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Higher Order Thinking Abilities: Critical Thinking Abilities on Science Process Skills the Subject of Elasticity and Hooke's Law

Astalini[1*], Darmaji[2], Dwi Agus Kurniawan[3], Sri Muslimatul Husna[4]

[1,2,3,4]Physics Education Department, Universitas Jambi, Jambi, Indonesia

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ABSTRAK

Perkembangan dunia pendidikan yang semakin pesat menuntut peserta didik untuk memiliki kemampuan berpikir kritis dan keterampilan proses ilmiah agar mampu menghadapi berbagai permasalahan yang terdapat dalam kehidupan sehari-hari. Penelitian ini bertujuan untuk menganalisis pengaruh keterampilan berpikir kritis terhadap keterampilan proses ilmiah pada pokok bahasan elastisitas bahan dan hukum Hooke. Jenis penelitian yang digunakan dalam penelitian ini adalah penelitian kuantitatif asosiatif. Populasi yang digunakan adalah seluruh siswa dengan sampel yang digunakan adalah 30 siswa kelas XI. Teknik pengambilan sampel menggunakan purposive sampling. Instrumen penelitian yang digunakan adalah tes uraian dan lembar observasi. Teknik analisis data yang digunakan adalah uji statistik deskriptif, uji asumsi adalah uji normalitas dan uji linearitas, serta uji hipotesis adalah uji regresi linier sederhana. Hasil uji statistik deskriptif menunjukkan bahwa kemampuan berpikir kritis siswa pada setiap SMA Negeri berbeda-beda, begitu pula dengan keterampilan proses sains siswa di setiap SMA Negeri juga berbeda-beda, Hasil uji normalitas menunjukkan data berdistribusi normal dengan sig. > 0,05 maka hasil uji linieritas menunjukkan data linier dengan sig. > 0,05, dan hasil uji regresi linier sederhana menunjukkan terdapat pengaruh antara keterampilan berpikir kritis terhadap keterampilan proses sains dengan nilai sig. < 0,05. Jadi dapat disimpulkan bahwa kemampuan berpikir kritis berpengaruh terhadap keterampilan proses ilmiah pada elastisitas material dan hukum Hooke.

ABSTRACT

The rapid development of the world of education requires students to have critical thinking skills and scientific process skills in order to be able to face various problems in everyday life. This study aims to analyze the effect of critical thinking skills on scientific process skills on the subject of material elasticity and Hooke's law. The type of research used in this study is associative quantitative research. The population used was all students with a sample of 30 grade XI students. The sampling technique used purposive sampling. The research instruments used were essay tests and observation sheets. The data analysis technique used was descriptive statistical tests, the assumption test was the normality test and linearity test, and the hypothesis test was a simple linear regression test. The results of the descriptive statistical test showed that the critical thinking skills of students in each State High School were different, as well as the science process skills of students in each State High School were also different. The results of the normality test showed that the data was normally distributed with sig. > 0.05, then the results of the linearity test showed linear data with sig. > 0.05, and the results of the simple linear regression test showed that there was an influence between critical thinking skills and science process skills with a sig. < 0.05. So, it can be concluded that critical thinking skills influence scientific process skills in material elasticity and Hooke's law.

1. INTRODUCTION

Physics as one of the main subjects in the education curriculum in Indonesia studies a collection of knowledge about natural objects and phenomena obtained from the results of thinking with experimental skills through the scientific method. The aim of learning physics is to equip students with knowledge about the basic laws of nature and the basic processes of equipment performance that we often encounter in everyday life (Husna et al., 2022; Prasetya et al., 2022). Students who study physics are expected to be able

Corresponding author
*E-mail addresses: astalinizakir@unja.ac.id (Astalini)

to master the principles and concepts of physics and know how to use critical thinking based on a scientific attitude in solving problems (Astalini et al., 2022; Septyaningrum & Lestari, 2023). This is because there are still various problems that are difficult to solve in physics such as working on practice questions and memorizing formulas, resulting in low student achievement (Jufrida et al., 2019; Nainggolan et al., 2023). Therefore, training and developing critical thinking skills in learning physics is important because the learning needs of students are increasingly complex and important, and students will become familiar with analysis and problem solving through critical thinking.

