Journal of Education Technology
Volume 6, Number 2, 2022 pp. 350-362
P-ISSN: 2549-4856 E-ISSN : 2549-8290
Open Access: https://ejournal.undiksha.ac.id/index.php/JET

Group Investigation Flipped Learning in Achieving of Students' Critical and Creative Thinking Viewed from Their Cognitive Engagement in Learning Physics

I Made Tegeh[1*], I Wayan Santyasa[2], Ketut Agustini[3], Gede Saindra Santyadiputra[4], Made Juniantari[5]
[1,2,3,4,5] Universitas Pendidikan Ganesha, Singaraja, Indonesia

ARTICLE INFO

Article history:
Received February 08, 2022
Revised February 12, 2022
Accepted May 12, 2022
Available online May 25, 2022

Kata Kunci:
Group Investigation Flipped Learning, Direct Flipped Learning

Keywords:
Group Investigation Flipped Learning, Direct Flipped Learning

DOI:
https://dx.doi.org/10.23887/jet.v6i2.44417

ABSTRAK

Pada abad 21, siswa di sekolah khususnya dalam pembelajaran fisika harus difasilitasi dengan model pembelajaran yang berpusat pada siswa yang terintegrasi dengan teknologi, seperti group investigation flipped learning (GrIFL) sebagai pengganti model direct flipped learning (DFL). Penelitian ini bertujuan untuk menganalisis pengaruh utama dan interaktif antara model GrIFL dan model DFL terhadap kemampuan berpikir kritis dan kreatif siswa ditinjau dari keterlibatan kognitifnya dalam pembelajaran fisika. Untuk mencapai tujuan ini, penelitian eksperimental dilakukan dengan menggunakan post test only control group design. Sampel dipilih dengan teknik class random. Data penelitian dikumpulkan dengan tes berpikir kritis, tes berpikir kreatif, dan angket keterlibatan kognitif. Data penelitian dianalisis dengan menggunakan analisis varians dua arah multivariat. Hasil penelitian menunjukkan bahwa berpikir kritis dan berpikir kreatif siswa yang belajar dengan model GrIFL lebih tinggi daripada siswa yang belajar dengan model DFL; siswa yang memiliki keterlibatan kognitif tinggi menunjukkan kemampuan berpikir kritis yang sama dengan siswa yang memiliki keterlibatan kognitif rendah, tetapi berpikir kreatif siswa yang memiliki keterlibatan kognitif tinggi lebih tinggi daripada siswa yang memiliki keterlibatan kognitif rendah; tidak terdapat pengaruh interaktif antara model pembelajaran dan kognitif ingagement siswa terhadap berpikir kritis dan berpikir kreatif. Implikasi dari penelitian ini adalah untuk mencapai berpikir kritis dan berpikir kreatif yang optimal, pembelajaran fisika akan lebih baik jika menggunakan model GrIFL.

ABSTRACT

In 21st century, students in schools especially in learning physics must be facilitated with student centered learning models that are integrated with technology, such as group investigation flipped learning (GrIFL) as instead of direct flipped learning (DFL) model. This study aims to analyze the main and interactive effects between the GrIFL model and the DFL model on students' critical and creative thinking viewed from their cognitive ingagement in learning physics. To achieve this goal, experimental research was conducted using a post test only control group design. The sample was selected by class random technique. The research data were collected by critical thinking tests, creative thinking tests, and cognitive engagement questionnaires. The research data were analyzed using two-way multivariate analysis of variance. The results showed that the critical thinking and creative thinking of students who studied with the GrIFL model were higher than students who studied with the DFL model; students who had high cognitive engagement showed the same critical thinking skills as those who had low cognitive involvement, but creative thinking of students who have high cognitive involvement is higher than students who have low cognitive involvement; there is no interactive effect between learning models and students' cognitive ingagement on critical thinking and creative thinking. The implication of this research is that in order to achieve optimal critical thinking and creative thinking, physics learning will be better if using the GrIFL model.

1. INTRODUCTION

The 21st century is a digital era marked by the rapid development of science and technology (Nurtanto et al., 2020; Trisnawati & Sari, 2019). In this century, all advances in information and communication have become media that can help every human activity (Rubini et al., 2019; Sadaf & Gezer, 2020). However, the 21st century is not an easy matter to deal with. This is caused by the development of science and technology that is not limited to starting various changes in the order of human life. These changes resulted in the emergence of global competition that cannot be avoided by everyone, including the people of Indonesia (Harahap et al., 2020; Sumantri, 2019). In overcoming this, the Indonesian people need to be directed at improving the quality of

* *Corresponding Author: I Made Tegeh: im-tegeh@undiksha.ac.id*

human resources. One effective way to improve the quality of human resources (HR) is through improving the quality of education (Dishon & Gilead, 2020; Kim et al., 2019). In this case, educational institutions play an important role in preparing human resources, namely increasing the competence of graduates to have abilities and skills that are in accordance with the demands of the 21st century (Erdogan, 2019; Kids, 2019). The 21st century skill that is meant is that everyone masters the 4Cs which are the means to achieve success in life in society. The 4C skills in question are communication skills, collaboration, critical thinking and problem solving (critical thinking and problem solving), and creativity and innovation (Afandi et al., 2019; Erdogan, 2019). The hope of education applied in the 21st century is to be able to guide students how they should learn and think in the global era. A conscious effort that has been made in Indonesia is to develop and implement the 2013 Curriculum (K-13). K-13 is the current curriculum in the Indonesian education system (Haniah et al., 2020; Mulyasa, 2014). K-13 requires the learning system to be student centered and no longer teacher centered. K-13 emphasizes a scientific approach which consists of observing, asking, exploring, reasoning, and communicating activities, so that it is expected to build skills according to the bill of the 21st century (Sadikin, 2017; Said et al., 2016). The 21st century skill in question is that everyone masters the 4Cs which are the means to achieve success in life in society. The 4C skills in question are communication skills, collaboration, creative thinking and problem solving (critical thinking and problem solving), and creativity and innovation (Levin-Goldberg, 2012). The ability to think critically and think creatively are abilities that students need to have in dealing with life in the family, school, community in a global and all-digital era (Nugraha et al., 2017; Waite et al., 2020). Students with the ability to think critically and creatively tend to plan and solve problems systematically (Putra et al., 2018; Zou'bi, 2021). In addition, the ability to think critically and think creatively leads students to be able to overcome real problems that arise in everyday life (R. Ennis, 2013; Putra et al., 2018). Moreover, as a technology user and recipient of information, critical thinking and creative thinking skills will be needed to distinguish truth or lies, facts or opinions, and filter the information received correctly.

