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Cognitive Engagement and Creative Thinking: Intervention with Research-Based e-Learning and Students' Social Attitudes in Learning Physics at Public High School

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ABSTRACT

Physics learning in high school is closely related to students' social attitudes in conducting cognitive engagement to achieve creative thinking. This study aims to analyze students' cognitive engagement and creative thinking using research-based e-learning (RBeL) and directed learning (DeL) about students' social attitudes. The samples were randomly selected from 4 classes (two experimental and two control classes). This study used a post-test-only control group design. Data on social attitudes and cognitive engagement were collected using questionnaires, and data on creative thinking using essay tests. Data were analyzed using a two-way Manova and hypothesis testing using a significance level of 5%. The results showed significant differences in the cognitive engagement of students who were intervened using RBeL and DeL. Intervention using RBeL was more effective than DeL in achieving cognitive engagement. There is a significant difference between the creative thinking of students who are intervened using RBeL and DeL. The RBeL intervention was more effective than DeL in achieving creative thinking. There are similarities in cognitive engagement and creative thinking among students with HSA and LSA. There was no interaction between learning models and social attitudes regarding cognitive engagement and creative thinking in students. The achievement of cognitive involvement and creative thinking of 10th-grade students in learning physics is more effective using research-based e-learning models.

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I. Introduction

We must realize that school learning still tolerates how the teacher delivers material orally. Teachers are likelier to deliver one-way learning material (teacher-centered learning/TCL) [1]. Weimer identified five activities carried out by TCL teachers, namely having full power in the class as a source of learning content, dominating roles in class, the teacher being more responsible in learning, dominating the learning process, and separate evaluation [2]. The impact is felt that learning with TCL becomes one of the obstacles to an optimal learning process, which ultimately leads to low learning products [1], [3]–[5]. Physics learning with TCL tends to hinder students from building physics knowledge [6]–[8].

Along with the times, to match the needs of students in improving their personal quality, student-centered learning (SCL) models have emerged as an alternative to learning to answer the problem of incompatibility with TCL models. A learner-centered learning strategy is SCL. According to the SCL approach, teachers must effectively fulfill their duties as facilitators, innovators, and motivators. [4]. Kurniawan *et al.* [4] argued more forcefully that teachers were also expected to assist students in finding solutions to problems when they encountered challenges during the learning process, in addition to giving lessons in front of the class.

In recent decades, SCL has become an effective environment for enhancing student learning experiences [3], [6]. SCL is more effective in achieving student learning outcomes than traditional learning [5]. According to Yilmaz [5], pull-out learning, teacher demands, and knowledge, skill, and experience transmission are the main focuses of conventional education. Unlike SCL, which emphasizes process, output, and result. SCL aids in the development of practical skills in pupils, including teamwork and problem-solving. Active learning, small group learning, question-directed instruction, Inquiry-guided learning, cooperative learning, problem-based learning, peer instruction, active learning, collaborative learning, inquiry-based learning, project-based learning, and just-in-time teaching are some of the approaches used in SCL [9].

In entering the classroom, students already have knowledge, skills, attitudes, and beliefs about the content of various subjects. So, when they come to class, they already have an initial knowledge about the new knowledge they will learn. Therefore, teachers should consider and empower students' prior knowledge in designing and implementing meaningful learning. Before teaching new material, teachers should assume their students' prior knowledge if they wish to develop SCL for effective learning. In this situation, the teacher can quiz the students on their knowledge of the subject [10]. Active participation and permanent learning are very important factors for learning. The active learning framework is aimed at three strategies for students to be intellectually active, socially active, and physically active [11]. Small group projects, entire class activities, and conversations in small groups can all be used to create socially engaged learning practices. Both the teacher and the pupils receive feedback from the system employed in the classroom. As a result, the class begins to discuss the feedback, including correct or incorrect replies. Active learning is affected by interactions between students and between students and teachers during debates.

