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Analysis The Effect of Problem Based Approaches and Media Experiment on Learning Interest and Critical Thinking Using Structural Equation Modeling

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Abstract

The 21st-century national education paradigm requires students to have new abilities, such as critical thinking ability. However, students' critical thinking skills are still low. Likewise, interest in studying physics is still low. Physics is often considered a difficult subject, discouraging interest in studying physics. This study aims to examine the effect of a problem-based approach and experimental media on the interest in learning physics and the critical thinking skills of class XI high school students using SEM analysis. This research was conducted at senior high school on 4 Jember. The research data were collected using a questionnaire tested for validity and reliability. Furthermore, the data were analyzed using SEM analysis, developing a theoretical model, developing a flow chart, and evaluating the goodness of fit criteria. The results obtained, the problem-based approach has a significant effect on the interest in learning physics, the media for the experimental tool has a significant effect on the interest in learning physics, the problem-based approach has a significant effect on students' critical thinking skills, and the media for the experimental tool has a significant effect on the critical thinking skills of grade XI high school students. In addition, it was found that the interest in learning physics was able to mediate the effect of a problem-based approach on critical thinking skills and the influence of experimental media on critical thinking skills. So we can conclude that each dependent variable and the independent variable influence each other significantly.

Keywords: critical thinking skills; experimental media; interest in learning physics; problem-based approach

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INTRODUCTION

The 21st-century national education paradigm requires students to have the knowledge, new skills, and various ways of learning that can be used as student assets in facing the challenges of an ever-changing world. One of these abilities is thinking critically (Kuhlthau, 2010). The ability to think critically is needed to decide something rational about the actions done and believed so that someone will not fall and suffer the consequences of making inappropriate decisions (Ennis, 2011). Of course, this is very necessary for living life. However, the critical thinking skills possessed by students are still low. This is the same as the research conducted by the Program

for International Student Assessment (PISA). Namely, in 2015, Indonesia was ranked 62 out of 72 countries in terms of critical thinking (Agnafia, 2019). Another research conducted by Hayudiyani et al. (2017) also stated that students' critical thinking skills are still low.

Physics is a branch of Natural Education that studies nature phenomena and their interactions. Physics is closely related to natural phenomena and their applications in everyday life. So, physics needs to be studied because every human being is inseparable from all events, phenomena, forms, properties, and symptoms that exist in nature, which are related to physics (Alfiani, 2020).

Physics is a means to train students to master knowledge that includes the concepts and principles of physics. However, the fact is that often, teachers apply a learning approach that is only teacher-centred, and students only receive information or knowledge provided by the teacher without knowing how the information can be formed. Students are only given knowledge in the form of formulas without knowing the physical meaning of the formula. This causes students to think that physics is a difficult subject (Nurhudayah, Lesmono & Subiki., 2016).

Students do not like and are afraid of physics lessons. Thus, students' interest in learning physics is still low (Supardi et al., 2012). Self-study interest is a feeling of liking, pleasure and attention to efforts to gain knowledge. The descriptions above indicate problems in physics learning activities, namely the low interest in learning physics and students' critical thinking skills. To solve these problems, it is necessary to make efforts to improve learning strategies (Bektiarso, 2015). One of these strategies is to apply a problem-based approach and experimental media. The problem-based approach is one of the approaches used in learning activities, which uses a problem as a first step to gaining new knowledge. At the same time, the experimental media is a tool that can be seen using the sense of sight and can be heard using the sense of hearing, which has the function of assisting a teacher in achieving a more effective and more efficient learning process.

Based on research conducted by Palestina et al. (2014), a problem-based approach can improve students' critical thinking skills. Likewise, Sohibi dan Siswanto (2012) research also states that a problem-based approach affects students' critical thinking skills. It affects critical thinking skills. According to Nardin et al. (2016), the problem-based approach also affects students' interest in learning physics. In addition to being influenced by a problem-based approach, according to Agustianti et al. (2015), interest in learning physics is also influenced by experimental media. This is supported by research conducted by Sari et al. (2019), which states that experimental tools can increase interest in learning physics. In addition, the experimental media can be used to train students' critical thinking skills (Triwiyono, 2011).

