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Correlation Between Scientific Creativity and Students' Science Attitude in Creative Responsibility-Based Learning Integrated STEM from The Covid-19 Pandemic

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Abstract. In the era of technology and information, scientific creativity and attitudes significantly affect individuals' success in their lives and careers. However, these two competencies need more attention in schools, especially during the covid-19 pandemic. Therefore, this study analyses the correlation between scientific attitudes and students' scientific creativity after applying STEM-integrated Creative Responsibility Based Learning (STEM-CRBL) during the covid-19 pandemic. This study involved 22 high school class X students in Banjarmasin City, Indonesia. The data were obtained through a scientific creativity test and a scientific attitude questionnaire. The results showed: (1) scientific creativity has a correlation with aspects of fluency, flexibility, and originality is significant and strong; (2) scientific creativity has a correlation with indicators of scientific imagination, problem-solving, and product design is significant and strong; and (3) scientific attitudes with scientific creativity turns out the correlation is insignificant and weak, even the correlation of scientific attitudes with problem-solving and product design is very weak. Therefore, the habituation of scientific creativity and attitude is designed to complement each other in STEM-CRBL.

INTRODUCTION

In the industrial era 4.0, the development of science and technology is increasingly complex and diverse [1], especially during the covid-19 pandemic. This pandemic has tremendously impacted teachers, parents, and students [2]. Internet network constraints and a need for technology and laboratory equipment are the main obstacles to learning physics online (Wijaya et al., 2021). This provides challenges and opportunities for creative teachers to produce innovative products that support online learning [3]. Creative teachers can equip students with 21st-century skills, such as scientific creativity and attitudes [4][5]. Like creativity in general, scientific creativity involves fluency, flexibility, and originality [6][7]. However, this scientific creativity emphasizes problem-finding, planning and problem-solving, science experiments and creative activities [8][9]. Students produce a variety of creative thoughts and ideas and actual work in overcoming life's problems, including during this pandemic [10]. For creative individuals, every problem becomes a source of inspiration to produce innovative products to overcome the problem [11]. Thus, scientific creativity is essential to develop all students' talents and abilities to support their success in life and career [12][13]. However, students' creative potential can only be maximized if the cultivation of scientific creativity in schools is integrated with the development of scientific attitudes [9].

A scientific attitude is a scientist's character in seeking and discovering scientific knowledge. In schools, scientific attitudes describe students' nature, determination, control, and thinking in exploring and constructing their scientific knowledge [14][15]. For scientific attitudes to be possessed by every student, it is essential to train and cultivate these attitudes in physics learning at school. Every individual thinks creatively when facing problems in life and career [16].

Creative thinking and scientific attitude are essential characteristics of humans who are curious about the issues they face, understand the problem, and try to find various alternative solutions [8][18]. In this study, scientific attitudes emphasize student cooperation, responsibility, and honesty while learning physics in class. Students are responsible and cooperative in organizing materials, completing group investigations and creative tasks, and evaluating and reflecting. In addition, students are accustomed to being honest in presenting the information. Thus, the integration of scientific creativity and scientific attitudes mutually makes physics learning more meaningful [8].

Scientific creativity and scientific attitudes significantly correlate with students' cognitive learning outcomes [8][18][19]. Physics learning involves STEM in scientific investigations and real-life problem solving but needs to pay more attention to the habituation of students' scientific creativity and scientific attitudes [9]. Therefore, teachers can consider STEM-integrated CRBL (STEM-CRBL) as an alternative model to cultivate students' scientific creativity and attitudes in physics learning in the classroom [20]. In CRBL, scientific perspectives and STEM are integrated into scientific investigations and creativity tasks. Thus, the STEM approach can increase students' creativity and motivation in learning and career choices [21].