As an effort to train students' critical thinking and creative thinking skills, learning physics plays a very important role in advancing human thinking (Hasan et al., 2019; Tanti et al., 2020). In the Regulation of the Minister of National Education No. 22 concerning content standards, it is stated that physics is indispensable in life to solve real problems critically and creatively. Therefore, physics needs to be studied by students in order to improve the ability to think logically, critically, creatively, systematically, and analytically (Puspitasari et al., 2020; Yu & Mohammad, 2019). Physics in learning requires higher-order thinking skills (Hastuti et al., 2018; Seventika et al., 2018). Studying the subject matter of physics means solving and discovering why and how phenomena occur. Physics is not only a theoretical science, but also empirical, which means that everything that is studied in physics is based on observations of nature and its phenomena so that the ability to think critically and creatively is needed (Astalini et al., 2020; Jian-hua & Hong, 2012). As a component in the curriculum, physics becomes a meaningful lesson in fostering intellectuals, attitudes, interests, skills, creativity, and various thinking abilities. One of the goals of physics is as a means to foster scientific attitudes in students as well as being critical, creative, and analytical in dealing with problems, as well as being able to work together with others (Fakhriyah et al., 2017; Maison et al., 2020). Through the purpose of learning physics, students should be able to think critically and creatively to overcome the problems they face and make the right decisions in improving their quality. Some research results show that students' critical and creative thinking are still low, not a few students are less skilled in solving problems with various alternative answers (Hajiyakhchali, 2013; Zhou et al., 2013). This can be found when students find math problems, students tend to open references to be able to find similar questions so that they can solve the problem. If students do not find similar examples, students assume that the problem is difficult and do not want to work on it. This shows that students' critical and creative thinking skills are still low. However, the reality on the ground shows that there are still many students who have less than optimal critical and creative thinking skills. Trends in Mathematics and Science Study (TIMSS) has shown that Indonesia from 2007 to 2019 had an average score below the international average and ranked some of the lowest among other participating countries (Abdiyani et al., 2019; Pribadi et al., 2015). The data illustrates that the quality of education and human resources in Indonesia, especially in science, is still very low and below average. Indirectly, Indonesia's ranking data in the TIMSS also indicates that the critical thinking skills of students in Indonesia are less than optimal. In line with the research data by TIMSS, the report data on the results of the National Ministry of Education and Culture (Kemendikbud) for the 2019 Academic Year also shows that the average result of the physics national exam (UN) for high school students in Indonesia is still low at 46.47 from scale of 100.0. This is also supported by empirical facts from several other research results. Researchers found facts showing that students' critical thinking skills in schools are still low (Karakoc, 2016; Saputro et al., 2020). Students show an inability to remember information that has been received in the learning process, which is evidence of less-than-optimal critical thinking skills of students (Abdulah et al., 2021; Hart et al., 2021). Based on the fact that students' critical and creative thinking in Indonesia is still low, it indirectly indicates that there are still gaps in learning. The gap is caused by the selection of models and learning media that are not appropriate to be applied in schools. The learning model that tends to be used by educators in Indonesia so far is the direct instruction (DI) learning model which is teacher centered. Learning that is still teacher centered is one of the causes of students' low critical and creative thinking skills (Z. Aini et al., 2018; Gunawan et al., 2019). The teacher centered model is believed to have not been able to improve students' critical and creative thinking skills, especially in learning physics. Therefore, the role in the selection of physics learning models and media needs to be done properly in order to produce a learning process that supports the growth and development of students' critical and creative thinking skills.

Regarding the lack of accommodativeness of the DI model in physics learning, DI model is only able to empower a small number of students to play an active role in the learning process (Rante et al., 2013; Yunita et al., 2019). In other words, the DI learning model is not able to become an arena for most students in developing their critical and creative thinking skills. In the DI model, students are immediately asked to work on questions together in groups. This method makes students not have the responsibility individually in advance to solve the problems given. DI model the teacher is the only main and all-knowing source, while students only accept what is given by the teacher so that learning outcomes cannot optimally achieve learning objectives, especially learning objectives that are accommodating to bills of the 21st century, for example critical and creative thinking skills. Students only acquire theoretical knowledge and act passively, while teachers act actively in providing information. Students' critical thinking and creative thinking skills can develop if physics learning applies learning models that are able to involve reason, scientific attitude, engage in the research process and investigate. So, the group investigation flipped learning (GrIFL) learning model must be implemented in order to develop students' critical and creative thinking in learning physics in high school. In an effort to encourage students to be technology literate, the GI model can be used as e-learning content to realize the Group Investigation Flipped Learning (GrIFL) model. In this case, E-Learning has a function as a complement to flipped learning, and can be used as an alternative to innovative learning (Arianti, 2020; Saehana et al., 2021). E-Learning is a student-centered learning. The investigative group model that is used as e-learning content so that the investigation flipped learning group learning is formed can actually develop students' critical thinking in learning physics (Wahyudi, 2017). The class that applied the investigative group learning model was better than the class that applied the Guided Inquiry model (A. N. Aini et al., 2020; Z. Aini et al., 2018). The investigative group learning model is very suitable for fields of study that require integrated project study activities including physics teaching oriented to acquisition, analysis, and synthesis of information in an effort to solve problems (Santyasa et al., 2019). In class XI high school physics learning, it was found that the critical thinking skills of students who studied with the Group Investigation Flipped Learning model were better than the critical thinking skills of students who studied with Direct Flipped Learning (Krisparinama et al., 2020). Based on the background, this study aims to analyze a difference in the main and interactive effects between the group investigation flipped learning model and the direct flipped learning model on students' critical and creative thinking viewed from their cognitive involvement in learning physics.