Based on the above studies, the researcher tries to confirm the theories and studies that state the relationship between variables in this study by using SEM (*Structural Equation Modeling*) analysis. SEM analysis is the second derivative of a multivariate data analysis technique, which allows a researcher to test the relationship between complex variables to obtain a comprehensive picture of the whole model. The purpose of this study was to determine the effect of applying a problem-based approach on interest in learning physics and critical thinking skills, the effect of applying experimental media on students' interest in learning physics and critical thinking skills, and the effect of interest in learning on students' critical thinking skills.

METHOD

This research is quantitative research, which is a process of finding knowledge which usually uses data in the form of numbers as material to analyze information about things you want to know. In this study, the process was carried out to find the influence of each variable in the study. The data were obtained using a questionnaire, which resulted in numerical data, namely a Likert scale, for further analysis, including data related to students' critical thinking skills. However, the difference is that the questionnaire used contains statements about physics problems that can encourage students to think critically.

This research was conducted at senior high school 4 Jember. The population used in this study was all XI classes in senior high school 4 Jember with 318 students. Meanwhile, the number of samples used in this study was 177 students. The method used in determining the sample to be used in this study is a purposive sampling method, taking carefully selected samples by taking particular research objects.

This research consists of several stages, namely the preparation stage, which includes determining the school, school observation, and making research instruments, namely a questionnaire, which is then tested for validity and reliability to determine the feasibility of the questionnaire. The next stage is data collection and analysis using SEM analysis assisted by the AMOS program.

The problem-based approach and experimental tool media used in this study referred to the experimental approaches and tools previously applied by the teacher who taught in the class. So in this study, there were no learning activities held by researchers. Researchers only distribute questionnaires that have been tested for validity.

SEM analysis consists of several stages, namely (1) developing a model based on theory, (2) developing a path diagram, (3) developing structural equations, (4) selecting input matrices and model estimation, (5) assessing the identification of structural models, (6) Assessing the Goodness of Fit criteria, and (7) Model interpretation and modification.

SEM analysis in this study was used to test: (1) the effect of a problem-based approach on the students' interest in learning physics in high school class XI, (2) the effect of a problem-based approach on the critical thinking skills of class XI high school students, (3) the effect of experimental media on interest learning physics high school students class XI, (4) the effect of media experimental tools on the critical thinking ability of class XI high school students, (5) the effect of interest in learning physics on critical thinking skills of class XI high school students, (6) The effect of using experimental media on critical thinking skills through an interest in learning physics for high school students in class XI. (7) The effect of interest in learning physics on the critical thinking skills of high school students in class XI.

The research hypothesis is (1) There is a significant effect of applying a problem-based approach to the interest in learning physics for high school students in class XI, (2) There is a significant effect of the application of a problem-based approach on the critical thinking skills of high school students in class XI (3) There is a significant effect of using experimental media on interest in learning physics for high school students in class XI. (4) There is a significant effect of using experimental media on the critical thinking skills of high school students in class XI. (5) There is a significant effect of applying a problem-based approach to critical thinking skills through an interest in learning physics for high school students in class XI. (6) There is a significant effect of using

experimental media on critical thinking skills through an interest in learning physics for high school students in class XI. (7) There is a significant effect of interest in learning physics on the critical thinking skills of high school students in class XI.

In addition, in this study, a mediation analysis using the Sobel test was used to determine whether the influence of variable A and variable B must pass through the N variable. In this study, the mediation analysis using the Sobel test was used to test: (1) the significant effect of applying a problem-based approach to critical thinking skills through the students' interest in learning physics in high school class XI and (2) the significant effect of using experimental media on thinking skills. Critical through the interest in learning physics high school students class XI.