Several previous studies have explained the relationship between scientific creativity and other competencies. Scientific creativity is significantly correlated with science process skills [22], cognitive learning outcomes [18][19], and student enjoyment [23]. Several studies regarding the correlation of scientific attitudes with other competencies show that scientific perspectives have a robust correlation with scientific work [24], and learning achievement [25]. In contrast, scientific attitudes are not correlated with student learning achievement [26]. The correlation between scientific creativity and scientific attitudes has perspective studied in this study. Therefore, the purpose of the study was to determine the correlation between scientific attitudes and scientific creativity after applying STEM-CRBL.

RESEARCH METHOD

This correlational study is intended to determine whether or not there is a correlation between scientific attitudes and students' scientific creativity after STEM-CRBL is applied. In this study, 22 students of class X SMAN in Banjarmasin City, South Kalimantan, Indonesia, were involved in STEM-CRBL for three meetings. The variables in this study were scientific attitude and creativity, with operational definitions of the variables as follows: (1) scientific perspectives emphasized the philosophy of cooperation, responsibility, honesty, and thoroughness of students while participating in STEM-CRBL during the covid-19 pandemic. This scientific attitude data is obtained from student self-assessment by filling out a scientific attitude questionnaire using a google form at the end of each meeting; (2) scientific creativity, in the form of an essay test on effort and energy material adapted from the scientific creativity assessment [27]. Scientific creativity was assessed from fluency, flexibility, and originality, as well as from scientific imagination, problem-solving, and product design indicators. Before being used, both instruments were validated by three physics learning experts, resulting in validity scores of 3.43 and 3.27 (0-4 scale range) and reliability of 0.76 and 0.78, respectively. Thus, the scientific creativity test and scientific attitude questionnaire are suitable for use as research instruments. The hypotheses in this study can be presented below:

(1) There is a significant correlation between students' scientific attitudes and aspects of scientific creativity (fluency, flexibility, and originality) after applying STEM-CRBL.
(2) There is a significant correlation between students' scientific attitudes and scientific creativity indicators (scientific imagination, problem-solving, and product design) after applying STEM-CRBL
(3) There is a significant correlation between students' scientific attitudes and creativity after applying STEM-CRBL.

Data analysis was conducted descriptively and qualitatively, followed by a normality test. When the prerequisites of normality were met, bivariate correlation analysis with the help of SPSS 16.0 was continued.

RESULTS AND DISCUSSION

Scientific creativity and scientific attitudes are believed to be critical factors for science and technology innovation [12]. Learning scientific creativity involves complex thinking processes. Like creativity in general, the development of scientific creativity in STEM-CRBL involves fluency, flexibility, and originality. It emphasizes the process of finding problems, solving problems, science experiments, and creative science activities. The results of the analysis of fluency, flexibility, and originality are presented in Table 1.

TABLE 1. The scores of students' scientific creativity aspects after participating in STEM-CRBL

Students	Fluency		Flexibility		Originality	
	Score	Criteria	Score	Criteria	Score	Criteria
S1	42.50	Less	66.67	Good	16.67	Not good
S2	57.50	Enough	52.75	Less	83.33	Very good
S3	55.00	Less	75.00	Good	33.33	Not good
S4	90.00	Very good	75.00	Good	100.00	Very good
S5	45.00	Less	55.58	Enough	50.00	Less
S6	90.00	Very good	72.25	Good	100.00	Very good
S7	42.50	Less	75.00	Good	66.67	Good
S8	57.50	Enough	72.25	Good	33.33	Not good
S9	55.00	Less	66.67	Good	50.00	Less
S10	47.50	Less	36.08	Not good	66.67	Good
S11	87.50	Very good	75.00	Good	83.33	Very good
S12	45.00	Less	47.25	Less	0.00	Not good
S13	32.50	Not good	38.92	Not good	50.00	Less
S14	67.50	Good	75.00	Good	83.33	Very good
S15	55.00	Less	75.00	Good	50.00	Less
S16	67.50	Good	66.67	Good	83.33	Very good
S17	67.50	Good	66.67	Good	33.33	Not Good
S18	55.00	Less	58.33	Enough	16.67	Not Good
S19	22.50	Not good	44.42	Less	66.67	Good
S20	80.00	Good	88.92	Very good	83.33	Very good
S21	55.00	Less	83.33	Very good	66.67	Good
S22	55.00	Less	83.33	Very good	66.67	Good

Based on Table 1, students' scientific creativity in fluency, flexibility, and originality are in varying criteria. The achievement of scientific creativity is briefly presented in Figure 1.