Critical thinking skills are important for students to support their learning process, especially in learning natural sciences. Critical thinking skills can encourage students' curiosity, increase student creativity and improve students' problem solving abilities (Hasanah et al., 2022; Kurniawan et al., 2023). With the ability to solve problems, students can consider making the right decision. The ability to think critically consists of five indicators, namely providing simple explanations (elementary clarification), developing basic skills (basic support), conclusions (inference), making further explanations (advanced clarification), and developing strategies and tactics (strategies and tactics) (Kartin et al., 2023; Rohmah et al., 2023). To support students to think critically can be done by practicing science process skills (Nuvitalia et al., 2021; Rahma et al., 2023).

Science process skills are scientific skills in the form of investigations or observations that are carried out by someone by using a rational way of thinking and through their basic abilities. Science process skills are important for students because the science process can help students be directly involved in learning and motivate them to prove their curiosity (Inayah et al., 2020; Rahma et al., 2023; Yuliati & Susianna, 2023). In learning activities and practicum science process skills are needed to help students understand the concepts of a material (Darmaji et al., 2020; Kurniawan et al., 2023). Science process skills are divided into two, namely skills basic science process and integrated science process skills. Basic science process skills consist of observing, inferring, measuring, communicating, classifying, and predicting, while integrated science process skills consist of skills in controlling variables, defining variables operationally, formulating hypotheses, interpreting data, conducting experiments and creating models (Darmaji, Astalini, et al., 2019; Senisum, 2021).

Research related to critical thinking skills and scientific process skills has been carried out by many previous researchers. Among them is analyzing critical thinking skills and process skills in junior high school students (Rini & Aldila, 2023). Then, analyze the relationship and differences in students' science process skills and critical thinking skills based on gender (Darmaji, Kurniawan, et al., 2019). Next, analyze the relationship between science process skills and cognitive biology learning outcomes for high school students (Ilma et al., 2020). Analysis of the relationship and comparison of interests and science process skills of junior high school students has also been researched by (Budiarti et al., 2022). Then, science process skills and creative thinking skills in junior high school level science learning have been described, using descriptive qualitative methods (Wirayuda et al., 2022). Next, we tested the effect of STEM education in environmental simulation-based inquiry learning (SBIL) on science process skills in science education (Sari & Andriyani, 2020)From this research, no research has been found regarding the influence of critical thinking skills on science process skills on elasticity and Hooke's law in high school students using an associative quantitative approach.

The novelty of this research lies in the subject matter tested, namely the elasticity of materials and Hooke's law. Apart from that, the sample used was different, namely high school students, and the type of research used was also different, namely quantitative research. Based on the background above, it is known that critical thinking skills are very important in learning physics so that students can analyze and solve complex problems. Apart from that, students need to be directly involved in learning so they can understand material concepts through science process skills. Therefore, this research aims to analyze the influence of critical thinking skills on science process skills on the subject of elasticity of materials and Hooke's law. The novelty of this research contributes to the existing body of knowledge by exploring the interplay between higher-order thinking abilities, specifically critical thinking, and science process skills within the specific context of elasticity and Hooke's law.

2. METHOD

The research method used in this research is associative quantitative research. Quantitative research as a process of obtaining knowledge based on numerical or numerical data (Mubarak, 2022; Sabil et al., 2023). Associative quantitative research aims to connect existing variables, both as correlational and regression research. The population in this study were all students of class XI MIPA SMA Negeri 6 Jambi City and all students of class XI MIPA SMA Negeri 8 Jambi City. While the samples used in the study were 15 students of class XI MIPA 1 at SMA Negeri 6 Jambi City and 15 students from class XI MIPA 1 at SMA Negeri

8 Jambi City. This sample was taken using a purposive sampling technique. Purposive sampling is a sampling technique for data sources with certain considerations (Campbell et al., 2020; Sulistiyo, 2019). The criteria for taking this sample are students who are ranked in the top 15 and are studying elasticity and Hooke's law.

The research instruments used in this study were essay tests to measure students' critical thinking skills and observation sheets to measure students' science process skills. The essay test used consisted of 10 questions, while the observation sheet used consisted of 15 statements. The rating scale used for the essay test corresponds to the scoring rubric for each question, while the scale used in the science process skills observation sheet is a Likert scale with 5 scales namely (1) Very Low, (2) Low, (3) Fair, (4) High, (5) Very High. The critical thinking ability essay test grid can be seen in Table 1. Then, the observation sheet lattice of science process skills can be seen in Table 2.