The Sobel test is carried out using the equation:

$$z = \frac{ab}{\sqrt{(b^2SE_a^2)+(a^2SE_b^2)}} \qquad (1)$$

Where a is the regression coefficient for the effect of exogenous variables (independent variables) on the mediating variable, b is the regression coefficient from the mediating variable to the endogenous variable (dependent variable), SEa is the standard error of estimation of the effect of exogenous variables on the mediating variable and SEb is the standard error of estimation of the effect of the mediating variable on the endogenous variable. As with other hypothesis tests, in the Sobel-test, to accept the hypothesis, the z value must be $\geq 1{,}98$ with a significance level of $\leq 0{,}05$ (Ferdinand, 2014).

RESULT AND DISCUSSION

The data that have been obtained in this study are presented in SPSS for later analysis using SEM analysis assisted by AMOS program. The steps and results of doing SEM analysis in this study are the first to develop a model based on the theory. In this step, the researcher conducts a scientific exploration of the libraries related to the model to be developed. This is done because SEM analysis aims to confirm a theoretical model, not to produce a model. The second step is to develop a flowchart or path diagram. The model developed based on the theory is depicted in a flowchart. Developing the flowchart is to make it easier for researchers to observe the causal relationship to be studied.

The third step is to construct structural equations. Then, the fourth step is to select the input matrix and model estimation. SEM analysis uses a covariance matrix as input data in the overall estimation carried out. These inputs will then be converted into a correlation matrix or covariance matrix. The fifth step is to assess the structural model identification. SEM analysis can be done if the model has been identified and the results indicate that the model is included in the over-identified model. The identification of the model is made by evaluating the df value of the model that has been made. The results of the structural model identification in this study can be seen in Table 1.

Table 1 *Computation of degrees of freedom output*

Number of distinct sample moments	630
Number of distinct parameters to be estimated	74
Degrees of freedom	556

Table 1 shows that the output computation of the degrees of freedom (DF) model is 556, which means that the value of the degrees of freedom is positive, so it can be concluded that the model is included in the over-identified category and can be continued to the next stage of analysis.The sixth step is to assess the Goodness of Fit (GOF) criteria. This stage aims to evaluate the model's suitability by examining the various Goodness of Fit (GOF) criteria.

However, prior to that, an evaluation of the assumptions in the SEM analysis was carried out. So, if the SEM assumptions have been fulfilled, the model can be tested at a later stage. The assumptions include the assumption of normality and outliers and the assumption of multicollinearity and singularity. In testing the normality of the data used in this study, the overall c.r value was 1.953. This value is in the range -2,58 $<$ c. r $<$ +2,58, so it can be concluded that multivariate data are normally distributed and can be further processed using SEM analysis.

Then to determine whether or not data is a multivariate outlier, it can be seen in the AMOS output, namely in the Mahalanobis distance section. The multivariate outlier test was carried out using the Mahalanobis distance at p $<$ 0,001. Mahalanobis distance is evaluated using the chi-square (X^2) in degrees of freedom according to the number of indicator variables used in a study. In this study, the number of indicator variables is 35 indicators, so if there is data that has a Mahalanobis distance greater than X^2 (35, 0.001) = 66,62, then the data is a multivariate outlier. Based on the output of the AMOS program on the SEM analysis that has been carried out, it is found that there are no data that has a Mahalanobis distance value greater than 66.62. So it can be concluded that there are no multivariate outlier data.

The assumption of multicollinearity and singularity can be evaluated using the determinant of the covariance matrix. The small determinant value of the covariance matrix indicates that there is a problem with the multicollinearity or singularity of the data. However, in general, the SEM program has provided a warning facility "warning" if there is multicollinearity or singularity of data in SEM analysis. Based on the output of SEM analysis assisted by the AMOS program that has been carried out, it was found that the value of the determinant of the sample covariance matrix is 0.000; however, in the analysis carried out using the Amos program, there is no warning "warning", so that the analysis can be continued because the other SEM assumptions have been fulfilled.