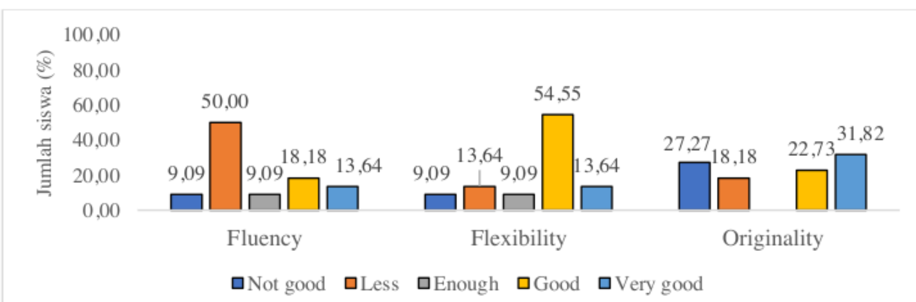

FIGURE 1. Students' scientific creativity scores after participating in STEM-CRBL

In the fluency aspect (Figure 1), only 31.82% of students showed fluency in providing problem solutions, while 59.09% of other students were not. In the flexibility aspect, 68.19% of students could use various points of view in presenting different problem solutions, while 21.73% needed to be more flexible. In addition, 54.55% of students showed originality in providing problem solutions. Thus, some students still need help presenting fluency, flexibility, and identity in providing problem solutions. This finding is supported by the results of the analysis of scientific creativity indicators, as shown in Table 2.

TABLE 2. Students' scientific creativity scores and their indicators after participating in STEM-CRBL

Students	Scientific Imagination		Problem-Solving		Product Design		Scientific Creativity	
	Score	Criteria	Score	Criteria	Score	Criteria	Score	Criteria
S1	18.18	Not good	53.33	Less	62.50	Enough	49.32	Less
S2	63.64	Enough	57.78	Enough	87.50	Very good	76.88	Good
S3	36.36	Not good	53.33	Less	87.50	Very good	65.21	Good
S4	90.91	Very good	93.33	Very good	87.50	Very good	100.00	Very good
S5	54.55	Less	35.56	Not good	75.00	Good	60.76	Enough
S6	100.00	Very good	82.22	Very good	87.50	Very good	99.26	Very good
S7	18.18	Not good	86.67	Very good	100.00	Very good	75.38	Good
S8	72.73	Good	35.56	Not good	62.50	Enough	62.85	Enough
S9	54.55	Less	53.33	Less	75.00	Good	67.30	Good
S10	81.82	Very good	51.11	Less	12.50	Not good	53.52	Less
S11	72.73	Good	100.00	Very good	75.00	Good	91.16	Very good
S12	36.36	Not good	35.56	Not good	12.50	Not good	31.07	Not Good
S13	36.36	Not good	68.89	Good	12.50	Not good	43.33	Less
S14	72.73	Good	86.67	Very good	75.00	Good	86.26	Very good
S15	36.36	Not good	86.67	Very good	62.50	Enough	68.27	Good
S16	63.64	Enough	86.67	Very good	75.00	Good	82.91	Very good
S17	72.73	Good	70.00	Good	12.50	Not good	57.12	Enough
S18	36.36	Not good	70.00	Good	12.50	Not good	43.74	Less
S19	18.18	Not good	51.11	Less	87.50	Very good	57.70	Enough
S20	90.91	Very good	75.56	Good	100.00	Very good	98.06	Very good
S21	72.73	Good	53.33	Less	100.00	Very good	83.19	Very good
S22	72.73	Good	53.33	Less	100.00	Very good	83.19	Very good

Table 2 shows that students' scientific creativity achievements in the indicators of scientific imagination, problem-solving, and product design also varied. The accomplishments of each hand of scientific creativity are briefly presented in Figure 2.