SCL is a learning approach that can replace lecture learning with active learning, integration of SCL programs, or group collaboration, and in the end, students take responsibility for their progress [12]. The SCL environment has an advantage over the TCL approach because, in SCL, students are provided time to exchange ideas and complement and interact with one another. With SCL, students can better understand themselves as subjects and the content's nature. The SCL environment provides students with a major focus on knowledge sharing, and when learning is done properly, SCL can become a lifelong learning process [12], [13].

TCL uses lecture and class discussion learning strategies, while in the SCL class, the strategies used are research, collaborative, and discovery learning, which invite students to formulate questions [12]. SCL models lead to finding basic information and possible solutions to formulated questions, including in an investigation-based debate. In the SCL learning environment, students can perform complex functions such as finding and empowering information from complex conceptual frameworks, interacting with the social environment to impart knowledge, and controlling their learning through reflection [13]. This shows that the social attitudes of students greatly determine the learning process and product. Discovery-based collaborative activities, social attitudes, formulating questions, and gathering information to formulate solutions based on conceptual frameworks will develop students' cognitive engagement and creative thinking. Meanwhile, social interaction activities and learning to control learning based on self-reflection lead to the synergy between students to interact with learning models.

The way teachers teach creates an impact on student learning development. Teaching approaches and teacher strategies influence students' learning skills and strategies [13]. Thus, teachers should change their views which are implemented in practice, to apply SCL in their teaching. SCL becomes a resistance for students to master their learning skills and strategies, and they can develop their learning methods. If the teacher has skills in organizing the preparation and delivery of learning with SCL, students can develop these learning skills. When teachers use SCL more in class, students' learning skills and strategies develop significantly. The use of SCL by teachers provides more opportunities for improving student learning skills and strategies [13].

Based on the explanation above, SCL models are appropriate for students to make them learn by doing. Students need to be involved in their learning process to adapt their skills and strategies to become responsible learners. Students must develop their learning skills and strategies as SCL provides a vehicle for students to build life-long learning skills that they can use not only for learning in school but also as an effort to prepare for their future in the next life. Based on these thoughts, this study initiated the SCL application and examined its effect on cognitive engagement attitudes and creative thinking in terms of student attitudes in learning physics in high school.

Based on this background, the research problem can be formulated, namely, "Are there differences in the main effect and interactive effect of the SCL model compared to the TCL model in achieving cognitive involvement and creative thinking in terms of students' attitudes in learning physics in high school?"

II. Theory

SCL provides an active learning process for students inside and outside the classroom. Active learning is a relevant strategy in SCL implementation [14]. Active learning strategy is learning oriented towards student activities and applies the principle of learning by doing. Active participation and permanent learning are critical

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factors. The purpose of SCL is to influence academic achievement and social skills. They show that SCL models can improve the performance of students from low age to high age in school. In SCL, students engage in new experiences by fulfilling their responsibilities or projects in class. In SCL, students have direct access to the knowledge base, work individually, and are empowered in small groups to solve authentic problems. The social attitudes of students largely determine the success of learning in small groups.

The component of interpersonal intelligence is social attitude. Social attitudes include four main components, group management attitudes, problem-solving attitudes, attitudes to upholding interpersonal bonds, and attitudes to conducting social analysis [15]–[17].

The governing group's mindset is a social mindset that a learner frequently needs for learning. This approach entails organizing and leading initiatives to move people. A mediator's skill in averting or ending confrontations is their approach to negotiating solutions. This mindset is the foundation for coming to an agreement, resolving or mediating conflicts, and having the diplomatic and social skills necessary to resolve conflicts. Being able to empathize and forge relationships has frequently been referred to as having a relationship-building mentality. With this mindset, it is simpler for individuals to interact with others or to identify and address the sentiments and problems of others. Students with this mindset make dependable "team players," dependable partners, devoted friends, or trusted business associates. They can be effective supervisors, salespeople, or teachers in the workplace. The mindset required for social analysis is the mindset needed to recognize and comprehend the thoughts, feelings, and concerns of others. Pleasant intimacy or a sense of belonging will result from understanding the other person's emotions.

