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Developing Scientific Creativity through STEM Project Based Learning Orientation

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Abstract

Creativity is always associated with STEM Education but being creative does not mean having acquired scientific creativity skills. Scientific creativity skills are important in STEM Education as it helps students to provide different possible solution to solve a problem. The purpose of this study is to investigate the effect of STEM Project Based Learning (PBL) Orientation on students' scientific creativity skills. The study was carried out in three phases on 33 lower secondary school students, employing a one group quasi-experimental design. The first phase is the development of knowledge followed by second phase, the project development and ended with the third phase, competition based phase. A set of questionnaire on the aspect of scientific creativity skills was given to the students after the intervention phase. The construct for scientific creativity was divided into two, namely, the inquiry skills and creative thinking. Inquiry skills element in this study were students' observation skills, hypothesis making, giving explanation and inferences making. Whereas creative thinking element consists of divergent thinking, convergent thinking and combination thinking. The findings revealed that through Integration STEM PBL Orientation, students' scientific creativity skills are significantly increased. The findings also showed that there is a relationship between scientific creativity with the STEM PBL Orientation conducted.

1. Introduction

Scientific creativity refers to the response and process involving experience, response to simulation of such an object, symbol, idea, situation and human circumstances. Someone who has good scientific creativity skills is able to produce something new and thinking extraordinarily. Cropley [1], stated that, the experts in the field of creativity believe that creativity has three core elements, namely, the product authenticity aspect, extraordinary action or idea, secondly, effectiveness and the third is ethical element. STEM education is defined as an approach to teaching and learning process that is closely related to any subject of component in STEM [2]. It is the integration of design concepts in technology and engineering into the teaching and learning of science and mathematics [3]. Integration of various elements of teaching methods, STEM elements, encouraging students to think creatively and innovatively, and increasing debating session of science and technology between these students is a good initiative to produce dynamic students for the century [4]. The three key elements in the process of creative thinking are proficiency (fluency), flexibility and originality [5]. Proficiency or fluency implies the ability to generate the original idea. Flexibility means "the ability to exchange" with not only rely on only one idea or situation but he will soon turn to new ideas to find the best solution and conclusion. Originality means the ability to provide exceptional verifiable facts without analyzing the actual sample first. This element shows that originality of ideas or ability to solve problem is thought by someone on his own without knowing the situation any further.

2. Conceptual Framework

2.1 Three-Dimensional Model Scientific of Creativity Park 2012 and Inquiry Based Learning

Three-Dimensional Model of Creativity Scientific Park 2012 contains three axes of creative thinking, scientific knowledge and scientific inquiry skills. Inquiry skills involve science process skills such as observation, hypothesis, analyze and conduct experiments. Based on this model, creative thinking will be actively used during the process of scientific inquiry activities and application of scientific knowledge. When a person generates ideas of suggestions, it should be reviewed, filtered, clarified or selected based on scientific knowledge and inquiry process using convergent thinking. In this model, there are nine elements of creative minds involved that divergent thinking (fluency, flexibility,

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exceptional thought), convergent thinking (coherent, synthesis, simple) and combination thinking (analogy, metaphor and abduction).