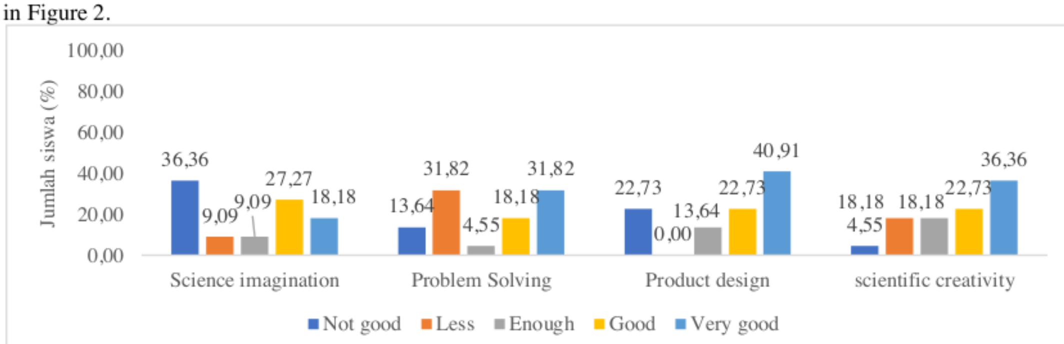

FIGURE 2. Students' scientific creativity indicator scores after participating in STEM-CRBL

Figure 2 shows that 59.09% of students have mastered scientific creativity in good/perfect criteria. The achievement of scientific creativity is in line with the achievement of students' ability to design creative products (63.64%), while scientific imagination (45.45%) and problem-solving (50.00%). Thus, some students need help developing scientific imagination, problem-solving, and product design. Time constraints, internet networks, laboratory infrastructure, and technological literacy are believed to be obstacles for students [28]. Students need more time (more than three meetings) to increase their scientific imagination, solve problems, and design products to overcome environmental difficulties. In addition, the constraints of the internet network, laboratory equipment, knowledge of technology, and negative self-confidence are believed to interfere with individual students' ability to recognize their creative ideas [4][12]. Despite the perceived barriers to creativity, students were happy to present unusual creative ideas and felt valued. Students can generate innovative and practical ideas [12]. This is in line with the findings [23] that creativity correlates significantly with students' pleasure in learning physics. These findings are supported by the achievement of students' scientific attitudes at each meeting which can be seen in Table 3.

TABLE 3. Students' scientific attitudes during STEM-CRBL

Students	1 Meeting		2 Meeting		3 Meeting	
	Score	Criteria	Score	Criteria	Score	Criteria
S1	52.50	Less	65.00	Enough	72.50	Good
S2	48.75	Less	72.50	Good	76.25	Good
S3	56.25	Enough	63.75	Enough	66.25	Good
S4	50.00	Less	81.25	Very good	88.75	Very good
S5	63.75	Enough	77.50	Good	76.25	Good
S6	70.00	Good	75.00	Good	75.00	Good
S7	81.25	Very good	83.75	Very good	81.25	Very good
S8	80.00	Good	83.75	Very good	83.75	Very good
S9	56.25	Enough	80.00	Good	83.75	Very good
S10	68.75	Good	85.00	Very good	90.00	Very good
S11	65.00	Enough	58.75	Enough	75.00	Good
S12	28.75	Not Good	50.00	Less	57.50	Enough
S13	41.25	Less	68.75	Good	71.25	Good
S14	71.25	Good	75.00	Good	76.25	Good
S15	90.00	Very good	88.75	Very good	93.75	Very good
S16	68.75	Very good	78.75	Good	71.25	Good
S17	60.00	Enough	85.00	Very good	87.50	Very good
S18	58.75	Very good	75.00	Good	81.25	Very good
S19	73.75	Very good	80.00	Good	78.75	Good
S20	97.5	Very good	93.75	Very good	97.50	Very good
S21	75.00	Good	72.50	Good	85.00	Very good
S22	75.00	Good	85.00	Very good	85.00	Very good

Table 3 shows that the average value of students' scientific attitudes has increased, where at meeting 1, it was in the good enough criteria, then became good at meetings 2 and 3. The achievement of scientific attitudes is summarized in Figure 3.