Table 1. Critical Thinking Skills Essay Test Grid

No.	Indicator	Statement Number
1.	Providing Simple Explanations (Elementary Clarification)	1, 2
2.	Developing Basic Skills (Basic Support)	3, 4
3.	Conclusions (Inference)	5, 6
4.	Making Further Explanations (Advanced Clarification)	7, 8
5.	Developing Strategies And Tactics (Strategies And Tactics)	9, 10

Table 2. Science Process Skills Observation Sheet Grid

No.	Indicator	Statement Number
1.	Observe	1, 2, 3, 4, 5
2.	Measure	6, 7, 8, 9, 10
3.	Doing Experiments	11, 12, 13, 14, 15

The data analysis technique used is descriptive statistics and inferential statistics. descriptive statistics consist of mean, median, min, max, and categories. Meanwhile, inferential statistics consist of assumption tests and hypothesis tests. The assumption test used in this study is the normality test and linearity test. While the hypothesis test used is a simple linear regression test. Simple linear regression is a hypothesis test to determine the linear relationship between the dependent variable and the independent variable. The decision-making requirements of a simple linear regression test are if the significance value < probability value is 0.05, then the independent variable has a significant effect on the dependent variable, and if the significance value > probability value is 0.05, then the independent variable has no significant effect on the dependent variable. The data obtained were analyzed using the SPSS application. Intervals and categories of critical thinking skills can be seen in Table 3, then Intervals and categories of science process skills can be seen in Table 4.

Table 3. Interval of Critical Thinking Ability Essay Test Scores

Range	Category
0 – 20	Very Low
21 – 40	Low
41 – 60	Enough
61 – 80	High
81 – 100	Very High

Table 4. Interval of Observation Sheet Science Process Skills Scores

Range Indicator			Category
Observe	Measure	Doing Experiments	
5 – 9	5 – 9	5 – 9	Very Low
10 – 13	10 – 13	10 – 13	Low
14 – 17	14 – 17	14 – 17	Enough
18 – 21	18 – 21	18 – 21	High
22 – 25	22 – 25	22 – 25	Very High

3. RESULT AND DISCUSSION

Result

The results of the descriptive statistical test for the variable critical thinking skills in the material elasticity and Hooke's law can be seen in Table 5.

Table 5. Critical Thinking Ability Description Test

School	Category	Range	F	%	Mean	Median	Min	Max
SMAN 6 Jambi City	Very Low	0 – 20	0	0%				
	Low	21 – 40	1	6.67%				
	Enough	41 – 60	3	20%	73.80	76	38	97
	High	61 – 80	5	33.33%				
	Very High	81 – 100	6	40%				
SMAN 8 Jambi City	Very Low	0 – 20	0	0%				
	Low	21 – 40	2	13.33%				
	Enough	41 – 60	2	13.33%	69.20	74	36	94
	High	61 – 80	7	46.67%				
	Very High	81 – 100	4	26.67%				

From the description of Table 5, it can be seen that the percentage value for students' critical thinking skills at SMAN 6 Jambi City is higher than the students' critical thinking skills at SMAN 8 Jambi City which is 46.67% in the high category. Then a descriptive statistical test was carried out on the variable science process skills on elasticity and Hooke's law for indicators of observing, measuring, and conducting experiments which can be seen in Table 6.

Table 6. Test The Description of Science Process Skills

Indicator	School	Category	Range	F	%	Mean	Median	Min	Max
Observe	SMAN 6 Jambi City	Very Low	5 – 9	0	0%				
		Low	10 – 13	2	13,33%				
		Enough	14 – 17	4	26,67%	18,13	18	11	25
		High	18 – 21	6	40%				
		Very High	22 – 25	3	20%				
	SMAN 8 Jambi City	Very Low	5 – 9	0	0%				
		Low	10 – 13	1	6,67%				
		Enough	14 – 17	3	20%	19,87	20	13	25
		High	18 – 21	5	33,33%				
		Very High	22 – 25	6	40%				
Measure	SMAN 6 Jambi City	Very Low	5 – 9	0	0%				
		Low	10 – 13	0	0%				
		Enough	14 – 17	5	33,33%	18,93	18	15	25
		High	18 – 21	7	46,67%				
		Very High	22 – 25	3	20%				
	SMAN 8 Jambi City	Very Low	5 – 9	0	0%				
		Low	10 – 13	2	13,33%				
		Enough	14 – 17	3	20%	20,20	22	13	25
		High	18 – 21	2	13,33%				
		Very High	22 – 25	8	53,33%				
Doing Experiments	SMAN 6 Jambi City	Very Low	5 – 9	0	0%				
		Low	10 – 13	1	6,67%				
		Enough	14 – 17	3	20%	19,60	19	12	25
		High	18 – 21	6	40%				
		Very High	22 – 25	5	33,33%				
	SMAN 8 Jambi City	Very Low	5 – 9	0	0%				
		Low	10 – 13	0	0%				
		Enough	14 – 17	5	33,33%	19,73	19	15	25
		High	18 – 21	4	26,67%				
		Very High	22 – 25	6	40%				