After fulfilling the assumptions in the SEM analysis, a further test is carried out, namely the Goodness of Fit (GOF) feasibility test in the initial research model, as seen in Figure 1. While the Goodness of Fit (GOF) output of the initial research model can be summarized as shown in Table 2.

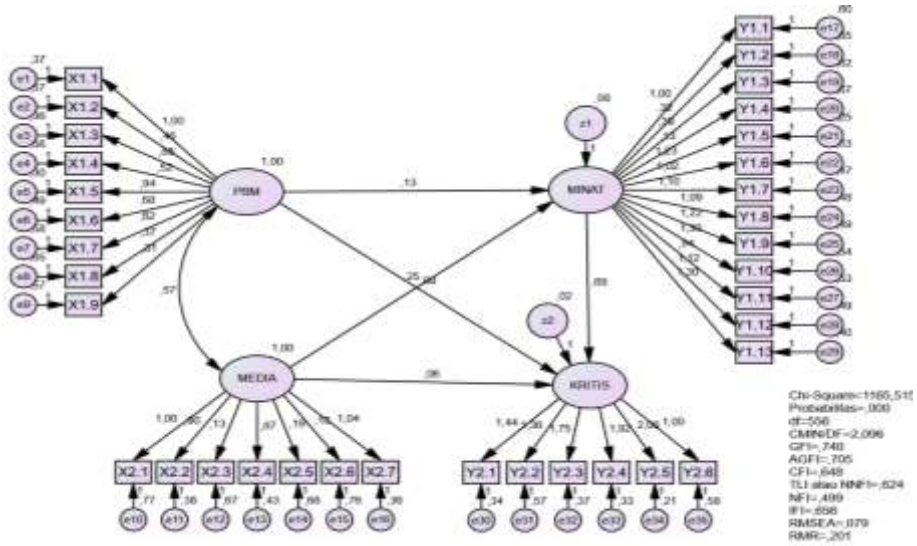

Figure 1 Preliminary research model using SEM analysis assisted by AMOS program

Table 2 Initial model Goodness of Fit (GOF) output

GOF Index	Cutt of Value	Output	Information
Chi-square	expected small	1165,515	
Probability	≥ 0,05	0,000	*poor fit*
CMIN/DF	≤ 2	2,096	*poor fit*
GFI	≥ 0,90	0,740	*poor fit*
AGFI	≥ 0,90	0,705	*poor fit*
CFI	≥ 0,90	0,648	*poor fit*
TLI or NNFI	≥ 0,90	0,624	*poor fit*
NFI	≥ 0,90	0,499	*poor fit*
IFI	≥ 0,90	0,656	*poor fit*
RMSEA	≤ 0,08	0,79	*poor fit*
RMR	≤ 0,05	0,201	*poor fit*