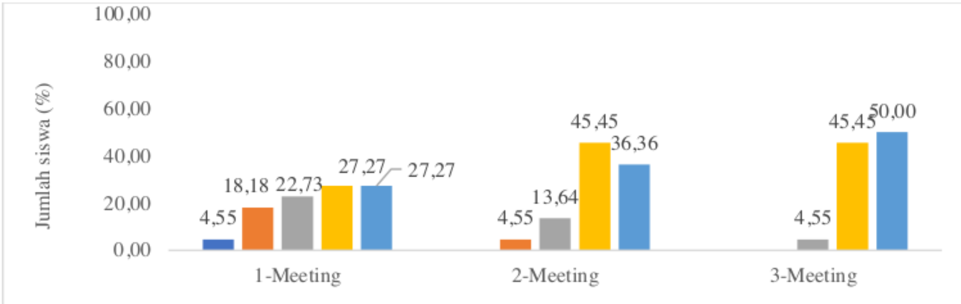

FIGURE 3. Students' scientific attitude during STEM-CRBL

Based on Figure 3, students' scientific attitudes at meeting 1 were generally good, but there were still students in the criteria quite good (22.73%), less good (18.18%), and even 4.55% of students still needed to be better. The achievement of students' scientific attitudes at meetings 2 and 3 has increased in perfect criteria. In line with Kustijono et al. (2018), students' scientific attitudes as individual behaviour can be trained and developed at school.

Furthermore, statistical tests determine whether there is a correlation between scientific attitudes and students' scientific creativity after participating in STEM-CRBL. This test begins with a normality test using a one-sample Kolmogorov-Smirnov. The test results are presented in Table 5.

TABLE 5. Results of One-Sample Kolmogorov-Smirnov Test on scientific creativity and scientific attitude

		F	Fl	O	SI	PS	PD	SC	SA
N		22	22	22	22	22	22	22	22
Normal Parameters[a]	Mean	57.840	65.913	58.333	57.851	65.455	66.477	69.840	79.715
	Std. Deviation	17.682	14.606	27.578	24.866	19.631	32.133	19.455	92.737
Most Extreme Differences	Absolute	.190	.202	.164	.180	.186	.241	.113	.100
	Positive	.190	.131	.091	.170	.186	.181	.078	.100
	Negative	-.118	-.202	-.164	-.180	-.133	-.241	-.113	-.090
Kolmogorov-Smirnov Z		.889	.950	.770	.843	.873	1.130	.529	.470
Asymp. Sig. (2-tailed)		**.408**	**.328**	**.593**	**.476**	**.431**	**.155**	**.942**	**.980**

Note: F = Fluency, Fl = Flexibility, O = Originality, SI = Scientific Imagination, PS = Problem Solving, SC = Scientific Imagination, SA = Science Attutude

The one-sample Kolmogorov-Smirnov test (Table 5) on all research variables obtained a sig value. (2-tailed) > 0.05. All research variables have met the normality prerequisites and can continue using the Pearson correlation test. The test results are presented in Table 6.

