The Profile of Students Creative Thinking Skill in Designing Optical Instruments Prototype

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Abstract. The paper explained the profile of students' creative thinking skills in designing an optical instrument prototype. The research method used a mixed-method with the explanatory sequential design model. The research design was experimental. The subject of this study consist of 22 students on the 11 th grade in one of Senior high school. Students were assigned to design a prototype which is the problem solution of optical tools practice. The instrument of assessment design used in this research was an assessment of the design process that consists of 5 assessment aspects that implicated STEM field (Science, Technology, Engineering, and Mathematics). The result of this study showed by using STEM approach method, students can think creatively in the process of design with a percentage rate of around 66.25%.

Keywords: Instrument, Prototype, STEM (Science, Technology, Engineering, and Mathematics) Field.

1 Introduction

The data that has been explored by the Global Creativity Index which reviewed from technology and talent aspects, showed that Indonesia is on the 115 ranks from 139 [1]. A growing urgency to prepare students for 21st century challenges has many educators looking for new instructional approaches. In the 2013 curriculum, there are several competencies and expertise that want to be trained through the implementation of learning, one of which is the ability to think creatively [2]. Creative thinking skill produces new things [3]. Creative thinking skill comprises fluency of thinking, the flexibility of thinking and originality of thinking [3]. Learning that integrated into STEM could improve students to get used to solving the problem that has been discovered in the real-life [4]. STEM is learning that combines different disciplines Science, Technology, Engineering, and Mathematics which are integrated [4]

These four aspects are compatible partner among happening problems in the real-life [5], in STEM learning, creativity and knowledge are used parallel by the students [6]. The stem education framework is a new framework for preparing human resources capable of competing and ready to face challenges in this century globally. The basic framework for stem education is the integration of science, technology, engineering, and mathematics.[7]. One of the capabilities involved in STEM is the ability of the design process (Engineering design

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process). The purpose of the stem itself is to prepare students to be able to apply their knowledge to solve complex problems and develop STEM competencies [8]. engineering as both a body of knowledge about the design and creation of human-made products and a process for solving problems [9]. The ability of the design process in the stem domain can refer to the engineering stages or commonly known as the engineering design process (EDP). The engineering design process is the formulation of plans or schemes to assist an engineer in creating a product. This engineering design process consists of steps including research, conceptualization, feasibility assessment, design, planning, and production[10]. The researcher expects this article can be useful to obtain a research overview regarding students' creative thinking skills with a STEM approach in the process of prototype design in optical instruments material.

2 Method

2.1 Design

The research method used in this research is mixed-method with the explanatory sequential design model. collection and analysis of quantitative data in the first stage using a design process assessment sheet followed by the collection and analysis of qualitative data in the second stage which is built on the initial quantitative results. The research design is an experiment.

2.2 Participant

The research subject consists of 22 Grade XI students in one of senior high school in Jambi, consisted of 7 male students, and 15 female students around 16-17 years old.

2.3 Instrument

An instrument used in this research is the evaluation of the design process by adapting the rubric made by Ernst & Glennie [11]. The rubric then has been modified and adjusted to this research. Before conducting an evaluation, students are asked to sit in a group and get the problems to find the solution. There are steps in giving problems such as; including the design proses in creating a product of optical instruments material. The solutions and design process offered by students are assessed by using assessment sheets. There are 5 assessment aspects and 4 assessment scales from assessment evaluation related to creative thinking skills. Each problem that has been offered had an appropriate assessment with the assessment aspect. Assessment aspect is presented in this table 1.

Table 1. Design Process Assessment.

Phase	The discipline of knowledge involved	Aspect	Scale			
			1 Beginning to Attain Standard	2 Nearly Attained Standard	3 Achieved standard	4 Exceeded standard
1	*Science*	Choice	Solution	The solutions	The	

Phase	The discipline of knowledge involved	Aspect	Scale			
			1 Beginning to Attain Standard	2 Nearly Attained Standard	3 Achieved standard	4 Exceeded standard
		of problem solution	does not suit the background of the problem	provided are not appropriate with the background of the problem, but the underlying reasons are not strong enough	solutions provided are according to the background of the problem. The underlying reason is strong	The solution provided exceeds the expected standard (improvised) the underlying reason is strong.
2	*Science*	Image forming of shadow	Image is not accompanied by the forming of shadow lines	The picture is accompanied by the forming of shadow lines but not accompanied by images of objects and images of eye position	The picture is accompanied by the formation of shadow lines, but not accompanied by images of objects and images of eye position. But the arrow pointer is wrong	The line of formation of the shadow but not accompanied by an image of an object and an image of the eye's position are indicated by the correct arrow pointer
3	*Science, technology and engineering*	Periscope whole design	Periscope design is drawn in origin and does not include the description and appearance of the inside	The periscope design drawn as a whole includes the appearance of the inside of the periscope	The periscope body design is drawn as a whole, including the appearance of the parts in the preparation of different periscopes marked with different shades and patterns	The periscope body design is drawn as a whole, including the appearance of the inside of the periscope. Each different periscope part, shaded / colored with a different pattern. Each part is drawn and given a