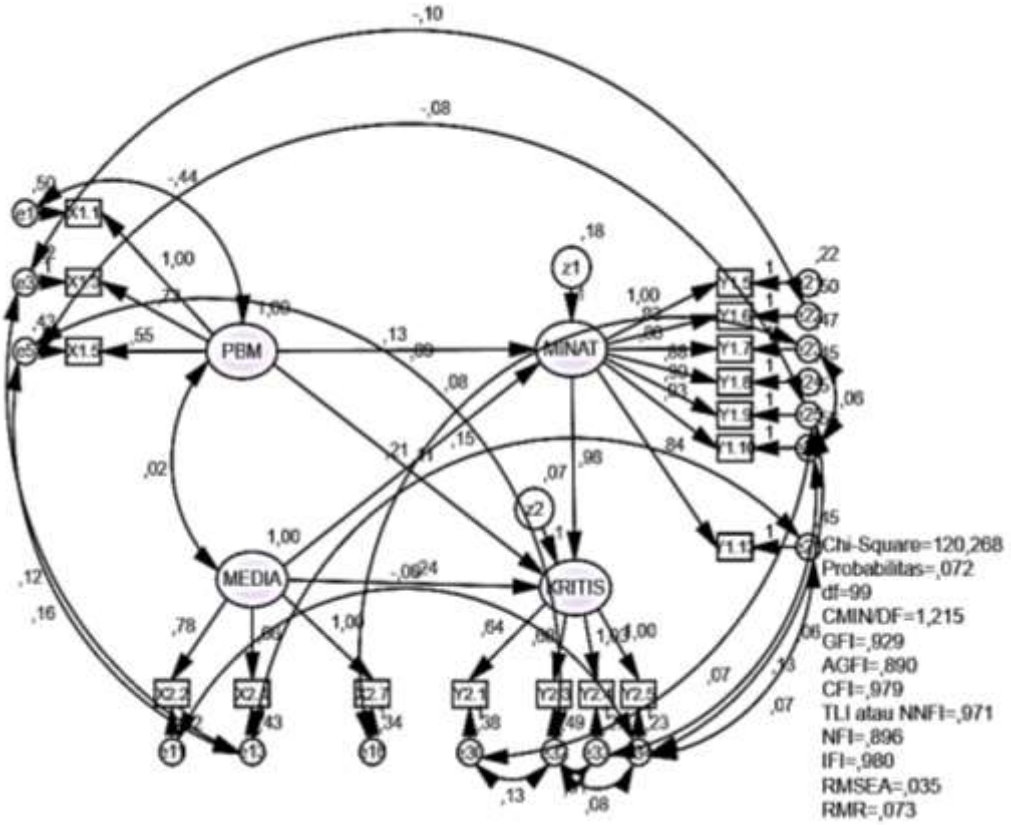

Figure 2 Final research model after modification

Based on Table 2 above, it can be concluded that the research model is not yet fit, so it is necessary to modify the model. Model modification is included in the seventh step in SEM analysis, namely model interpretation and modification. Model modification is done by removing or reducing the variables used in the study, adding variables if possible, and adding or subtracting links or connection lines. In this study, modification of the model was carried out several times to obtain a fit model, and then the final research model was obtained, as shown in Figure 2. The output of the Goodness of Fit (GOF) model can be seen in Table 3.

Table 3 Goodness of Fit (GOF) output of the final modification of the research model

GOF Index	Cutt of Value	Output	Information
Chi-square	expected small	120,268	
Probability	≥ 0,05	0,072	*Good fit*
CMIN/DF	≤ 2	1,215	*Good fit*
GFI	≥ 0,90	0,929	*Good fit*
AGFI	≥ 0,90	0,890	*Marginal fit*
CFI	≥ 0,90	0,979	*Good fit*
TLI or NNFI	≥ 0,90	0,971	*Good fit*
NFI	≥ 0,90	0,896	*Marginal fit*
IFI	≥ 0,90	0,980	*Good fit*
RMSEA	≤ 0,08	0,035	*Good fit*
RMR	≤ 0,05	0,073	*Poor fit*

Based on Table 3, it can be concluded that the research model fits because there is more than 5 Goodness of Fit criteria that have met the cut of value Goodness of Fit (GOF) so that it can be continued by testing the research hypothesis. The research hypothesis testing in the analysis is carried out by observing the output of Regression Weights: (Group Number 1 - Default Model) from the fit model. If the value of the Critical Ratio (C.R.) $\geq 1{,}967$ or the value of probability (P) $\leq 0{,}05$, then H0 is rejected, and the research hypothesis can be accepted. The output of Regression Weights: (Group Number 1 - Default Model) on the full fit model of this study can be seen in Table 4.