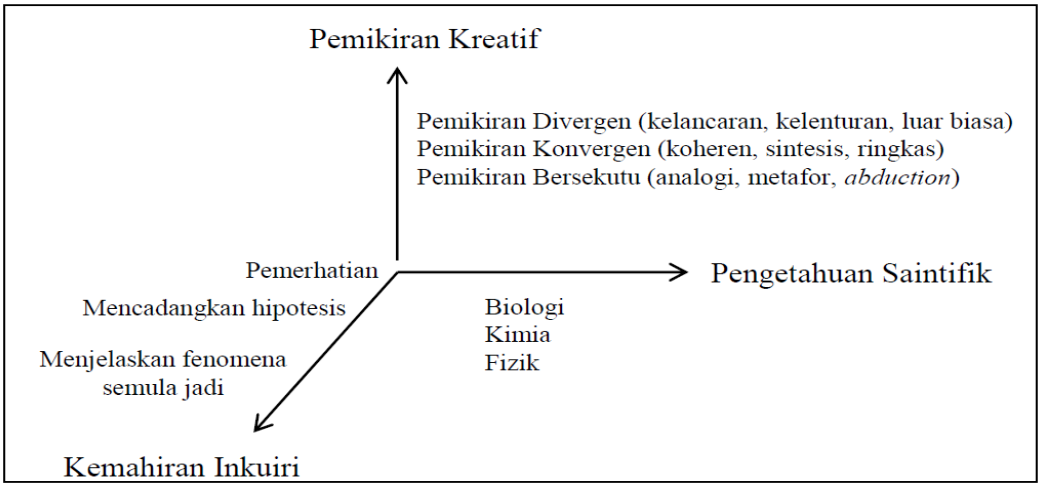

Fig. 1. Three-Dimensional Model of Creativity Scientific Park 2012

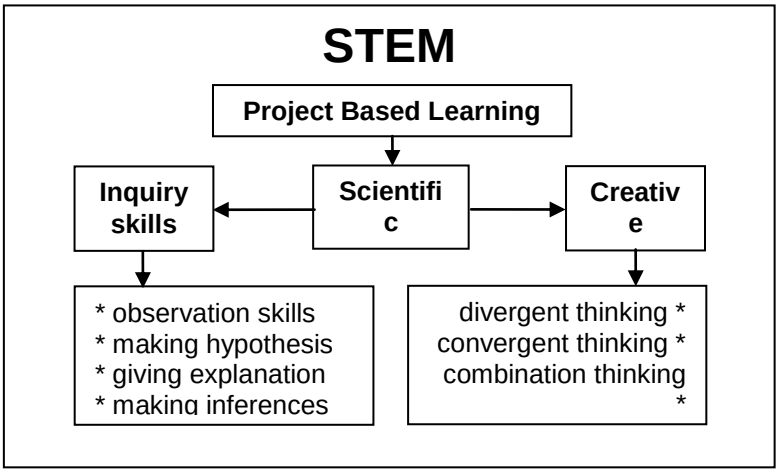

Fig. 2. Research Conceptual Framework

This study involves a method of PBL in STEM Education to understand its effects on the development of scientific creativity. Major construct of scientific creativity is divided into two, namely, inquiry skills and creative thinking. Creative feature in scientific creativity is examined from the elements in the Three-Dimensional Model of Creativity Scientific Park 2012.

3. Methodology

This study was conducted to investigate the effect of STEM PBL Orientation on students' scientific creativity. The first phase is knowledge development, followed by project development and ended with competition based programme. The programme which conducted with project-based activities was divided into four separated modules, namely, Energy, Urban Infrastructure, Transportation and Wireless Communication. There were 12 facilitators among postgraduates students in the field of STEM were involved to develop and facilitate students' learning process during the programme. The participants of the programme were lower secondary school students aged 13 to 14 from selected secondary schools in Malaysia. This study involves 33 students with the percentage of 60.7% female and 39.3% male. The overall three phases programme was held in schools. A set of questionnaire on scientific creativity skills aspects was administered to the students after the intervention phase. The construct for scientific creativity was divided into two, namely inquiry skills and creative thinking. The inquiry skills in this study were observation skills, making hypothesis, giving explanations and making inferences. Creative thinking consists of divergent thinking, convergent thinking and combination

thinking. Pre-survey were administered at the beginning of the programme in order to determine students' pre-existing interest towards STEM subjects and careers. At the end of the programme, post-survey were administered to the students. The range of mean score for high level of interest was high (3.67-5.00); moderate (2.34-3.66); and low (1.00-2.33).

4. Result and Discussion

The means, standard deviations, t-test scores, and p-values are shown in Table 1. To conduct this analysis, the data matching all pre-test scores to post-test scores were conditioned. A series of paired sample t-test were conducted using pre and post-test scores. The analysis revealed that the mean scores for students' inquiry skills increases after the participating the programme. This increase is significant for interest all sub construct (observation skills, making hypothesis, giving explanation and making inference) of inquiry skills ($p<0.05$). Whereas for creative thinking remain at moderate level, but the construct of convergent thinking and combination thinking are at high level except for divergent thinking maintain moderate after the students' participation in the programme.

Table 1.

N=100						
Aspects					**Paired sample t-test**	
		Mean	**S.D**	**Level**	**t**	**P**
inquiry skills	Pre	3.39	0.98	Moderate	23.54	0.001*
	Post	3.84	0.95	High		
observation skills	Pre	3.47	0.94	Moderate	29.20	0.014*
	Post	4.10	0.80	High		
making hypothesis	Pre	3.09	1.07	Moderate	20.12	0.011*
	Post	3.52	0.97	Moderate		
giving explanation	Pre	3.47	0.59	Moderate	26.20	0.001*
	Post	4.18	0.92	High		
making inferences	Pre	3.33	0.89	Moderate	18.65	0.018*
	Post	3.55	1.10	Moderate		
creative thinking	Pre	3.17	0.99	Moderate	21.84	0.001*
	Post	3.57	0.98	Moderate		
divergent thinking	Pre	3.07	0.89	Moderate	17.09	0.014*
	Post	3.06	1.03	Moderate		
convergent thinking	Pre	3.03	0.88	Moderate	29.28	0.011*
	Post	3.85	0.76	High		
combination thinking	Pre	3.02	0.89	Moderate	19.16	0.012*
	Post	3.80	1.15	High		
scientific creativity	Pre	3.01	0.79	Moderate	33.89	0.001*
	Post	3.47	0.59	Moderate		

*significant at $P<0.05$

5. Conclusion

Through the integrated STEM project based learning of this programme the findings indicate that the intervention was effective at developing students' inquiry and creative thinking. The outcomes of this study provide evidence that exposing the students at early secondary has positive impact on their level of inquiry skills and creative thinking. These data provide insight that the STEM learning through project oriented settings is highly influential as the initial skill for students, and should be strongly encouraged.

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