Learning physics using the SCL model is successfully implemented by students at school. Based on observations, students generally begin to understand the concept of SCL [6]. He stated that SCL provides a learning process for students to develop interpersonal and independent learning skills, practice on time, actively generate ideas in groups, and are good motivators to friends. In SCL, students tend to respond to learning positively, and teachers consider themselves successful in their quest to create more learner-centered learning [2].

In SCL, the development team members engage in open communication and a genuine desire to succeed. Most of the time is spent, for instance, on creating novel task types, adapting tools to evaluate how students work in groups, and attempting to make sense of the data gathered during laboratory learning [7]. Therefore, students can use creative thinking in SCL to support better learning processes and products. The creativity of students who follow SCL learning strategies is higher than students who follow direct learning strategies. There is a strong interaction between learning strategies and spatial abilities in achieving creativity, meaning that in achieving creativity, SCL tends to interact strongly with high spatial ability. In contrast, direct learning interacts strongly with low spatial ability. Research comparing TCL and SCL methods in medical science shows that many students tend to stick to traditional methods [12]. However, evidence shows that the increase in learning processes and products is higher for those who use SCL [12]. This shows that the SCL learning environment must be created sustainably in learning, although the application of SCL often experiences obstacles in practice.

III. Method

This quasi-experimental study used a post-test-only control group design. This design is used because the school randomly and naturally forms the subjects, so academically homogeneous classes are formed. This study's population was five classes consisting of 185 10th-grade students from a Public High School 2 in Singaraja. Four classes, totaling 149 students (79.7% of the population), were chosen randomly to make up the sample. Furthermore, with this technique, two classes (75 students) were also assigned as an experimental group using the RBeL model and two classes (75 students) as a control group using the DeL model. For purposing data analysis, each group was divided into high and low social attitudes. The basis is 27% of the total number of students in each group, so the fourth unit cell in the analysis design is 20 students.

The variables examined in this study were RBeL and DeL as independent variables, high and low social attitudes as moderator variables, and cognitive engagement and students' creative thinking as dependent variables, respectively. A Likert model questionnaire measured students' social and cognitive engagement attitudes, and a physics test measured students' creative thinking.

The concept of social attitudes—which includes four main dimensions [15]–[17]—was used to develop the social attitude scale. These dimensions are 1) the attitude of maintaining personal relationships; 2) the attitude of conducting social analysis; 3) the attitude of negotiating solutions; and 4) the organizing group's attitude. The 30 items on social attitude instruments are divided into four social attitude dimensions. A Likert Rating Scale is used for each item. The total-item correlation coefficient of the social attitude questionnaire varied from 0.36 to 0.60, according to the trial findings with 291 respondents, and 30 questions had a Cronbach alpha reliability coefficient = 0.91, which was an excellent qualification.

The Motivated Strategy and Learning Use Questionnaire (MLSQ) [18], [19] can be used to gauge students' cognitive engagement. Three indicators of self-regulation are 1) preparing cognitive methods for learning activities, 2) keeping track of the understanding gained from the subject matter being studied, and 3) correcting incorrect learning behaviors. Three aspects comprise the cognitive strategy: training, elaboration, and knowledge organization for in-depth understanding. Twenty-nine questionnaire items measuring cognitive engagement were

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created based on these factors and evaluated on 185 students. The item-total correlation increases from r = 0.318 to r = 0.591 after the test results. Cronbach's Alpha was used to assess the reliability of 29 items from the cognitive engagement questionnaire, and a value of 0.864 was achieved, placing the items' reliability in the very high category.