2. METHOD

The research design used is a one-way posttest only non-equivalent control group design, which is a type of research with one main independent variable treatment (Ahsanah, 2015; Syahrial et al., 2019). The main independent variable is the Group Inverstigation Flipped Learning (GrIFL) model which is juxtaposed with Direct Flipped Learning (DFL). The dependent variable that is measured is students' critical thinking and creative thinking in learning physics in high school. This study also examines the moderator independent variables, namely students' cognitive involvement as a separator over two dimensions in the analysis design, namely high cognitive involvement and low cognitive involvement.The population of the study was students of class XI MIPA SMA Negeri 1 Kediri Tabanan, totaling 5 classes or 170 students. The research sample was selected using a random class technique, obtained 4 classes or 104 students. The research variables consist of 1) Independent variables, namely Group Investigation Flipped Learning (GrIFL) compared to Direct Flipped Learning (DFL). This variable is not measured, but manipulated with the lesson plan and implementation and student worksheets. 2) Moderator variable, namely cognitive involvement, as measured by the ICAP model questionnaire (Chi & Wylie, 2014). 3) Critical thinking is measured by a physics critical thinking test (R. Ennis, 2013; Putri et al., 2019). 4) Creative thinking is measured by a physics creative thinking test (R. H. Ennis, 2018). Research data were analyzed by descriptive statistics and parametric statistics, with the meaning of each result carried out in a qualitative descriptive manner. Descriptive statistics were used to describe the mean (M) and standard deviation (SD) in each analysis cell. Decision making on the description of the average value and standard deviation uses a five-scale absolute value conversion guideline, namely $M > 85$ is very high, $70 < M$ 85 is high, $55 < M < 70$ is moderate, $40 < M < 55$ is poor, and $M < 40$ is very less. Parametric statistical analysis techniques were used to test the null hypothesis (Ho) against the research hypothesis (Ha). Decision-making uses the criteria, that the two-way MANOVA F value shows significant figures less than 0.05, both for testing the main influence and testing for interactive influences, meaning Ho is rejected, in other words Ha is accepted. However, before the two-way MANOVA, the assumptions were first tested, namely 1) the data were normally distributed, 2) the variance of the average value of the dependent variable between treatments was homogeneous, and 3) there was no collierity effect between the dependent variables. Testing the assumption of normality of data distribution using the criteria, that the F values of Kolmogorov-Smirnov and Shapiro-wilk show significant figures greater than 0.05, meaning the data is normally distributed. Testing the assumption of homogeneity of variance using the criteria, that the variance F values show significant figures greater than 0.05, meaning that the dependent variable variance between treatments is homogeneous. Testing the assumption that there is no collierity effect between the dependent variables uses the criteria that the product moment correlation coefficient $r < 0.80$.

3. RESULT AND DISCUSSION

Result

This study uses two-way MANOVA as data analysis. The results of data analysis are used to test hypotheses. As the assumptions of MANOVA are 1) the data distribution is normally distributed, 2) the variance between the dependent variables is homogeneous, and 3) there is no collinearity effect between the dependent variables. To test the normality of the data distribution, the Kolmogorov-Smirnov statistic and the Shapiro-Wilk statistic were used. The results of the analysis are shown in Table 1 and Table 2.

Table 1. Normality Test of Data Distribution Based on GrIFL vs. DFL. Model

DV	Model	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical	1.00	0.166	34	0.119	0.946	34	0.093
	2.00	0.136	34	0.110	0.955	34	0.168
Creative	1.00	0.220	34	0.088	0.860	34	0.088
	2.00	0.184	34	0.095	0.851	34	0.097

Table 1 shows the results of the analysis of the normality of the distribution of the distributed variable (DV) data based on the learning model. The table shows that the Kolmogorov-Smirnov statistics and Shapiro-Wilk statistics, both for DV critical thinking and DV creative thinking students have sig values. > 0.05. Thus, all DV data are normally distributed.

Table 2. Normality Test of Data Distribution Based on HCE vs. LCE

DV	CE	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical	1.00	0.131	34	0.146	0.944	34	0.080
	2.00	0.170	34	0.094	0.941	34	0.066
Creative	1.00	0.144	34	0.072	0.906	34	0.087
	2.00	0.140	34	0.087	0.955	34	0.178

Table 2 shows the results of the analysis of the normality of the distribution of the distributed variable (DV) data based on cognitive engagement (CE). The table shows that the Kolmogorov-Smirnov statistics and Shapiro-Wilk statistics, both for DV critical thinking and DV creative thinking students have sig values. > 0.05. Thus, all DV data are normally distributed. To test the assumption that the data variance between DV is used Levene's statistic. The results of the analysis are presented in Table 3 and Table 4.

Table 3. Variant Homogeneity Test Based on GrIFL vs. DFL Model

DV	Statistic Based On	Levene Statistic	df1	df2	Sig.
Critical	Based on Mean	0.131	1	66	0.719
	Based on Median	0.232	1	66	0.631
	Based on Median and with adjusted df	0.232	1	64.538	0.631
	Based on trimmed mean	0.153	1	66	0.697
Creative	Based on Mean	1.592	1	66	0.211
	Based on Median	0.845	1	66	0.361

DV	Statistic Based On	Levene Statistic	df1	df2	Sig.
	Based on Median and with adjusted df	0.845	1	65.977	0.361
	Based on trimmed mean	1.767	1	66	0.188

Table 3 shows the results of the analysis of the variance of the derived variable (DV) data based on the learning model. The table shows that Levene's statistical figures based on mean, median, median with adjusted df, trimmed mean, both for the DV variant of critical thinking and the DV variant of students' creative thinking between the GrIFL and DFL learning model groups have sig values. > 0.05. Thus, the variance of the DV data between the two learning models is homogeneous.

Table 4. Variant Homogeneity Test Based on HCE vs. LCE GrIFL vs. DFL Research

DV	Statistic Based On	Levene Statistic	df1	df2	Sig.
Critical	Based on Mean	1.764	1	66	0.189
	Based on Median	1.796	1	66	0.185
	Based on Median and with adjusted df	1.796	1	64.546	0.185
	Based on trimmed mean	1.762	1	66	0.189
Creative	Based on Mean	1.338	1	66	0.252
	Based on Median	1.130	1	66	0.292
	Based on Median and with adjusted df	1.130	1	62.791	0.292
	Based on trimmed mean	1.474	1	66	0.229

Table 4 shows the results of the analysis of the variance of the derived variable (DV) data based on the difference in CE. In the table it appears that Levene's statistical figures based on mean, median, median with adjusted df, trimmed mean, both for the DV variant of critical thinking and the DV variant of creative thinking of students who have HCE and DCE have sig values. > 0.05. Thus, the variance of the DV data between students who had HCE and LCE was homogeneous.The collierity test between DV is also an assumption of MANOVA. To test the collierity effect, the Pearson Correlation statistic was used with the criteria of r(count) < 0.80. The results of the analysis are shown in Table 5. In the table it appears that r(count) = 0.375 with sig. = 0.001 < 0.05. This value of r(count) is < 0.80, so that there is no collierity effect between the two DVs.

Table 5. Colinearity Test Between DV Research GrIFL vs. DFL

DV	Statistic	Critial	Creative
Critical	Pearson Correlation	1	0.278
	Sig. (2-tailed)		0.022
	N	68	68
Creative	Pearson Correlation	0.278	1
	Sig. (2-tailed)	0.022	
	N	68	68

The next MANOVA assumption is that there is no difference in Covariance Matrices DV. This assumption is tested with Box's Test, with the criteria that the Box's Test statistic has a sig value. > 0.05. The results of the analysis of these assumptions are presented in Table 6. These results show that the Box's Test statistic is F = 1.078 with sig. = 0.375 > 0.05. Thus, the DV covariance matrices are the same.

Table 6. Box's Test of Equality of Covariance Matrices Research GrIFL vs. DFL

Box's M	10.285
F	1.078
df1	9
df2	46939.370
Sig.	0.375

The next analysis is a multivariate test of the effect of the GrIFL vs. DFL learning model on students' critical and creative thinking in learning physics with the moderator variable being students' cognitive engagement (Cognitive engagement/CE). The CE variable is divided into two categories, namely High CE (HCE) and Low CE (LCE). The results of this multivariate analysis are presented in Table 7.

