in students' critical thinking skills of 0.49 which was in the medium category.

Keywords: Worksheets · Newton's Laws · Critical Thinking Skills

INTRODUCTION

Physics learning in the 21st century has a very close relationship with technological developments. Rapidly developing technology is able to make learning activities more flexible. The development of information and communication technology can be observed in its application in the learning process, especially in learning physics with material that has many abstract concepts. With the development of technology, it is possible that the diversity of information will flow quickly. With this in mind, it triggers students to have critical thinking skills to receive all information about physics material. Referring to 21st-century learning, critical thinking skills consist of ways to think (knowledge, critical and creative thinking), ways to learn (literacy and soft skills), and ways to learn with others (personal, social, and civic responsibilities) (Zubaidah, 2016). Or what we currently know as 4C which consists of critical thinking skills, creative thinking skills, communication skills and collaboration skills. These skills are needed by students to be able to analyze, observe and solve problems related to physics objects. However, in reality students still have difficulty thinking critically and thinking at a higher level about physics objects. Students perform significantly better at low-level cognitive skills than higher- order thinking skills (HOTS) (Casagrand & Semsar, 2017).

One of the skills that must be built is critical thinking skills. Aspects of higher order thinking according to 21st century skills in the aspect of soft skills are the ability of scientific

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creativity, critical thinking ability, and creative thinking ability. The aspects that are measured in learning are aspects of scientific creativity, critical thinking skills, and creative thinking skills (Astutik et.al., 2020). So with this in mind, as a prospective teacher must be able to change the way students think and students' perspectives on physics material. The critical goal of science education is not only to learn science concepts, but rather to build students' competencies for active learning (Chang et.al., 2010). Critical thinking is reasonable and reflective thinking that focuses on deciding what to believe or do. Then it is also explained that deciding what to believe or do can be assisted by a set of dispositions and critical thinking skills described (Ennis, 2011). It was also explained that critical thinking skills are a process of thinking skills based on the results of analysis and evaluation of a problem (Yulianti, 2020). The results of the study stated that the critical thinking skills of high school students were included in the low category (Herdianto & Setyarsih, 2014). This is due to the lack of awareness of learning physics.

In learning, one of the abstract physics materials to be understood by students is Newton's law. It was continued that most students did not understand the concept. students only remember the sound of Newton's laws and do not understand the physical meaning of these laws (Januarifin et.al., 2018). In the analysis of research needs for teachers and students at MAN 3 Banda Aceh stated that the material that was difficult to understand was Newton's law of gravity. In addition, the teaching materials used are in the form of LKPD (Student Worksheets) and student books whose contents have not yet been designed for students to discover and apply their own ideas (Rahmatina et.al., 2020). Therefore we need teaching materials that can improve students' critical thinking skills.

The teaching material in question is in the form of student worksheets that are oriented to measuring students' critical thinking skills. Through student worksheets developed by the teacher it is hoped that each student will have more directed guidelines in carrying out their learning activities so that it makes it easier to develop critical thinking skills (Utaminingsih & Rahayu, 2021). LKS is an indication of the implementation of learning tasks carried out by students with reference to the basic competencies that must be achieved. The thing that is of added value is that LKS can be made according to the conditions and situation of the school. Both from the ability of each student, the learning facilities / resources used by students, the learning model used and so on. LKS can also be made following the construct of the material that has been taught. Also adjusted to how deep the material that students want to explore so that students are able to analyze, observe and solve these problems (Harwati & Rokhmat, 2021). Therefore researchers are interested in conducting research and development with the title " The Effect of Using Newton's Law Worksheets to Improve Students' Critical Thinking Skills ".

This study aims to produce Newton's law worksheets that can empirically train students' critical thinking skills. To be able to achieve the research objectives, a research question was formulated, namely how to increase students' critical thinking skills between before and after learning using the developed LKPD. The contribution of this research to the development of physics education practices includes completing previous research, producing a product in the form of Newton's law worksheets to improve students' critical thinking skills which can be used by teachers and students as teaching materials or learning resources.