The creative thinking test instrument includes four dimensions: fluent thinking, flexible thinking, original thinking, and elaborative thinking. The creative thinking test developed consists of 15 items, with the distribution of 4 items of fluent thinking, three of flexible thinking, 4 of original thinking, and 4 of elaborative thinking. The test's internal consistency improved from r = 0.388 to r = 0.772, and the test's reliability was measured by Cronbach's alpha, which was 0.897 with a very high category. This value indicates that the test used is reliable in measuring the ability to think creatively.

This research was conducted for six weeks, from Apr 1 to May 12, 2020. Each week the students studied with a time allocation of 120 minutes. The intervention with the RBeL model and the DeL model used each model's operational learning steps as the e-learning pedagogy's content. RBeL uses SCL operational steps, while DeL uses TCL operational steps.

The stages of the Research Based e-Learning (RBeL) paradigm include the following steps: Creating a general question, reviewing the research literature; defining the question; planning the research activities, outlining the methods/methodologies; conducting the investigation, analyzing the data; interpreting and taking into account the results; reporting, and presenting the findings [20].

DI learning steps include (1) Setting learning goals for lessons, activities, and projects and ensuring students understand the goals first. (2) Deliberately planning and organizing the sequence of lessons, assignments, and projects that advance students toward a more profound understanding and achievement of specific academic goals. (3) Review activity instructions or carry out procedures, such as a science experiment, so students understand what is expected of them. (4) Provide detailed explanations, descriptions, and examples to students about the concepts and skills being taught. (5) Check whether students understand what has been taught by asking them questions [21].

Data analysis using two-way Manova. Manova analysis takes place if the assumptions of normality, homogeneity, non-collinearity, and similarity of the covariance matrix are met. The first assumption test uses Kolmogorov-Smirnov and Shapiro Wilk statistics, the second assumption uses the Levene statistic, the third assumption uses the product-moment correlation statistic, and the fourth assumption uses the Box'M statistic. Hypothesis examiners use a sig. level of 5%.

IV. Results and Discussion

The results of the descriptive analysis of the effect of RBeL on cognitive engagement and creative thinking in terms of students' social attitudes are presented in Figure 1. Figure 1 shows that students who study with RBeL have cognitive engagement CE-M_{t1} = 44.93 with SD = 4.45, which is included in the low category. Likewise, those who studied with DeL CE-M_{t2} = 41.13 with SD = 4.96 were included in the low category. Meanwhile, for students who learn to use RBeL to think creatively, CT-M_{t1} = 61.28 with SD = 6.85 in the medium category, and for students who learn to use DeL, CT-M_{t2} = 43.83 with SD = 8.05 in the low category. Judging from the influence of social attitudes, students with high social attitudes (HSA) show cognitive engagement CE-M_{1t} = 43.73 with SD = 4.87 in the low category. Likewise, students with low social attitudes (LSA) with cognitive engagement are CE-M_{2t} = 42.33 with SD = 5.20, also in the low category. While the creative thinking of students who have HSA is CT-M_{1t} = 53.40 with SD = 10.88 in the low category, and those who have LSA are CT-M_{2t} = 51.80 with SD = 12.18 in the low category.

The results of the normality test of cognitive engagement (CE) data distribution and creative thinking (CT) are presented in Table 1. Table 1 show that numbers of sig > 0.05 accompany all Kolmogorov-Smirnov and Shapiro-Wilk statistical values. These results indicate that CE and CT data distribution is normally distributed.

The results of the homogeneity test of the CE and CT variants between those who studied with RBeL and DeL are presented in Table 2, sig. > 0.05 accompany the Levene statistical values. This states that the CE and CT variants are homogeneous according to grouping based on learning models and social attitudes.

The next Manova assumption is that there is no collinearity effect between the two dependent variables, CE and CT. The correlation test results in Table 3 prove that the correlation coefficient between CE scores and CT scores is r = 357. This r value is < 0.80, so there is no collinearity effect between the two dependent variables.