From Table 6 it can be seen that the science process skills of students of SMAN 8 Jambi City on the observing indicator are higher than students of SMAN 6 Jambi City with a percentage value obtained of 40% with a very high category. Likewise, science process skills on indicators measuring it is known that the percentage value of students at SMAN 8 Jambi City is higher than students at SMAN 6 Jambi City with a percentage value of 53.33% in the very high category. And also science process skills on the indicator of conducting experiments shows that the percentage value of students at SMAN 8 Jambi City is higher than students at SMAN 6 Jambi City with a percentage value of 40% in the very high category. Then a normality test was carried out for the variables of critical thinking ability and science process skills, the results obtained can be seen in Table 7.

Table 7. Test the Normality of Critical Thinking Skills and Science Process Skills

School	Variable	N	Sig. (2-tailed)
SMAN 6 Jambi City	Critical Thinking Ability	15	0.315
	Science Process Skills	15	0.314
SMAN 8 Jambi City	Critical Thinking Ability	15	0.174
	Science Process Skills	15	0.168

From the description of Table 7, it shows that the normality test was carried out using the Kolmogorov-Smirnov test, the result was that the data was normally distributed, with a significance value of > 0.05. Where the significance value of critical thinking skills of students of SMAN 6 Jambi City is 0.315 and the significance value of critical thinking abilities of students of SMAN 8 Jambi City is 0.174. While the significance value of the science process skills of students of SMAN 6 Jambi City was 0.314 and the significance value of science process skills of students of SMAN 8 Jambi City was 0.168. Then a linearity test was carried out for the critical thinking ability variable and the science process skills variable which can be seen in Table 8.

Table 8. Linearity Test of Critical Thinking Skills and Science Process Skills

School	Variable	N	Sig. (2-tailed)
SMAN 6 Jambi City	Critical Thinking Ability	15	0.065
	Science Process Skills	15	0.066
SMAN 8 Jambi City	Critical Thinking Ability	15	0.063
	Science Process Skills	15	0.064

From the description of Table 8 above, it shows that the results of the linearity test show that the data is stated to be linear, with a significance value of > 0.05. Where the significance value of critical thinking skills of students of SMAN 6 Jambi City is 0.065 and the significance value of critical thinking abilities of students of SMAN 8 Jambi City is 0.063. While the significance value of the science process skills of students of SMAN 6 Jambi City was 0.066 and the significance value of science process skills of students of SMAN 8 Jambi City was 0.064. Then a regression hypothesis test (ANOVA) was carried out for the variable critical thinking ability and science process skills variable which can be seen in Table 9.

Table 9. Regression Hypothesis Test (ANOVA) Critical Thinking Skills and Science Process Skills

	Sum of Squares	df	Mean Square	F	Sig.
Regression	2469.342	1	2469.342	76.993	0.000
Residual	898.025	28	32.072		
Total	3367.367	29			

From Table 9 it is known that the results of the regression test (ANOVA) show that critical thinking skills affect students' science process skills, where the significance value is 0.000 <0.005. Then a regression test (summary model) was carried out for the variables of critical thinking skills and science process skills, the results can be seen in Table 10.

Table 10. Regression Test (Summary Model) Critical Thinking Skills and Science Process Skills

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.856[a]	0.733	0.724	5.66324

Table 10 shows that the results of the regression test (summary model) obtained an R value of 0.856, R Square of 0.733, Adjusted R Square of 0.724, and Std.Error of the Estimate of 5.66324. Then a regression test (coefficients) was carried out for the variables of critical thinking skills and science process skills, the results obtained are shown in Table 11.

Table 11. Regression Tests (Coefficients) of Critical Thinking Skills and Science Process Skills

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Critical Thinking Ability >< Science Process Skills	19.124	4.575		4.180	0.000

Table 11 shows that there is an influence between critical thinking skills and science process skills, with a significance value of 0.000 < 0.05.