METHODS

The method used in this research is R&D (Research and Development). Because this research focuses on developing Newton's law student's worksheet teaching materials based on concept mastery and critical thinking skills. The development of Newton's law worksheet refers to the ADDIE research model (1) Analysis, (2) Design, (3) Development, (4) Implementation & (5) Evaluation. The population in the study were students of class XI MIPA at SMA Negeri 6 Bandung in physics subject. The samples taken were in the form of answers/responses from 75 students of class XI MIPA 1, 2 and 3 and 3 physics teachers who were taken through a purposive sampling technique.

The instruments used in this study consisted of pre-test and post-test instruments. Before using the pre-test and post -test instruments for implementation, an empirical validation test was carried out first. This aims to determine the validity and reliability of the critical thinking skills test instrument.

The research begins with an analysis of the problems of physics material that students consider difficult, an analysis of the use of teaching materials/worksheets by teachers, and an analysis of students' critical thinking skills level. Then proceed with the analysis of Core Competencies (KI), Basic Competencies (KD), aspects and indicators of critical thinking skills (CBC) and indicators of understanding concepts.

Then proceed to the stage of designing Newton's law worksheets based on concept mastery and critical thinking skills. Then the next stage is development by testing the validity of Newton's law worksheets based on critical thinking skills by experts/lecturers.

Next is the implementation stage, in this stage an empirical validation test is carried out on 50 students in class XI MIPA 4 and 5. The results of this test will be analyzed using the Rasch model. Test the validity of each item about critical thinking skills obtained through the output tables menu item: measure. An item is said to be valid if it meets the criteria which can be seen in the following table (Boone, 2014).

Table 1. Fit Index for Fit Items

Criteria	Understanding	Fit Index
Outfit mean Square values (MNSQ)	The remaining sum of squares for the item is divided by the number of people who responded to the item	0.50 – 1.50
Outfit z-standardized values (ZSTD)	Standardized value	-2.00 – 2.00
Point Measure Correlation (Pt Mea Corr)	The value of item polarity	0.40 – 0.85

Table 2. Interpretation of the Quality of Question Items

Interpretation	Criteria
Perfect fit	All Three Criteria Fulfilled
In accordance	Two Criteria Fulfilled
Less Appropriate	One Criterion Fulfilled
It is not in accordance with	Three Criteria Not Fulfilled

The results of the item validity test can be seen in the following table:

Table 3. Validity Test Results for Each KBK Question Item

Question Items	*MNSQ outfit* score	**ZSTD** *outfit* values	**Value of Pt Mea Corr**	Interpretation
S1	1.18	0.60	0.12	In accordance
S2	1.26	1.42	0.41	Perfect fit
S3	0.67	-1.39	0.09	In accordance
S4	0.57	-1.86	0.43	Perfect fit
S5	0.84	-0.89	0.63	Perfect fit
S6	1.45	2.00	0.11	In accordance
S7	1.23	1.44	0.37	In accordance
S8	0.71	-1.74	0.53	Perfect fit
S9	1.33	2.00	0.23	In accordance
S10	0.87	0.63	0.20	In accordance
S11	0.72	-2.92	0.26	Less Appropriate
S12	0.94	-0.12	0.36	In accordance
S13	1.16	0.96	0.39	In accordance
S14	0.81	-0.52	0.46	Perfect fit

From the results of the table above, the items with the interpretation of "Very Appropriate and Appropriate" can be used. While the questions with the interpretation of "Inappropriate and Inappropriate" are not used accordingly. Items that are not used are S11.

The reliability test of the test items for understanding concepts and critical thinking skills can be obtained through the output table menu in the summary statistics section. Reliability value can be interpreted through Table 4.