Table 7. Multivariate Test of the Effect of GrIFL vs. DFL and Cognitive Engagement on Critical and Creative Thinking

Effect	Statistic	Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	0.997	11318.160	2.000	63.000	0.000
	Wilks' Lambda	0.003	11318.160	2.000	63.000	0.000
	Hotelling's Trace	359.307	11318.160	2.000	63.000	0.000
	Roy's Largest Root	359.307	11318.160	2.000	63.000	0.000
Model	Pillai's Trace	0.756	97.393	2.000	63.000	0.000
	Wilks' Lambda	0.244	97.393	2.000	63.000	0.000
	Hotelling's Trace	3.092	97.393	2.000	63.000	0.000
	Roy's Largest Root	3.092	97.393	2.000	63.000	0.000
CE	Pillai's Trace	0.116	4.134	2.000	63.000	0.021
	Wilks' Lambda	0.884	4.134	2.000	63.000	0.021
	Hotelling's Trace	0.131	4.134	2.000	63.000	0.021
	Roy's Largest Root	0.131	4.134	2.000	63.000	0.021
CE * Model	Pillai's Trace	0.084	2.881	2.000	63.000	0.064
	Wilks' Lambda	0.916	2.881	2.000	63.000	0.064
	Hotelling's Trace	0.091	2.881	2.000	63.000	0.064
	Roy's Largest Root	0.091	2.881	2.000	63.000	0.064

Table 7 shows that 1) the statistical figures of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root based on the influence of the learning model (GrIFL vs. DFL) have sig values. = 0.001 < 0.05. So, there are differences in students' critical thinking and creative thinking between those who study with the GrIFL model compared to those who study with the DFL. 2) The statistical figures for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root based on the influence of CE (HCE vs. LCE) have sig values. = 0.021 < 0.05. So, there are differences in students' critical thinking and creative thinking between those who have HCE compared to those who have LCE. 3) The statistical figures for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root based on the interactive effect between CE*Model have sig values. = 0.064 > 0.05. So, there is no interactive effect between the learning model and cognitive engagement on students' critical thinking and creative thinking in learning physics. The follow-up to the multivariate analysis was the Tests of Between-Subjects Effects learning model and cognitive engagement on each student's critical thinking and creative thinking in learning physics. However, the Tests of Between-Subjects Effects assumes that there is no difference in Error Variances between DVs. To test the Equality of Error Variances used Levene's Test. The results of the analysis are presented in Table 8 which shows that the Levene statistic numbers F = 1.389 with a sig. = 0.25 for critical thinking DV, and F = 2.088 with sig. = 0.110 for creative thinking DV. sig values. each statistic for each DV > 0.05, so the Error Variances between DV are the same.

Table 8. Levene's Test of Equality of Error Variances research GrIFL vs. DFL

DV	F	df1	df2	Sig.
Critical	1.389	3	64	0.254
Creative	2.088	3	64	0.110

The results of the Tests of Between-Subjects Effects learning model (GrIFL vs. DFL) and cognitive engagement (HCE vs. LCE) on critical thinking and creative thinking of students in learning physics are presented in Table 9.

Table 9. Tests of Between-Subjects Effects of GrIFL vs. DFL and Cognitive Engagement on Critical and Creative Thinking

Source	DV	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Critical	2340.588[a]	3	780.196	66.944	0.000

Source	DV	Type III Sum of Squares	df	Mean Square	F	Sig.
	Creative	3428.632[b]	3	1142.877	5.051	0.003
Intercept	Critical	266375.529	1	266375.529	22856.197	0.000
	Creative	314568.015	1	314568.015	1390.322	0.000
Model	Critical	2306.118	1	2306.118	197.875	0.000
	Creative	1350.132	1	1350.132	5.967	0.017
CE	Critical	13.235	1	13.235	1.136	0.291
	Creative	1386.015	1	1386.015	6.126	0.016
CE * Model	Critical	21.235	1	21.235	1.822	0.182
	Creative	692.485	1	692.485	3.061	0.085
Error	Critical	745.882	64	11.654		
	Creative	14480.353	64	226.256		
Total	Critical	269462.000	68			
	Creative	332477.000	68			
Corrected Total	Critical	3086.471	67			
	Creative	**17908.985**	**67**			

Based on Table 9, the following research findings can be presented. First, based on the source of the influence of the learning model (GrIFL vs. DFL) on students' critical thinking, it was found that the statistical value of F = 197,875 with sig. = 0.001 < 0.05. These results indicate that there is a difference in the effect between GrIFL and DFL on students' critical thinking in learning physics. Based on Table 10, it appears that M(GrIFL) = 68,412; SD = 0.585, while M (DFL) = 56,765 with SD = 0.585. The difference between the two mean values is M = 11,647 with SE = 0.828 and sig. = 0.001 (11). So, the critical thinking of students who studied with the GrIFL model was significantly higher than those who studied with the DFL model.

Table 10. The mean (M) and Standard Deviation (SD) Based on the GrIFL vs. DFL Model

DV	Model	M	SD	95% Confidence Interval	
				Lower Bound	Upper Bound
Critical	1.00	68.412	0.585	67.242	69.581
	2.00	56.765	0.585	55.595	57.934
Creative	1.00	72.471	2.580	67.317	77.624
	2.00	63.559	2.580	58.405	68.712

Table 11. Comparison of the Mean (M) and Standard Error (SE) Based on the GrIFL vs. DFL . Model

DV	(I) Model	(J) Model	Mean Difference (I-J)	SE	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Critical	1.00	2.00	11.647*	0.828	0.000	9.993	13.301
	2.00	1.00	-11.647*	0.828	0.000	-13.301	-9.993
Creative	1.00	2.00	8.912*	3.648	0.017	1.624	16.200
	2.00	1.00	-8.912*	3.648	0.017	-16.200	-1.624

Second, based on the source of the influence of the learning model (GrIFL vs. DFL) on students' creative thinking, it was found that the statistical value of F = 5.967 with sig. = 0.017 < 0.05 (Table 9). These results indicate that there is a difference in the effect between GrIFL and DFL on students' creative thinking in learning physics. Based on Table 10, it appears that M (GrIFL) = 72,471; SD = 2,580, while M (DFL) = 63,559 with SD = 2,580. The difference between the two mean values is M = 8,912 with SE = 3,648 and sig. = 0.017 (Table 11). So, the creative thinking of students who studied with the GrIFL model was significantly higher than those who studied with the DFL model. Third, based on the source of the influence of CE (HCE vs. LCE) on critical thinking, it was found that the statistic number F = 1,136 with sig. = 0.291 > 0.05 (Table 9). These results indicate that there is no difference in the effect between HCE and LCE on students' critical thinking in learning physics. Based on Table 12, it appears that M(HCE) = 62,147; SD = 0.585, while M (LCE) = 63.029 with SD = 0.585. The difference between the two mean values is M = 0.882 with SE = 0.828 and sig. = 0.291 > 0.05 (Table 13). So, the critical thinking of students who have HCE is not significantly different compared to those who have LCE.