Phase	The discipline of knowledge involved	Aspect	Scale			
			1 Beginning to Attain Standard	2 Nearly Attained Standard	3 Achieved standard	4 Exceeded standard
						complete description
4	*Mathematic*	Scale design of parts	Create a periscope section stretch design without networking and without scaling	Make a stretch of the periscope part of the network without the proper scale designation.	Creating a periscope section design with a network that is accompanied by an appropriate scale but not in accordance with the results of the product being made	Creating a periscope section design with a network that is accompanied by an appropriate scale and in accordance with the results of the product being made
5	*Technology and Engineering*	Material selection	Selection of inappropriate material (not strong enough to be made into periscope forming components)	Selection of the appropriate material (strong to be made into periscope forming components) but not right in argumentation and not in accordance with product results	Selection of suitable materials (strong to be made into periscope forming components) in accordance with the results of the product but not logically appropriate to the problem	Material selection is more than the standard and in accordance with the background of the problem / purpose

2.4 Data Analysis

To investigate students' creative thinking skills in the designing process, first the writer calculating the point that already obtained by grouping students with the standard in table 1. The total number of point that gets from students are divided with an overall total point that multiplied with percent to see the percentage of students' achievement in that aspect [8]. The calculation result will be interpreted to some categories such as; very good, good, enough, less, very less [9]. The categorization is conducted to see achievement result process of students' design in a grouping or overall students in a class. Here is the table interpretation that users could be seen in table 2.

Table 2. Interpretation Percentage Design Process.

Percentage (%)	Interpretation
81-100	Very Good
61-80	Good
41-60	Enough
21-40	Less
0-20	Very Less

3 Result and Discussion

According to the finding and data analysis of ability profile students creative thinking in overall designing process with score 66.25 is on the good intrepretation. While percentage of each aspects has variative score. This is shown in the diagram **Figure 1**.

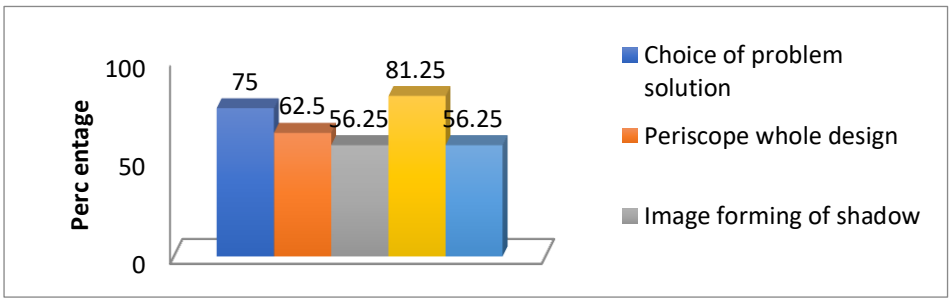

Fig. 1. Percentage of students in each aspect of the design process assessment.

Research data in picture 1 showed that in assessment aspect of material selection, all students have a percentage in the great category. This is shown by students' scores that reach 81.25%. This result showed that students are great in the planning of material selection that exceeds the standard to design the prototype of simple periscope. Good material selection is considered from the endurance side, economic in material, and match with standard and problem background. This result also related to the students' skill in creative thinking that showed by the way of wide thinking and fluently in choosing good material regarding assessment standards.

For selecting problem solutions and periscope intact design, students showed a good score. This case is showed by the diagram pictured above with the percentage score continuously reach 75% and 62.5%. The selection problem solution is based on the exact solution for solving the problem. It is related to the students' creative thinking in widely thinking and fluently thinking. In intact design score of periscope that suitable for to process of an assessment design standard. The result also showed students' creative thinking skills in a thinking manner of originality. Although in the good percentage, however, this score feels like they have the lowest score and almost reach enough number. It showed that students are not capable enough n designing intact periscope with assessment standard. Most of them also have a design that almost identical to other groups.

Aspect 4th and 5th are the lowest aspects have a similar percentage that is 56.25% with enough interpretation. This is shown that assessment aspects of creating shadow pictures and design scale part is good enough conducted by students. As is the criteria of designing assessment process, in the process students have weaknesses in drawing shadow creation and designing periscope part. Most of the students are not creating scale and shadow lines that appropriate with assessment standard.

4 Conclusion

According to the discussion above, it can conclude that students' creative thinking skill in the design process with STEM approach has a good score. It is showed by **Figure 1**, which one aspect of material selection has a very good score. While for the aspect of drawing shadow creation and part design scale have enough score. The major percentage is influenced by students' creative thinking skills.

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