Table 4. Interpretation of Person Reliability, Item Reliability and Cronbach Alpha

Criteria	Explanation	Fit Index	Interpretation
Cronbach Alpha	Conformity of items or items with *the person* (students)	$x \leq 0.5$	Bad
		$0.5 < x \leq 0.6$	Bad
		$0.6 < x \leq 0.7$	Enough
		$0.7 < x \leq 0.8$	Good
		$x > 0.8$	Very good
Item Reliability and Person Reliability	Instrument reliability and student reliability	$x \leq 0.67$	Weak
		$0.67 < x \leq 0.80$	Enough
		$0.80 < x \leq 0.90$	Good
		$0.90 < x \leq 0.94$	Very good
		$x > 0.94$	Special

The results of the item reliability test can be seen in the Table 5.

Table 5. Reliability Results of Critical Thinking Skills Test Instruments

Cronbach Alpha	Interpretation	Personal reliability	Interpretation	Reliability items	Interpretation
0.35	Bad	0.33	Weak	0.88	Good

From the table above it can be said that students are not consistent in answering existing questions. then the interaction between the consistency of students' answers with the bad test instrument. However, the quality of the question item shows the number 0.88 which can be interpreted as good. So that the test instrument remains reliable to use.

Based on the results of the data above, of the 14 item description questions, there are 13 items that are valid and can be used for implementation. To see the reliability of the items, the Alpha Cronbach method was used. Based on the results of data analysis, the value of the reliability coefficient for the item description is 0.88 with good criteria. Therefore the critical thinking skills test instrument is stated to be reliable, so that the test instrument has good consistency to be done by anyone.

Followed by giving a pre-test to 75 students of class XI and then given Newton's law worksheets based on critical thinking skills. After the students study independently, they are then given a post- test to find out the students' critical thinking skills possessed by the students after being given Newton's law worksheets. The pre-test & post-test results were processed based on the normalized average gain presentation. N-Gain formula (Hake, 1999) is as follows:

$$\langle g \rangle = \% \langle G \rangle / \% \langle G \rangle_{max} = \left(\% \langle S_f \rangle - \% \langle S_i \rangle \right) / \left(100\% - \% \langle S_i \rangle \right) \qquad (1)$$

where S_f is average final class (*posttest*) and S_i is Average initial class (*pretest*) with the N-Gain value category as in Table 6.

Table 6. Category of N-Gain values

N-Gain Value	Level
($<g>$) ≥ 0.7	High
$0.7 > (<g>) \geq 0.3$	Medium
($<g>$) < 0.3	Low

In the next stage, 75 students and 3 physics teachers were directed to fill out a response questionnaire regarding the feasibility of Newton's law worksheets based on conceptual mastery and critical thinking skills.

stage in this research is evaluation, which includes processing data which is then used as feedback to be able to draw conclusions whether Newton's law worksheets to improve students' critical thinking skills that have been designed and given can measure students' critical thinking skills.

RESULT AND DISCUSSION

Improvement of Critical Thinking Skills Between Before and After Given Newton's Law Worksheets Based on Critical Thinking Skills

In the final implementation activity, the pre-test and post-test results were obtained which were calculated using the N-Gain calculation with the pre-test and post-test score rating scale being 0-100. Table 7 are the results of the pre-test and post-test.

Table 7. Student Pre-Test & Post-Test Results

Pre-Test	Post-Test	$<g>$	Criteria
58.6	79.0	0.49	Medium

Based on the table above, the result of increasing students' critical thinking skills is 0.49 which is included in the moderate category referring to Hake's categorization. So it can be said that students' critical thinking skills improve better after getting Newton's law worksheets based

on critical thinking skills. This is in line with research conducted (Alimahdi et.al., 2021) that there is an increase in critical thinking skills after being given student worksheets.