Table 12. The Mean (M) and Standard Deviation (SD) Based on the HCE vs. LCE GrIFL vs. DFL study

DV	CE	M	SD	95% Confidence Interval	
				Lower Bound	Upper Bound
Critical	1.00	62.147	0.585	60.977	63.317
	2.00	63.029	0.585	61.860	64.199
Creative	1.00	72.529	2.580	67.376	77.683
	2.00	63.500	2.580	58.347	68.653

Table 13. Comparison of Mean (M) and Standard Error (SE) Values Based on HCE vs. LCE GrIFL vs. DFL Studies

DV	(I) CE	(J) CE	Mean Difference (I-J)	SE	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Critical	1.00	2.00	-0.882	0.828	0.291	-2.536	0.772
	2.00	1.00	0.882	0.828	0.291	-.772	2.536
Creative	1.00	2.00	9.029*	3.648	0.016	1.741	16.317
	2.00	1.00	-9.029*	3.648	0.016	-16.317	-1.741

Fourth, based on the source of the influence of CE (HCE vs. LCE) on creative thinking, it was found that the statistic number F = 6.126 with sig. = 0.016 < 0.05 (Table 9). These results indicate that there is a difference in the effect between HCE and LCE on students' creative thinking in learning physics. Based on Table 14, it appears that M(HCE) = 72,529; SD = 2,580, while M (LCE) = 63,500 with SD = 2,580. The difference between the two mean values is M = 9,029 with SE = 3,648 and sig. = 0.016 < 0.05 (Table 15). So, the creative thinking of students who have HCE is significantly higher than those who have LCE. Fifth, based on the source of interactive influence (CE*Model) on critical thinking with F = 1.822; sig. = 0.182; and students' creative thinking with F = 3,061; sig. = 0.085 (Table 9), that there is no interactive effect between the learning model (GrIFL vs. DFL) and students' cognitive engagement (HCE vs. LCE) on each DV of critical thinking and creative thinking of students in learning physics.

Discussion

This study aims to analyze the main and interactive effects between the learning model (Group Investigation Flipped Learning/GrIFL vs Direct Flipped Learning/DFL) and cognitive engagement (HCE vs LCE) on students' critical thinking and creative thinking skills in physics learning in class XI SMA Negeri 1 Kediri Tabanan. The results of the study showed the following findings. First, in learning physics of wave and optical materials, students who study with the GrIFL model show higher critical thinking and creative thinking skills than those who study with the DFL model. Because the two learning models use the same flipped learning (FL) model, what causes differences in students' critical thinking and creative thinking skills is the group investigation (GrI) model which has a greater influence as pedagogical content than direct instruction pedagogy. DI) in DFL. In other words, the GrI model in GrIFL has a greater effect than the DI in DFL on critical thinking and creative thinking skills. This finding is in accordance with the results of previous studies (Z. Aini et al., 2018; Akcay & Doymus, 2012; Astiti, 2018; Parinduri et al., 2017; Pitoyo et al., 2014; Santyasa et al., 2019; Sari, 2017; Yuandini & Sahyar., 2017). The class that applied the GrI learning model was better than the class that applied the Guided Inquiry model in achieving critical thinking and creative thinking (Z. Aini et al., 2018). The GrI model has been tested for excellence in learning physics, motion and force materials for first semester students, compared to the DI model in achieving learning products (Akcay & Doymus, 2012). Physics learning in class XI SMA has proven that the GrI model is superior to the Jigsow model in achieving learning products (Astiti, 2018). In studying the physics concepts of temperature and heat, the GrI model is superior to the DI model in achieving conceptual understanding and science process skills (Parinduri et al., 2017). The GI model is the most superior compared to accelerated learning and role-playing models (Pitoyo et al., 2014). The GrI learning model is very suitable for students in physical learning who require project study activities oriented to acquisition, analysis, and synthesis of information in an effort to solve problems, so that students are able to display better critical thinking and creative thinking skills (Santyasa et al., 2019). In physics learning, the GrI model is superior to the DI model in achieving high school physics learning products (Sari, 2017). In physics learning in secondary schools, it has also been proven that the GrI model is superior to the DI model in achieving conceptual understanding (Yuandini & Sahyar., 2017). In an effort to encourage students to be technology literate, the GrI model can be used as e-learning content to realize the GrIFL model. In this case, Arianti (2020) stated that e-Learning has a function as a complement to flipped learning, and can be used as an alternative to innovative learning. Wahyudi (2017) states that e-Learning is a student-centered learning. Puspitasari (2018) states that the GrI model used as e-learning content so that GrIFL learning is formed can actually develop students' critical thinking to be better in learning physics. In class XI high school physics learning, it was revealed that the critical thinking skills of students who studied with the GrIFL model were higher than those of students who studied with DFL (Krisparinama, Santyasa, & Yasa, 2020).

Second, the results of the analysis of the main effect of students' cognitive engagement (HCE vs LCE) on students' critical thinking and creative thinking skills show that (a) there is no difference in critical thinking between students who have HCE and students who have LCE, (b) students who have HCE showed higher creative thinking skills compared to those with LCE. In the achievement of critical thinking, this finding is not in accordance with the results of research by Christopher et al. (2005), that high cognitive involvement is superior to low cognitive involvement in the achievement of critical thinking as a learning product. This is thought to be caused by the fact that students are not familiar with cognitive engagement strategies in learning. In other words, students do not fully understand the learning activities that must be carried out when they have high cognitive involvement, so that the activity of empowering their critical thinking and creative thinking skills has no typical difference with students who have low cognitive involvement. In achieving creative thinking skills, research shows that students who have HCE are more successful than those who have LCE. These results are in accordance with the statements of previous results (Fredricks et al., 2004; Greene, 2015; Smith et al., 2005). High cognitive engagement is characterized by processing mental connections and elaboration of higher-order cognitive knowledge, while shallow processing perpetuates rote learning caused by a lack of strong engagement with the learning material (Christenson et al., 2012), thus not supporting adequate efforts to acquire creative thinking. Cognitive engagement is a psychological investment that students make in learning, which shifts learning habits from memorization to the use of self-regulatory strategies to facilitate deep understanding (Fredricks et al., 2004). Learning based on self-regulation has the opportunity to form meaningful learning. Meaningful learning is based on the quality of cognitive engagement (Smith et al., 2005). Cognitive engagement is a hallmark of the principle of active learning which emphasizes the importance of cognitive engagement in learning. The quality of cognitive engagement has a direct influence on the quality of learning achievement (Greene, 2015). In other words, the ability to think creatively as a learning achievement will be more optimally obtained by students who have high cognitive involvement compared to students who have low cognitive involvement.Third, this study also reveals that there is no interactive effect between the learning model (GrIFL vs. DFL) and cognitive engagement (HCE vs. LCE) on students' critical thinking and creative thinking skills in learning physics. These findings indicate that both high cognitive engagement (HCE) and low cognitive engagement (LCE) are accommodated in both GrIFL and DFL models of physics learning. Cognitive involvement of students in learning physics is needed. Therefore, they must be guided and motivated to have adequate cognitive involvement in interacting with the facilitator, with other students, and most importantly interacting with the subject matter and other learning facilities. Intensive motivation and guidance from facilitators to students in terms of cognitive engagement will be a vehicle for students to change their minds from passive to active involvement, and from constructive to interactive engagement (Barlow et al., 2020). Changes in these thoughts will affect the effectiveness of the learning process and the optimization of learning products.