Discussion

Based on the test results of descriptive statistics for the variable critical thinking skills, it is known that the critical thinking skills of students of SMAN 6 Jambi City are higher than the critical thinking abilities of students of SMAN 8 Jambi City. Meanwhile, the results of the descriptive statistical test for the variable science process skills in the material elasticity and Hooke's law show that the science process skills of the students of SMAN 8 Jambi City for the indicators of observing, measuring and conducting experiments are higher than those of the students of SMAN 6 Jambi City. After obtaining the results of the descriptive statistical test, then the assumption test is carried out in the form of a normality test and a linearity test. Based on the results of the normality test carried out using the Kolmogorov-Smirnov test, it was found that the data were normally distributed. Then a linearity test was carried out for the critical thinking ability variable and science process skills variable with the results obtained that the data was stated to be linear. Then a hypothesis test was carried out using a simple linear regression test with the result that there was an influence between critical thinking skills and science process skills on elasticity and Hooke's law at SMAN 6 Jambi City and SMAN 8 Jambi City.

Research related to this has been carried out by previous researchers, including testing the effect of inquiry learning models using three-dimensional media on students' science process skills and physics learning outcomes (Maharani et al., 2020). Furthermore, it is related to the analysis of improving critical thinking skills and science process skills through practical activities using qualitative research (Putri et al., 2022). Then, analyze the correlation between science process skills and students' critical thinking skills in reflecting material on a flat mirror ((Purwanti & Heldalia, 2020). In addition, an analysis of the influence of using scientific-based teaching materials on students' critical thinking skills and science process skills has been carried out (Hardianti et al., 2020). Then, efforts were made to increase awareness of the importance of supporting educators' knowledge about critical thinking concepts and pedagogical approaches to improve students' critical thinking abilities (Pollarolo et al., 2023). Of these studies, not a single study has examined the influence of critical thinking skills on process skills for elasticity and Hooke's law. Apart from that, the research methods used are also different, where this research uses quantitative methods while previous research uses qualitative methods. In addition, this research focuses on analysing the influence of critical thinking skills on science process skills. By conducting this research, it can be used as motivation in various schools to correct mistakes in learning and improve students' critical thinking skills and science process skills.

Critical thinking skills include high-level thinking skills that students need to have in learning, because critical thinking skills can affect their learning outcomes. In addition, students' critical thinking skills will affect the way students solve problems contextually (Fikriyatii et al., 2022; Mulyanti & Gading, 2023; Rismayanti et al., 2022). Lack of problem solving skills has a negative impact on students in mastering understanding of concepts and subject matter. The ability to think critically is important for students to have, especially in learning physics, considering that physics is a part of learning science that cannot be separated from the ability to solve problems and think critically in solving phenomena that exist in the universe and the ability to think high-level students is very important. needed to help solve scientific problems (Alharbi et al., 2022; Damayanti & Wiarta, 2022). Students who are able to think critically will be trained to solve problems because critical thinking requires the ability to identify problems, analyze problems, evaluate problems, and conclude problems in the process of solving problems (Fauziah et al., 2022; Kartika & Rakhmawati, 2022).

Science process skills also affect student learning. Through science process skills, students can appreciate and practice values such as cooperation, rigor, accuracy, objectivity, and master communication

and critical thinking skills, which are very important for everyday life (Mahmudah, 2021; Wiratman et al., 2023). Therefore, learning with science process skills is very important for the development of students' critical thinking skills. Science process skills can improve students' academic abilities including observing, conducting, experimenting, analyzing data, communicating, and concluding (Hediana & Nurita, 2022; Sasmitha et al., 2023). The importance of science process skills in the world of education because with the development of science process skills, basic competencies will develop, namely students' scientific attitudes and problem solving skills, so creative, competitive, innovative, and critical students can be formed in competition in the global world in society (Gasila et al., 2019; Khamhaengpol et al., 2021).

The limitations of this research are that it only examined two high school level schools with a small number of samples and only focused on elasticity and Hooke's law. Therefore, the researcher hopes that future researchers can conduct research using more than two schools so that a larger number of samples is used to produce more accurate data, and it is hoped that they can also take different school levels and different materials. In addition, the researcher also hopes that further research can make comparisons between the two variables.

4. CONCLUSION

Based on the results of the research, it can be concluded that critical thinking skills have a significant impact on students' science process skills, particularly in the context of understanding the concepts of material elasticity and Hooke's law. The ability to analyze, evaluate, and synthesize information enables students to grasp these scientific principles more effectively, as critical thinking promotes a deeper understanding of the underlying mechanisms and the application of these concepts in real-world situations. This influence is evident in the way students approach problem-solving and experimentation, reinforcing the importance of fostering critical thinking in science education.

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