Improvement of Critical Thinking Skills in Every Aspect

According to Ennis (2011) the aspect of critical thinking skills consists of 5 stages, namely basic clarification, two basis of decision, inference, advance clarification, and support & integration. Every aspect of critical thinking skills is analyzed based on the results of the N-Gain test on the pre-test and post-test that have been implemented. The following are the results of the N-Gain test on each aspect of critical thinking skills:

Table 7. Pre-test and post-test results for critical thinking skills

KBK aspect	KBK sub-aspect	<pretest>	<posttest>	<g>	Criteria
Basic clarification	Focus on a question	94	96	0.33	Medium
Basic clarification	Analyze arguments	57	77	0.46	Medium
Basic clarification	Analyze arguments	75	85	0.39	Medium
Basic clarification	Analyze arguments	75	88	0.31	Medium
Basic clarification	Ask and answer classifying and challenging questions	81	83	0.37	Medium
Two basis of decision	Assess the credibility of the source	43	71	0.49	Medium
Two basis of decision	Assess the results of the Observation	63	81	0.48	Medium
Inferences	Assess the results of the deduction	44	70	0.46	Medium
Inferences	Make induction	83	89	0.37	Medium
Inferences	Make and assess decisions	43	71	0.49	Medium
Advanced clarification	Identify assumptions	74	82	0.31	Medium
Support & integrate	Supportive thinking	54	70	0.35	Medium
Support & integrate	integrated	80	88	0.40	Medium

Based on the table above, it states that the aspects, sub-skills, and indicators of students' critical thinking skills referring to Ennis have increased in each aspect, sub-skills, and indicator. In the basic clarification stage with sub-skills focusing on a question and indicators formulating a question, the N-Gain value is 0.33 in the medium category. In the basic clarification stage with the sub-skills of analyzing arguments and indicators identifying conclusions, identifying reasons stated, and looking for similarities and differences each obtained an N-Gain value of 0.46; 0.39; and 0.31 in the moderate category. In the basic clarification stage with the sub-skills of asking and answering classification and challenging questions and the indicator question why, the N-Gain value is 0.37 in the moderate category. In the two bases of the decision stage with the sub-skills assessing the credibility of sources & assessing the results of observations
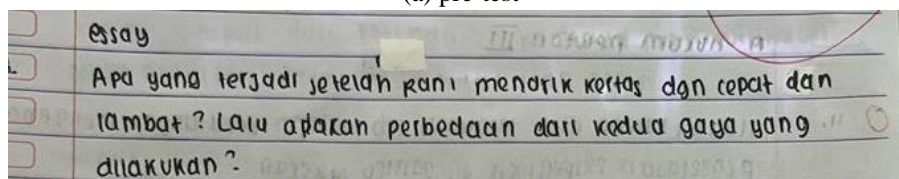
and indicators of experts & being involved in concluding each obtained an N-Gain value of 0.49 and 0.48 in the moderate category. In the inference stage with sub-skills assessing deduction results, making inductions & making and assessing decisions on deductive reasoning indicators that meet the requirements, making generalizations & alternatives each obtains an N-Gain value of 0.46; 0.37 and 0.49 with medium category. In the advance clarification stage with the sub identification of assumptions on the required assumption indicators each obtained an N-Gain value of 0.31 in the medium category. At the stage of suppotition & integrate with sub suppotitional thinking & integrate in indicators of consideration and reasons from premise & integrate character and other abilities in making and defending decisions each obtains an N-Gain score of 0.35 and 0.40 in the moderate category. The following is one of the students' answers during the *pre-test & post-test* :

5. Rani berencana melakukan percobaan menggunakan gelas dan kertas seperti pada gambar diatas. Percobaan tersebut dilakukan dengan 2 kondisi yang berbeda, yaitu menarik kertas dengan cepat dan menarik kertas dengan lambat. Rumuskan pertanyaan terhadap rencana percobaan Rani!

Jika benda terkena gaya pasti bergerak, jika kertas ditarik perlahan maka gaya tarik akan bersama gelas , namun jika berkecepatan tinggi gelas akan jatuh dan tidak akan tertarik bersamaan dengan kertasnya

(a) pre-test

Essay
Apa yang terjadi setelah Rani menarik kertas dgn cepat dan lambat ? Lalu apakah perbedaan dari kedua gaya yang dilakukan ?