4. CONCLUSION

There is a different effect between the group investigation flipped learning model and the direct flipped learning model on students' critical thinking and creative thinking. The critical thinking and creative thinking of students who study with the group investigation flipped learning model are significantly higher than those who study with the direct flipped learning model. There is no different effect between students who have high cognitive involvement and those who have low cognitive involvement on critical thinking, but there is a different effect between students who have high cognitive involvement and those who have low cognitive involvement on creative thinking. The creative thinking of students who have high cognitive involvement is significantly higher than students who have low cognitive involvement. There is no interactive effect between the learning model (group investigation flipped learning vs. direct flipped learning model) and cognitive engagement (high cognitive involvement vs. low cognitive engagement) on students' critical thinking and creative thinking in class XI physics learning in high school. The implication of the findings of this study is that in achieving critical thinking and creative thinking skills in physics learning, the group investigation flipped learning model and the direct flipped learning model are both accommodating to students' high cognitive engagement and low cognitive engagement. In studying physics in class XI SMA on wave and optical materials, the learning process and results, especially the students' creative thinking results, will be more optimally achieved if they are facilitated with the group investigation flipped learning model. Because in learning, students are influenced by their cognitive involvement, students who have low cognitive involvement should be given more intensive guidance so that they are able to do more activities, especially in increasing their cognitive involvement in order to optimize their learning process and in achieving their creative thinking skills in learning physics.

5. REFERENCES

Abdiyani, S. S., Khabibah, S., & Rahmawati, N. D. (2019). Profil Kemampuan Pemecahan Masalah Matematika Siswa SMP Berdasarkan Langkah-langkah Polya Ditinjau dari Adversity Quotient. *Al-Khwarizmi: Jurnal Pendidikan Matematika Dan Ilmu Pengetahuan Alam*, *7*(2), 123–134. https://doi.org/10.24256/jpmipa.v7i2.774.

Abdulah, A., Mustadi, A., & Fitriani, W. (2021). PBL-Based Interactive Multimedia in Improving Critical Thinking Skills. *JPI (Jurnal Pendidikan Indonesia)*, *10*(1), 136. https://doi.org/10.23887/jpi-undiksha.v10i1.25521.

Afandi, Sajidan, Akhyar, M., & Suryani, N. (2019). Development frameworks of the Indonesian partnership 21 st -century skills standards for prospective science teachers: A Delphi study. *Jurnal Pendidikan IPA Indonesia*, *8*(1), 89–100. https://doi.org/10.15294/jpii.v8i1.11647.

Ahsanah, F. (2015). Group investigation: A cooperative learning method for the 10th grade students in speaking english classroom. *TELL Journal*, *3*(1), 57–69. https://doi.org/10.30651/tell.v3i1.311.

Aini, A. N., Hastuti, B., & Utami, B. (2020). The influence of the blended learning model supports elearning (edmodo) on student learning achievements the main material of buffer solutions in SMA 1 Banyudono academic year 2018. *Journal of Physics: Conference Series*, *1511*. https://doi.org/10.5539/ies.v13n6p117.

Aini, Z., Ramdani, A., & Raksun, A. (2018). Perbedaan penguasaan konsep biologi dan kemampuan berpikir kritis siswa kelas X pada penerapan model pembelajaran kooperatif tipe group investigation dan guided inquiry di MAN 1 Praya. *Jurnal Pijar MIPA*, *13*(1), 19–23. https://doi.org/10.29303/jpm.v13i1.466.

Akcay, N. O., & Doymus, K. (2012). The effects of group investigation and cooperative learning techniques applied in teaching force and motion subjects on students' academic achievements. *Journal of Educational Sciences Research*, *2*(1), 109–123.

Arianti, S. (2020). Pembelajaran model e-learning menggunakan aplikasi edmodo pada mata kuliah kosmografi mahasiswa semester iv program studi pendidikan geografi. *Jurnal Meretas*, *7*(1), 58–68. https://jurnal.upgriplk.ac.id/index.php/meretas/article/view/162.

Astalini, A., Darmaji, D., Kurniawan, D. A., Anggraini, L., & Perdana, R. (2020). E-Assessment on Student's Self-Concept for Physics Learning. *Jurnal Ilmu Pendidikan*, *25*(2), 73–81. http://dx.doi.org/10.17977/um048v25i2p73-81.

Astiti, K. A. (2018). The effect of group investigation learning model with brainstroming technique on students learning outcomes. *SHS Web of Conferences*, *42*. https://doi.org/10.1051/shsconf/20184200122.

Barlow, A., Brown, S., Lutz, B., Pitterson, N., Hunsu, N., & Adesope, O. (2020). Development of the student course cognitive engagement instrument (SCCEI) for college engineering courses. *International Journal of STEM Education*, *7*(22), 1–20. https://doi.org/10.1186/s40594-020-00220-9.

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, *49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823.

Christenson, S. L., Amy, L. R., & Chaty, W. (2012). *Handbook of research on students engagement*. Springer Science.

Dishon, G., & Gilead, T. (2020). Adaptability And Its Discontents : 21st- Century Skills And The Preparation For An Unpredictable Future. *British Journal of Educational Studies*, *00*(00), 1–21. https://doi.org/10.1080/00071005.2020.1829545.

Ennis, R. (2013). Critical thinking across the curriculum: The Wisdom CTAC Program. *Inquiry: Critical Thinking across the Disciplines*, *28*(2), 25–45. https://doi.org/10.5840/inquiryct20132828.

Ennis, R. H. (2018). Critical thinking across the curriculum: A vision. *Topoi*, *37*(1), 165–184. https://doi.org/10.1007/s11245-016-9401-4.