	RBeL	DeL	
HSA	CE-M_{11} = 45.45 SD = 3.59 CT-M_{11}= 61.55 SD = 7.16	CE-M_{12} = 42.00 SD = 5.43 CT-M_{12} = 45.05 SD = 6.95	CE-M_{1t} = 43.73 SD = 4.87 CT-M_{1t} = 53.40 SD = 10.88
LSA	CE-M_{21} = 44.40 SD = 5.21 CT-M_{21} = 61.00 SD = 6.69	CE-M_{22} = 40.25 SD = 4.39 CT-M_{22} = 42.60 SD = 9.03	CE-M_{2t} = 42.33 SD = 5.20 CT-M_{2t} = 51.80 SD = 12.18
	CE-M_{t1} = 44.93 SD = 4.45 CE-M_{t1} = 61.28 SD = 6.85	CE-M_{t2} = 41.13 SD = 4.96 CE-M_{t2} = 43.83 SD = 8.05	

Figure 1. Mean value (M) and standard deviation (SD) of cognitive engagement (CE) and creative thinking (CT)

The results of the covariance matrices similarity test are presented in Table 4, that the Box's M statistical value is F = 0.756 with a sig. = 0.658. The sig. number > 0.05,

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so the covariance matrices between the two dependent variables are not significantly different.

The results of the variance similarity test are simultaneously shown in Table 5, that the Levene statistical value is F = 0.980 for CE and F = 0.712 for CT, each with sig. = 0.407 and sig. = 0.548. The numbers of sig. > 0.05 so that the variants of the two dependent variables are not significantly different.

Next, the results of the Manova are presented in Table 6. In Table 6, it appears that from the source of the influence of MODEL simultaneously on the two dependent variables, the statistical values of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root are F = 56,471 each with a sig. = 0.001. This significant number is less than 0.05, so there is a significant difference in the learning model of RBeL and DeL simultaneously on the engagement of students' CE and their CT. However, from the SOCIAL impact source, there is no significant effect between the two levels of social attitudes on the students' CE and CT. Likewise, from the source of the influence of SOCIAL * MODEL, social attitudes and learning models have no significant interaction effect based on students' CE and CT.

The next step is to present the results of the Tests of Between-Subjects Effects, as shown in Table 7. First, from the source of the influence of MODEL on CE, it was found that the statistical value of F = 13.007 with a sig = 0.001. This significant number is smaller than the critical value of 0.05. These findings suggest that the RBeL and DeL models have differing effects on students' cognitive engagement. The average value in Table 8 shows that MCE-RBeL = 44,925; SD = 0.745 and MCE-DeL = 41,125; SD = 0.745, where MCE-RBeL > MCE-DeL, so it can be stated that the RBeL model has a greater effect than DeL on student cognitive engagement.

Table 1. Tests of normality based on the Learning Model and Social Attitude

Source	Model	Learning Model						Social Attitude					
		Kolmogorov-Smirnov[a]			Shapiro-Wilk			Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.	Statistic	df	Sig.	Statistic	df	Sig.
CE	1.00	0.121	40	0.146	0.970	40	0.359	0.155	40	0.017	0.967	40	0.298
	2.00	0.110	40	0.200*	0.976	40	0.538	0.100	40	0.200*	0.973	40	0.435
CT	1.00	0.124	40	0.120	0.961	40	0.186	0.089	40	0.200*	0.963	40	0.208
	2.00	0.140	40	0.046	0.964	40	0.231	0.125	40	0.120	0.951	40	0.083

Table 2. Test of homogeneity of variance based on the learning model and social attitude