TABLE 6. Pearson correlation test results on scientific creativity and scientific attitudes

		Fluency	Flexibility	Originality	Science Imagination	Problem-Solving	Product Design	Scientific Creativity
Fluency	PC	1	.594**	.547**	.787**	.605**	0.267	.758**
	Sig.		0.004	0.008	0	0.003	0.229	0
Flexibility	PC	.594**	1	0.295	0.352	0.389	.658**	.710**
	Sig.	0.004		0.182	0.108	0.074	0.001	0
Originality	PC	.547**	0.295	1	.610**	.591**	.599**	.871**

	Sig.	0.008	0.182		0.003	0.004	0.003	0
Science imagination	PC	.787**	0.352	.610**	1	0.235	0.179	.667**
	Sig.	0	0.108	0.003		0.292	0.425	0.001
Problem-solving	PC	.605**	0.389	.591**	0.235	1	0.193	.599**
	Sig.	0.003	0.074	0.004	0.292		0.391	0.003
Product design	PC	0.267	.658**	.599**	0.179	0.193	1	.764**
	Sig.	0.229	0.001	0.003	0.425	0.391		0
Scientific creativity	PC	.758**	.710**	.871**	.667**	.599**	.764**	1
	Sig.	**0**	**0**	**0**	**0.001**	**0.003**	**0**	
Science attitude	PC	0.251	0.366	0.339	0.403	0.234	0.181	0.387
	Sig.	**0.260**	**0.094**	**0.122**	**0.063**	**0.295**	**0.420**	**0.076**

Note: PC = Pearson Correlation, Sig. = sig. (2-tailed)

The Pearson Correlation test results (Table 6) between scientific creativity with fluency, flexibility, and originality obtained sig. (2-tailed) < 0.05 with correlation coefficients of 0.758; 0.710; and 0.871, respectively. This means there is a significant correlation between scientific creativity and its aspects in strong criteria. Likewise, the correlation test results between scientific creativity with scientific imagination, problem-solving, and product design obtained sig. (2-tailed) <0.05 with correlation coefficients of 0.667; 0.599; and 0.764, respectively. This means there is a significant correlation between scientific creativity and its indicators in the decisive criteria. Students feel happy to carry out scientific investigations and creativity tasks because creative and imaginative ideas are valued, and they do not feel worried if they make mistakes [12]. In CRBL, students' courage in presenting new and different ideas is the main concern. Students can be creative and innovative in scientific investigations and other creative tasks. At the end of learning, teachers provide evaluation and reflection to improve the quality of students' creative ideas. This is in line with previous research [18][19][23]; habituation of scientific creativity is related to students' process skills, enjoyment, and cognitive learning outcomes.

Conversely, the correlation test results between scientific attitudes and creativity and its aspects and indicators obtained sig. (2-tailed) > 0.05 with a correlation coefficient between 0.181-0.403. This means that the correlation between scientific attitudes and creativity is insignificant and weak; even the correlation between scientific attitudes and problem-solving and product design is very weak. In line with the recommendation [29], scientific attitudes are critical to planning and familiarizing physics learning at school. Scientific attitudes encourage students' curiosity about the problem, understand the problem, and find alternative solutions [17]. Students are encouraged to cooperate, be responsible for completing scientific investigations and creative tasks and be honest in presenting information without manipulation. Integrating scientific attitudes with scientific creativity makes students more eager to learn and never give up on achieving their learning goals. Unfortunately, although students' scientific attitudes are good (Figure 3), students' scientific creativity still needs to be in the good enough criteria (Figure 2). This is because the learning was only carried out in 3 meetings and the teacher needed help controlling students' enthusiasm and motivation to learn online. However, Table 6 reminds educators that the development of students' scientific creativity needs to be integrated with their scientific attitudes.

The two competencies complement each other and lead to an intelligent, creative, and characterized generation.

CONCLUSION

Scientific creativity and attitude are one of the uniqueness of STEM-CRBL. Scientific creativity has a significant and robust correlation with fluency, flexibility, and originality. Scientific creativity also correlates with indicators of scientific imagination, problem-solving, and product design is significant and influential. However, the correlation between scientific attitude and scientific creativity is insignificant and weak; even the correlation between problem-solving and product design could be more robust. Integrating scientific attitudes and creativity in STEM-CRBL makes physics learning more meaningful. Further research is on other scientific creativity indicators and increasing the learning allocation of at least five meetings.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9