Erdogan, V. (2019). Integrating 4C Skills of 21st Century into 4 Language Skills in EFL Classes Vacide Erdoğan. *International Journal of Education and Research*, *7*(11), 113–124.

Fakhriyah, F., Masfuah, S., Roysa, M., Rusilowati, A., & Rahayu, E. S. (2017). Student's science literacy in the aspect of content science? *Jurnal Pendidikan IPA Indonesia*, *6*(1), 81–87. https://doi.org/10.15294/jpii.v6i1.7245.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109. http://www.jstor.org/stable/3516061.

Greene, B. A. (2015). Measuring cognitive engagement with self-report scales: Reflections from over 20 years of research. *Educational Psychologist*, *50*(1), 14–30. https://doi.org/10.1080/00461520.2014.989230.

Gunawan, Harjono, A., Herayanti, L., & Husein, S. (2019). Problem-based learning approach with supported interactive multimedia in physics course: its effects on critical thinking disposition. *Journal for the Education of Gifted Young Scientists*, *7*(4), 1075–1089. http://dx.doi.org/10.17478/jegys.627162.

Hajiyakhchali, A. (2013). The Effects of Creative Problem Solving Process Training on Academic Well-being of Shahid Chamran University Students. *Procedia-Social and Behavioral Sciences*, *84*, 549–552. https://doi.org/10.1016/j.sbspro.2013.06.602.

Haniah, A. R., Aman, A., & Setiawan, R. (2020). Integration of Strengthening of Character Education and Higher Order Thinking Skills in History Learning. *Journal of Education and Learning (EduLearn)*, *14*(2), 183–190. https://doi.org/10.11591/edulearn.v14i2.15010.

Harahap, L. J., Ristanto, R. H., & Komala, R. (2020). Evoking 21st-Century Skills: Developing Instrument of Critical Thinking Skills and Mastery of Ecosystem Concepts. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *5*(1), 27–41. https://doi.org/10.24042/tadris.v5i1.5943.

Hart, C., Da Costa, C., D'Souza, D., Kimpton, A., & Ljbusic, J. (2021). Exploring higher education students' critical thinking skills through content analysis. *Thinking Skills and Creativity*, *41*(May), 100877. https://doi.org/10.1016/j.tsc.2021.100877.

Hasan, R., Lukitasari, M., Utami, S., & Anizar, A. (2019). The activeness, critical, and creative thinking skills of students in the Lesson Study-based inquiry and cooperative learning. *Jurnal Pendidikan Biologi Indonesia*, *5*(1), 77–84..

Hastuti, P. W., Nurohman, S., & Setianingsih, W. (2018). The Development of Science Worksheet Based on Inquiry Science Issues to Improve Critical Thinking and Scientific Attitude. *Journal of Physics: Conference Series*, *1097*(1), 1–7. https://doi.org/10.1088/1742-6596/1097/1/012004.

Jian-hua, S., & Hong, L. (2012). Explore the Effective Use of Multimedia Technology in College Physics Teaching. *Energy Procedia*, *17*, 1897–1900. https://doi.org/10.1016/j.egypro.2012.02.329.

Karakoc, M. (2016). The significance of critical thinking ability in terms of education. *International Journal of Humanities and Social Science*, *6*(7), 81–84.

Kids, B. for. (2019). Framework for 21st century learning definitions. In *Partnership for 21st Century Learning*.

Kim, S., Raza, M., & Seidman, E. (2019). Improving 21st-Century Teaching Skills: The Key to Effective 21st-Century Learners. *Research in Comparative and International Education*, *14*(1), 99–117. https://doi.org/10.1177/1745499919829214.

Krisparinama, C. G., Santyasa, I. W., & Yasa, P. (2020). Pengaruh model e-learning berbasis group investigation terhadap keterampilan berpikir kritis siswa di SMA. *Jurnal Pendidikan Fisika Undiksha*, *10*(2), 101–112. https://doi.org/10.23887/jjpf.v10i2.29927.

Levin-Goldberg, J. (2012). Teaching Generation TechX with the 4Cs: Using Technology to Integrate 21st Century Skills. *Journal of Instructional Research*, *1*, 59–66. https://doi.org/10.9743/jir.2013.8.

Maison, M., Haryanto, H., Ernawati, M. D. W., Ningsih, Y., Jannah, N., Puspitasari, T. O., & Putra, D. S. (2020). Comparison of student attitudes towards natural sciences. *International Journal of Evaluation and Research in Education*, *9*(1), 54–61. https://doi.org/10.11591/ijere.v9i1.20394.

Mulyasa, E. (2014). *Pengembangan dan Implementasi Kurikulum 2013* (5th ed.). Pt Remaja Rosdakarya.

Nugraha, A. J., Suyitno, H., & Susilaningsih, E. (2017). Analisis Kemampuan Berpikir Kritis Ditinjau dari Keterampilan Proses Sains dan Motivasi Belajar melalui Model PBL. *Journal of Primary Education*, *6*(1), 35–43. https://doi.org/https://doi.org/10.15294/jpe.v6i1.14511.

Nurtanto, M., Fawaid, M., & Sofyan, H. (2020). Problem Based Learning (PBL) in Industry 4.0: Improving Learning Quality through Character-Based Literacy Learning and Life Career Skill (LL-LCS). *Journal of Physics: Conference Series*, *1573*(1), 0–10. https://doi.org/10.1088/1742-6596/1573/1/012006.

Parinduri, S. H., Sirait, M., & Sani, R. A. (2017). The effect of cooperative learning model type group investigation for student's conceptual knowledge and science process skills. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *7*(4), 49–54.

Pitoyo, A., Waluyo, H. J., Suwandi, S., & Andayani. (2014). The effect of group investigation learning model, accelerated team and role playing on elementary school students' writing skills viewed from cognitive style. *Journal of Education and Practice*, *5*(1), 21–29.

Pribadi, A., Somakim, S., & Yusup, M. (2015). Pengembangan Soal Penalaran Model TIMSS pada Materi Geometri dan Pengukuran SMP. *Histogram*, *1*(2), 115–128. https://doi.org/10.31100/histogram.v1i2.30.

Puspitasari, R. D., Herlina, K., & Suyatna, A. (2020). A Need Analysis of STEM-Integrated Flipped Classroom E-Module to improve Critical Thinking Skills. *Indonesian Journal of Mathematics Education*, *3*(2), 178–184. https://doi.org/10.24042/ijsme.v3i2.6121.

Putra, M., Mulyadi, H., & Ahman, E. (2018). Critical thinking skill on economics subject of students in SMA Negeri 1 Cikaran Pusat. *Internasional Journal of Research and Rebiem (IJRR)*, *5*(6), 59–63.