Source		Learning Model				Social Attitude			
		Levene Statistic	df1	df2	Sig.	Levene Statistic	df1	df2	Sig.
CE	Based on Mean	0.001	1	78	0.977	0.000	1	78	0.998
	Based on Median	0.006	1	78	0.939	0.006	1	78	0.938
	Based on the Median and with adjusted df	0.006	1	75.140	0.939	0.006	1	73.971	0.938
	Based on trimmed mean	0.000	1	78	0.993	0.001	1	78	0.979
CT	Based on Mean	1.396	1	78	0.241	1.474	1	78	0.228
	Based on Median	1.603	1	78	0.209	1.380	1	78	0.244
	Based on the Median and with adjusted df	1.603	1	77.982	0.209	1.380	1	77.988	0.244
	Based on trimmed mean	1.429	1	78	0.236	1.454	1	78	0.231

Table 3. Correlations between CE scores dan CT scores

		CE	CT
CE	Pearson Correlation	1	0.357**
	Sig. (2-tailed)		0.001
	N	80	80
CT	Pearson Correlation	0.357**	1
	Sig. (2-tailed)	0.001	
	N	80	80

Table 4. Box's test of equality of covariance matrices

	Score
Box's M	7.145
F	0.756
df1	9
df2	66191.846
Sig.	0.658

Table 5. Levene's test of equality of error variances

Source	F	df1	df2	Sig.
COGMENT	0.980	3	76	0.407
CREATIVE	0.712	3	76	0.548

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Table 6. Multivariate test results

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	PT	0.992	4767.818[b]	2.000	75.000	0.000
	WL	0.008	4767.818[b]	2.000	75.000	0.000
	HT	127.142	4767.818[b]	2.000	75.000	0.000
	RLR	127.142	4767.818[b]	2.000	75.000	0.000
MODEL	PT	0.601	56.471[b]	2.000	75.000	0.000
	WL	0.399	56.471[b]	2.000	75.000	0.000
	HT	1.506	56.471[b]	2.000	75.000	0.000
	RLR	1.506	56.471[b]	2.000	75.000	0.000
SOCIAL	PT	0.030	1.160[b]	2.000	75.000	0.319
	WL	0.970	1.160[b]	2.000	75.000	0.319
	HT	0.031	1.160[b]	2.000	75.000	0.319
	RLR	0.031	1.160[b]	2.000	75.000	0.319
SOCIAL * MODEL	PT	0.005	0.196[b]	2.000	75.000	0.823
	WL	0.995	0.196[b]	2.000	75.000	0.823
	HT	0.005	0.196[b]	2.000	75.000	0.823
	RLR	0.005	0.196[b]	2.000	75.000	0.823

***Note:** PT = Pillai's Trace, WL = Wilks' Lambda, HT = Hotelling's Trace, RLR = Roy's Largest Root

Table 7. Tests of between-subjects effects

Source	DV	Type III Sum of Squares	df	MS	F	Sig.
Corrected Model	CE	330.450[a]	3	110.150	4.961	0.003
	CT	6153.100[b]	3	2051.033	36.279	0.000
Intercept	CE	148092.050	1	148092.050	6669.627	0.000
	CT	220920.200	1	220920.200	3907.635	0.000
MODEL	CE	288.800	1	288.800	13.007	0.001
	CT	6090.050	1	6090.050	107.721	0.000
SOCIAL	CE	39.200	1	39.200	1.765	0.188
	CT	45.000	1	45.000	0.796	0.375
SOCIAL * MODEL	CE	2.450	1	2.450	0.110	0.741
	CT	18.050	1	18.050	0.319	0.574
Error	CE	1687.500	76	22.204		
	CT	4296.700	76	56.536		
Total	CE	150110.000	80			
	CT	231370.000	80			
Corrected Total	CE	2017.950	79			
	CT	10449.800	79			

Table 8. Mean value (M) and standard deviation (SD) of cognitive engagement and creative thinking in the RBeL and DeL models

Dependent Variable	MODEL	M	SD	95% Confidence Interval	
				Lower Bound	Upper Bound
CE	RBeL	44.925	0.745	43.441	46.409
	DeL	41.125	0.745	39.641	42.609
CT	RBeL	61.275	1.189	58.907	63.643
	DeL	43.825	1.189	41.457	46.193

Second, from the source of the influence of MODEL (Table 7) on creative thinking (CT), it was found that the statistical value of F = 107,721 with a sig. = 0.001. This significant number is smaller than the critical value of 0.05. These findings suggest that the RBeL and DeL models have differing effects on students' creative thinking. Table 8 shows that the mean value of creative thinking is MCT-RBeL = 61,275; SD = 1.189 and MCT-DeL = 43,825; SD = 1.189, where MCT-RBeL > MCT-DeL. These findings imply that the RBeL model has a higher impact on creative thinking than the DeL model.