Table 4 The fit output regression weights full model

			Estimate	S.E.	C.R.	P	Label
INTEREST	<---	PBA	,134	,047	2,875	,004	par_1
INTEREST	<---	MEDIA	,210	,053	3,962	***	par_2
CRITICAL	<---	PBA	,105	,045	2,312	,021	par_3
CRITICAL	<---	MEDIA	,241	,055	4,374	***	par_4
CRITICAL	<---	INTEREST	,979	,146	6,687	***	par_5

Based on Table 4, the C.R value of the effect of a problem-based approach on interest in learning physics is 2.875, and the probability value is 0.004. This means that the C.R value of the effect of the problem-based approach to the interest in learning physics is $\geq 1{,}967$, and the probability value is $\leq 0{,}05$. So that H_0 is rejected, and the research hypothesis can be accepted, which means that the problem-based approach significantly affects the students' interest in learning physics in senior high school class XI.

The C.R value of the effect of the experimental media on interest in learning physics is 2.638, and the probability value is 0.008. The C.R value of the effect of the experimental media on interest in learning physics is $\geq 1{,}967$, and the probability value is $\leq 0{,}05$. So that H_1 (research hypothesis) can be accepted, which means that there is a significant effect of experimental media on the students' interest in learning physics in senior high school class XI.

The C.R value of the effect of a problem-based approach on critical thinking skills is 2.301, and the probability value is 0.021. The C.R value of the effect of a problem-based approach on critical thinking skills is $\geq 1{,}967$, and the probability value $\leq 0{,}05$. So that H_1 (research hypothesis) can be accepted, which means that there is a significant

effect of using a problem-based approach on the critical thinking skills of class XI senior high school students.

The C.R value of the effect of the experimental media on critical thinking skills is 2.725, and the probability value is 0.006. The C.R value of the influence of the experimental media on critical thinking skills is $\geq 1{,}967$, and the probability value is $\leq 0{,}05$. So that H_1 (research hypothesis) can be accepted, which means that there is a significant effect of the use of experimental media on the critical thinking skills of class XI high school students.

Meanwhile, the C.R value of the effect of interest in learning physics on students' critical thinking skills is 5.157, and there is a sign of *** for the probability value. The value of C.R, the effect of the interest in learning physics on students' critical thinking skills ≥1, 967, and the probability value is very significant. So that H_1 (research hypothesis) can be accepted, which means that there is a significant effect of interest in learning physics on the critical thinking skills of class XI high school students.

Furthermore, in the mediation analysis using the Sobel test, it was found that the value of the Sobel test statistic (z) the effect of a problem-based approach on critical thinking skills through the students' interest in learning physics in senior high school class XI was 4.67993763. This means that the Sobel test statistic (z) value is $\geq 1{,}98$ at the significance level of $\leq 0{,}05$.

Thus, the research hypothesis can be accepted, so it can be concluded that the problem-based approach significantly affects critical thinking skills through the students' interest in learning physics in senior high school class XI. Moreover, it can also be concluded that the interest in learning physics can mediate the effect of a problem-based approach on students' critical thinking skills.

Meanwhile, the value of the Sobel test statistic (z) the effect of experimental media on critical thinking skills through the students' interest in learning physics in senior high school class XI was 5.24187478. This means that the Sobel test statistic (z) value is $\geq 1{,}98$ at the significance level of $\leq 0{,}05$. Thus, the second research hypothesis using the Sobel test can be accepted in the mediation test. So, it can be concluded that the experimental media affect critical thinking skills through the students' interest in learning physics in senior high school class XI. Moreover, it can also be concluded that the interest in learning physics can mediate the influence of the experimental media on students' critical thinking skills.

The mediation analysis results using the Sobel test are in line with the results of the previous SEM analysis, where it can be concluded that the problem-based approach and the experimental media affect the interest in learning physics and the ability to think critically. Where someone who has an interest in learning is believed to be more enthusiastic about continuing to strive and never give up on facing challenges and obstacles encountered in the learning process so that they will be able to produce optimal learning achievement in which this interest in learning is one of the factors that affect students' critical thinking skills. Students who have a good interest in learning will positively respond to learning activities so that students can think critically if the teacher gives a problem.