(b) post-test

Figure 1. Answers to Pre-test & Post-test number 1 (KBK)

Several other studies also state that worksheets can improve students' critical thinking skills. Students' critical thinking skills are getting better embedded. These results were also supported by the students' LKM answers, where from the students' LKM answers the average score of 7 LKM was 76.3, where this value met the specified KKM (Utaminingsih & Rahayu, 2021). HOT'S LKS is a worksheet that contains questions about students' critical thinking skills, creative thinking skills, and scientific creativity abilities. Worksheets developed with the complexity of content and cognitive processes in physics learning resulted in increased conceptual understanding and critical thinking skills in the research sample (Putra et.al., 2019). Based on previous research that has been done with the findings of this study, it has the same tendency to improve students' critical thinking skills. The following is an example of a problem on Newton's law worksheet:
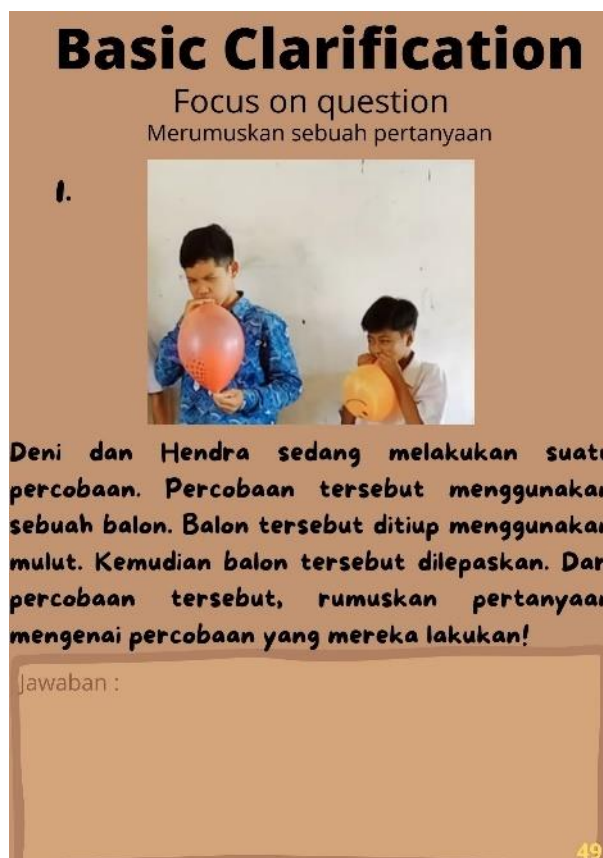
Figure 2. Sub Aspects of Critical Thinking Skills Practice Focusing on a Question in the Worksheet

CONCLUSION

Based on aspects, sub-skills and indicators of students' critical thinking skills referring to Ennis, students' critical thinking skills increased by 0.49 which is in the medium category. In every aspect, the sub and indicators have also increased. In the basic clarification stage with sub skills focusing on a question and indicators formulating a question, the N-Gain value is 0.33 in the medium category. In the basic clarification stage with sub-skills analyzing arguments and indicators identifying conclusions, identifying reasons stated, and looking for similarities and differences each obtained an N-Gain value of 0.46; 0.39; and 0.31 in the moderate category. In the basic clarification stage with the sub-skills of asking and answering classification and challenging questions and the question indicator why, it gets an N-Gain value of 0.37 in the medium category. In the two basis of decision stage with the sub-skills assessing the credibility of sources & assessing the results of observations and indicators of experts & being involved in concluding each obtained an N-Gain value of 0.49 and 0.48 in the moderate category. In the inference stage with the sub-skills assessing deduction results, making inductions & making and assessing decisions on deductive reasoning indicators that meet the requirements, making generalizations & alternatives each get an N-Gain value of 0.46; 0.37 and 0.49 with medium category. In the advance clarification stage with the sub identification of assumptions on the required assumption indicators each obtained an N-Gain value of 0.31 in the medium category. At the stage of suppotition & integrate with sub suppotitional thinking & integrate in indicators of consideration and reasons from premise & integrate character and other abilities in making

and defending decisions each obtains an N-Gain score of 0.35 and 0.40 in the moderate category.

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