Third, from the source of the effect of SOCIAL (Table 7) on cognitive engagement (CE) and creative thinking (CT), respectively, the statistical values of F = 1,765 with a significance value of sig. = 0.188 and F = 0.796 with a sig. = 0.375. The numbers of sig > 0.05. Therefore, the effect of students with high and low social attitudes on cognitive engagement and creative thinking is the same.

Fourth, from the source of the influence of SOCIAL * MODEL (Table 7) on CE and CT, respectively, the statistical values of F = 0.110 were found with a sig. = 0.741 and F = 0.319 with a sig. = 0.574. The numbers of sig. > 0.05. As a result, there is no significant interaction between the learning model and the social attitudes of the students concerning cognitive engagement and creative thinking. The weak interaction profiles are presented in Figure 2 and Figure 3, respectively.

Up to now, physics learning in high school mostly tolerates teacher-centered learning, which is one of the factors that causes students' less optimal cognitive engagement in learning, ultimately leading to low student creative thinking. Therefore, the study tested the student-centered learning model, research-based e-learning, with students' social attitudes as the moderator variable. The study aimed to examine the primary and interacting influences of social attitudes and learning models on students' cognitive engagement and creative thinking while learning physics in high school.

The results showed that the research-based e-learning (RBeL) model had a greater effect than the direct e-learning (DeL) model on students' cognitive engagement in learning physics. The study results follow the results of previous studies [20, 21]. The RBeL model becomes a facility for students to learn more actively in class and practice so that learning becomes more meaningful [22]. With RBeL, students become more active in group collaboration [22]. With RBeL, students become more active and creative in problem-solving learning than in DeL [23]. The students' activeness in learning, solving problems, in practice, and group work shows that enthusiastic students show optimal cognitive engagement performance. This is because, with RBeL, students feel aroused in their motivation and curiosity, so the learning process looks fun. Although quantitatively, MCE-RBeL = 44,925; SD = 0.745 and MCE-DeL = 41,125; SD = 0.745, where MCE-RBeL > MCE-DeL, but descriptively qualitatively on a scale of 100, the two mean scores are in a low category. These results are below the success criteria for learning physics at a Public High School 2 in Singaraja, namely 70.00. The low achievement is because students need to get used to learning using RBeL. Therefore, the RBeL model should be used on an ongoing basis so that students are familiar with the work steps offered by the model.

Regarding RBeL and DeL on students' creative thinking while learning physics, research shows that RBeL has a stronger impact than DeL on students' creative thinking. These results follow the results of previous studies [24]–[26]. RBeL can facilitate students to learn with high motivation and use their thinking logically, critically, and systematically, thus influencing the optimization of their creative thinking. Quantitatively, MCT-RBeL = 61,275; SD = 1.189 and MCT-DeL = 43,825; SD = 1.189, where MCT-RBeL > MCT-DeL. Descriptively qualitatively, students' creative thinking in the RBeL group, MCT-RBeL = 61,275 in the sufficient category, and the DeL group, MCT-DeL = 43,825 with the low category. The average score obtained by students in the RBeL group still needed to reach the success criteria, namely, 70.00. This is inseparable from changing students 'mindsets from learning habits with the DeL model to learning habits with the innovative RBeL learning model, which requires sufficient time according to students' abilities. Therefore, the RBeL model should be implemented continuously so that students become familiar with the RBeL learning process to achieve optimal creative thinking.