Putri, O. D., Nevrita, N., & Hindrasti, N. E. K. (2019). Pengembangan Instrumen Penilaian Keterampilan

Berpikir Kritis Siswa Sma Pada Materi Sistem Pencernaan. *BIOEDUKASI (Jurnal Pendidikan Biologi)*, *10*(1), 14. https://doi.org/10.24127/bioedukasi.v10i1.2004.

Rante, P., Sudarto, & Ihsan, N. (2013). Pengembangan multimedia pembelajaran fisika berbasis audio-video eksperimen listrik dinamis di smp. *Jurnal Pendidikan IPA Indonesia*, *2*(2), 203–208. https://doi.org/10.15294/jpii.v2i2.2724.

Rubini, B., Septian, B., & Permana, I. (2019). Enhancing critical thinking through the science learning on using interactive problem based module. *Journal of Physics: Conference Series*, *1157*(2). https://doi.org/10.1088/1742-6596/1157/2/022001.

Sadaf, A., & Gezer, T. (2020). Exploring factors that influence teachers' intentions to integrate digital literacy using the decomposed theory of planned behavior. *Journal of Digital Learning in Teacher Education*. https://doi.org/10.1080/21532974.2020.1719244.

Sadikin, M. (2017). Analisis Pembelajaran Sejarah dengan Pendekatan Saintifik pada Kurikulum 2013. *Sosial Horizon: Jurnal Pendidikan Sosial*, *4*(2), 219–227. https://doi.org/10.31571/sosial.v4i2.660.

Saehana, S., Ali, M., Darsikin, D., Nurgan, N., & Ratnaningtyas, D. I. (2021). Pelatihan Penggunaan Learning Management System (LMS) bagi Guru Sebagai Mitra Asistensi Mengajar Program MBKM Prodi Pendidikan Fisika FKIP Universitas Tadulako. *Bubungan Tinggi: Jurnal Pengabdian Masyarakat*, *3*(4), 441. https://doi.org/10.20527/btjpm.v3i4.4333.

Said, I. M., Sutadji, E., & Sugandi, M. (2016). The scientific approach-based cooperative learning tool for vocational students vocation program of autotronic (automotive electronic) engineering. *IOSR Journal of Research & Method in Education*, *6*(3), 67–73. https://doi.org/10.9790/7388-0603046773.

Santyasa, I. W., Kanca, I. N., Warpala, I. W. S., & Sudarma, I. K. (2019). Group investigation and explicit learning models in learning physics at senior high schools. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *5*(2), 203–216. https://doi.org/10.21009/1.05216.

Saputro, A. D., Atun, S., Wilujeng, I., Ariyanto, A., & Arifin, S. (2020). Enhancing pre-service elementary teachers' self-efficacy and critical thinking using problem-based learning. *European Journal of Educational Research*, *9*(2), 765–773. https://doi.org/10.12973/eu-jer.9.2.765.

Sari, E. (2017). Pengaruh model pembelajaran kooperatif tipe group investigation terhadap hasil belajar fisika ditinjau dati kemampuan berpikir logis. *Jurnal Pendidikan Fisika*, *6*(1), 27–32. https://jurnal.unimed.ac.id/2012/index.php/jpf/article/view/6341/5558.

Seventika, S. Y., Sukestiyarno, Y. L., & Mariani, S. (2018). Critical thinking analysis based on Facione (2015) - Angelo (1995) logical mathematics material of vocational high school (VHS). *Journal of Physics: Conference Series*, *983*(1). https://doi.org/10.1088/1742-6596/983/1/012067.

Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education*, *94*(1), 87–101. https://doi.org/10.1002/j.2168-9830.2005.tb00831.x.

Sumantri, B. A. (2019). Pengembangan Kurikulum Di Indonesia Menghadapi Tuntutan Kompetensi Abad 21. *At-Ta'lim : Media Informasi Pendidikan Islam*, *18*(1), 27. https://doi.org/10.29300/attalim.v18i1.1614.

Syahrial, S., Asrial, A., Kurniawan, D. A., Nugroho, P., Septiasari, R., Pratama, R. A., & Perdana, R. (2019). Increased Behavior of Students' Attitudes to Cultural Values Using the Inquiry Learning Model Assisted by Ethnoconstructivism. *Journal of Educational Science and Technology (EST)*, *5*(2), 166. https://doi.org/10.26858/est.v5i2.9670.

Tanti, T., Kurniawan, D. A., Kuswanto, K., Utami, W., & Wardhana, I. (2020). Science Process Skills and Critical Thinking in Science: Urban and Rural Disparity. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 489–498. http://doi.org/10.15294/jpii.v9i4.24139.

Trisnawati, W. W., & Sari, A. K. (2019). Integrasi Keterampilan Abad 21 Dalam Modul Sociolinguistics: Keterampilan 4C (Collaboration, Communication, Critical Thinking, Dan Creativity). *Jurnal Muara Pendidikan*, *4*(2), 455–466. https://doi.org/10.52060/mp.v4i2.179.

Wahyudi, I. (2017). Pengembangan program pembelajaran fisika sma berbasis e-learning dengan schoology. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *6*(2), 187–199. http://ejournal.radenintan.ac.id/index.php/al-biruni/article/download/1850/pdf.

Waite, L. H., Smith, M. A., & McGiness, T. P. (2020). Impact of a problem-based learning elective on performance in non-problem-based learning required courses. *Currents in Pharmacy Teaching and Learning*, *12*(12), 1470–1476. https://doi.org/10.1016/j.cptl.2020.07.015.

Yu, T. X., & Mohammad, W. R. W. M. (2019). Integration of 21st Century Learning Skills (4C Elements) in Interventions to Improve English Writing Skill Among 3K Class Students. *International Journal of Contemporary Education*, *2*(2), 100. https://doi.org/10.11114/ijce.v2i2.4498.

Yuandini, F., & Sahyar. (2017). The effect of cooperative learning model type group investigation assisted flash media, scientific attitude on students' conceptual knowledge. *Journal of Education and Practice*, *8*(17), 150–155.

Yunita, Y., Halim, A., & Safitri, R. (2019). Meningkatkan Penguasaan Konsep Mahasiswa Dengan Simulasi Physics Eduaction and Technology (PhET). *Jurnal Pendidikan Sains Indonesia*, *7*(1), 16–22. https://doi.org/10.24815/jpsi.v7i1.13492.

Zhou, Q., Huang, Q., & Tian, H. (2013). Developing students' critical thinking skills by task-based learning in chemistry experiment teaching. *Creative Education*, *4*(12). https://doi.org/http://dx.doi.org/10.4236/ce.2013.412A1006.

Zou'bi, R. Al. (2021). The impact of media and information literacy on acquiring the critical thinking skill by the educational faculty's students. *Thinking Skills and Creativity*, *39*(November 2020), 100782. https://doi.org/10.1016/j.tsc.2020.100782.