Based on the results of the analysis that has been carried out, both by using SEM analysis and mediation analysis using the Sobel test, it can be concluded that the increase in students' interest in learning physics is higher when in learning activities using experimental media compared to applying a problem-based approach. This is shown in the SEM analysis; the value of the Critical

Ratio (C.R) of the effect of the experimental media on the interest in learning physics is greater than the value of the Critical Ratio (C.R) of the effect of the problem-based approach on the students' interest in learning physics. The C.R value of the effect of the experimental media on students' interest in learning physics is 3,962. At the same time, the C.R value of the effect of a problem-based approach on students' interest in learning physics is 2.875. The C.R value itself is a reference in determining how strong the relationship between the two variables is in SEM analysis.

Similar to the interest in learning physics, based on the research that has been done, it is concluded that the increase in students' critical thinking skills is higher when in learning activities using experimental media than by applying a problem-based approach. This is indicated by the C.R value of the influence of the experimental media on the critical thinking ability is greater than the C.R value of the effect of the problem-based approach on the critical thinking skills of high school students. Where the C.R value of the effect of the experimental media on the critical thinking skills of high school students is 4.374, while the C.R value of the effect of a problem-based approach on the critical thinking skills of high school students is 2.312.

So, it can be concluded that the use of experimental media is very suitable for physics learning activities, especially to increase the interest in learning physics and the critical thinking skills of high school students. This is because, according to Jamaluddin (2016), with the use of experimental media in learning physics, students will feel more interested in knowing more about these tools and their relation to the material to be studied. In addition, students are required to seek and find their answers to a problem or a problem related to the concepts and theories of physics. So, students will directly think critically to solve these problems. So, it can be concluded that the use of experimental media is very suitable for physics learning activities, especially to increase interest in learning physics and the ability to think critically of high school students. According to Jamaluddin (2016), with the use of experimental media in learning physics, students will feel more interested in knowing more about these tools and their relation to the material to be studied. In addition, students are required to seek and find their answers to a problem or problem that is, of course, related to the concepts and theories of physics. So, students will immediately think critically to solve these problems.

Based on the research that has been done, it is also concluded that the interest in learning physics and the ability to think critically have a significant relationship. The relationship between the two is very strong, indicated by the value of C.R. The effect of the interest in learning physics on the critical thinking ability of high school students is quite large, equal to 6.687. Based on these results, we can conclude that improving critical thinking skills can be done by increasing student interest in learning physics. According to Haryati et al. (2019), students who have a high interest in studying physics will positively respond to learning activities because students will tend to have a higher willingness and initiative in learning. So, suppose the teacher gives a problem. In that case, the student will have high curiosity and take the initiative to solve the problem, which requires the ability to think critically in the problem-solving process.

CONCLUSION

Based on the research that has been done, it can be concluded that (1) The problem-based approach has a significant effect on the students' interest in learning physics in SMA class XI; (2) The experimental

media have a significant effect on the students' interest in learning physics in SMA class XI; (3) The problem-based approach has a significant effect on the critical thinking skills of class XI high school students; (4) The experimental media have a significant effect on the critical thinking skills of class XI high school students; (5) Interest in learning physics has a significant effect on the critical thinking skills of class XI high school; (6) Interest in learning physics can mediate the effect of a problem-based approach on the critical thinking skills of class XI high school students, and (7) Interest in learning physics can mediate the effect of the experimental media on the critical thinking skills of class XI high school students.

The researcher suggests that the teacher should apply a problem-based approach and experimental media in learning physics because it can increase students' interest in learning physics and critical thinking skills. It can be used as a reference for other researchers in developing or conducting similar research.

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