The main effect of the variable high social attitude and low social attitude showed no different results on students' cognitive engagement and creative thinking. Likewise, regarding the interactive effect of learning models and social attitudes on students' cognitive engagement and creative thinking, the results of this study indicate an insignificant interaction. These results indicate that the two learning models (RBeL and DeL) are accommodative of the two levels of social attitudes, namely high and low social attitudes.

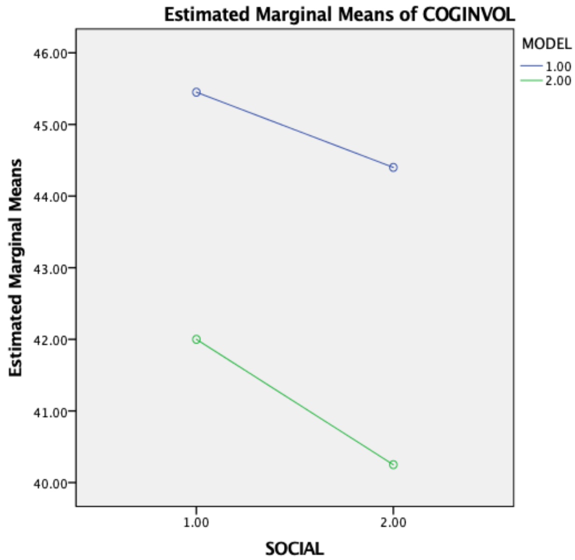

Figure 2. The profile of the weak interactive influence between the learning model (1 = RBeL and 2 = DeL) and social attitudes (1 = HSA, 2 = LSA) on students' CE.

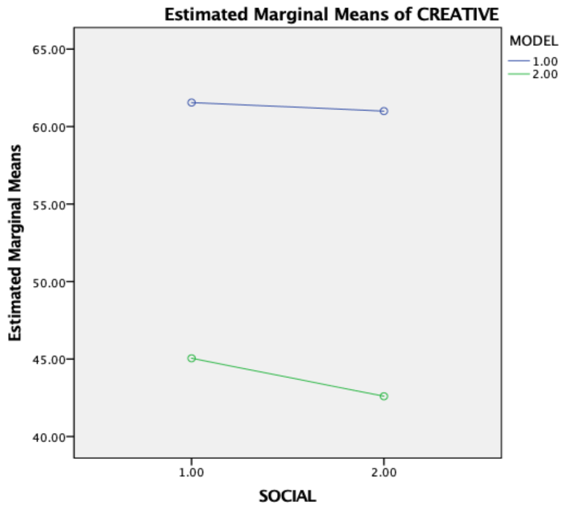

Figure 3. The profile of the weak interactive effect between learning models (1 = RBeL and 2 = DeL) and social attitudes (1 = HSA, 2 = LSA) on students' CT

V. Conclusion

The following research conclusions can be proposed based on the research results and discussion. There are differences in students' cognitive engagement between those who intervened with research-based e-learning and direct e-learning. Intervention with research-based e-learning is more effective than direct e-learning in achieving cognitive engagement. There are differences in students' creative thinking between those intervened with research-based e-learning and direct e-learning. Intervention with research-based e-learning is more effective than direct e-learning in achieving creative thinking. There is no difference in cognitive engagement and creative thinking between students with high and low social attitudes. There is no interactive effect between learning models and social attitudes on students' cognitive engagement and creative thinking.

In achieving students' cognitive engagement, and creative thinking in learning physics, 10th-grade students on the subject matter of work, energy, impulses, and momentum will be effective in achieving students' cognitive engagement and creative thinking if research-based e-learning models intervene them. Therefore, high school physics teachers should familiarize themselves with using research-based learning as e-learning content. Research-based physics learning is one of the innovative lessons rich in literacy processes in mind-on and hands-on activities.

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Declarations

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