Validity of Project Learning Model Based on STEMS to Improve Creativity in the 21st Century

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Abstract. This twenty-first-century education demands a appropriate learning strategy to attain the required skills, focusing on equipping students with creativity. The One of the innovative techniques that can increase students' creativity is the STEMS-based project learning paradigm. This research advances a adding a STEMS-based project learning methodology a adding a social component to the STEM (science, technology, engineering, mathematics, and social studies) learning approach (STEMS). The goal of this study was to create a reliable STEMS-based project learning paradigm to boost students' creativity when learning biology. This study employs the Design for plomp development research. Instruments Utilizing questionnaires, data were evaluated in a descriptive manner using the validation score sheet. Some experts endorsed the model. The validity finding demonstrated the viability of the STEMS-based project learning paradigm, criterion. The results of this study should thus inspire teachers to incorporate STEMS-based project learning methods in biology instruction to boost students' creativity.

Keywords: Creativity · Project · Learning Model · STEMS

1 Introduction

To accomplish the learning objectives, a suitable teaching-learning approach is needed that focuses on giving students 21st-century abilities. Particularly in gaining the students' creativity. Enhancing students' creativity in the classroom has become the most challenging role of teachers. The challenge increases with students having diverse learning styles. Learning models that support the development of creativity have been widely used. One example is the project-based learning model. The project-based learning model is in accordance with the requirements of the twenty-first century because is able toimprove higher-order thinking skills, especially creativity [1, 2].

In recent years, a project-based learning model has been implemented using the STEM approach [3–5]. An innovative new trend emerged in the learning model that

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aimed to improve students' creativity, called the STEM-based project learning model [6]. STEM-based project learning as a learning model for enhancing students' creativity is now well accepted at almost all levels of education [7]. Capraro et al. [4] have investigated that the project-based learning model is considered the most suitable to be implemented using the STEM approach. In addition, Hanif et al. [8] stated that the STEM-based project learning model also has a good impact on students' creativity. In addition, Rush [5] revealed that the most effective STEM-based project learning model process consists of five steps consisting of reflection, research, discovery, application, and communication.

However, these steps of the STEM-based project learning model have weaknesses. Projects (solutions) made by students to overcome problems in real life are not socialized to people who are experiencing problems. If students apply solutions only for themselves and are not dedicated to the wider community, then the project (solution) designed becomes less effective and useless. This is also supported by the opinion of Wagner et al. [9] who state that in biology learning the scope of STEM is much wider because students connect existing problems with impacts on the environment and society. Therefore, students should socialize and dedicate the resulting product to the wider community so that the community participates in getting solutions to problems that occur in real life.

According to Weber, something that can contribute to the improvement of society can be categorized into social elements [10]. The STEM-based project learning model does not have a social element that aims to socialize and dedicate the resulting product to the wider community so that the community participates in getting solutions to problems that occur in life. Based on this, this study added a social element to the STEM approach to answer the shortcomings of the existing STEM-based project learning model. This element is the novelty in this research. There are no STEM innovations that add social elements so that they can become novelties to be researched in an international scope.

The social element added to the STEM approach is in accordance with the structural-functional theory. The structural-functional theory states that The aim of education is to transform pupilsable to socialize as members of society and can appear as part of productive citizens [11]. In this structural-functional theory perspective, society is defined as a social system consisting of elements or parts that have their respective roles and are united in balance [12]. Changes that occur in one part will have an impact or change on other parts [13]. This is in accordance with the social element in the STEMS approach where the products produced by students must be socialized to the community so that they have a positive impact on problems that exist in the community.

According to Durkheim, every element in society has one function, namely to contribute to the survival of function as part of the system in the community by producing a product to overcome existing problems [14]. Students are also expected to contribute to the community by socializing the products produced for the realization of social balance.

Therefore, there needs to be a project-based learning model based on a science, technology, engineering, mathematics, and social (STEMS) approach which is expected to improve students' creativity in finding and dedicating or socializing products to solve real problems in society.

2 Research Purposes

The overall aim of The goal of this research is to create a reliable STEMS-based project learning paradigm that will foster students' creativity.

3 Methodology

3.1 Research Design

This study employed development research design. The development of Plomp [15] has 3 steps are preliminary research, prototyping step, and assessment step. This study is only preliminary research and prototyping step. The steps of preliminary analysis are a review of the literature, a need and context analysis, and the creation of a conceptual framework for the STEMS-based project A learning model was used. What needs and context analysis entails project-based education, pupil, curriculum, and resource analysis. The early study findings included a cutting-edge conceptual framework design of the STEMS-model for project-based learning.

The product design of the STEMS-based project learning model is carried out in the prototyping, which consists of a model book, teacher's book, student's book, and four Cs creativity assessment instruments. Subsequently, four experts in education science, biology education, educational technology, and the Indonesian language validated the product development.

3.2 Instruments and Data Analysis

The accuracy of the STEMS-model for project-based learning is actualized from the results of the accuracy of the model teacher's book, book, and student's manual. This validation instrument will use the four point Likert rating scale which are disagree, moderately agree, agree, and strongly agree. Interpretation of validation result are very valid ($X > 4{,}2$), valid ($X > 3{,}4 – 4{,}2$), quite valid ($X > 2{,}6 – 3{,}4$), less valid ($X > 1{,}8 – 2{,}6$), and not valid ($X < 1{,}8$) [16].

4 Results and Discussion

4.1 The Component of the STEMS-Based Project Learning Model

STEMS-based project learning model consist of six Fig. 1 and Table 1 show the syntax and lesson plan of the STEMS-based project-based learning to boost biology learning's creativity.

The teacher and student activity table shows that the time used is more than 150 min, the application of this model is carried out in several meetings. At the first meeting, the syntax reflection, research, and discovery were carried out. After students make project designs, students then make products according to the designs made in groups outside school hours. Project making is carried out outside school hours so that students have more time to make products so that the results are expected to be maximized. However,

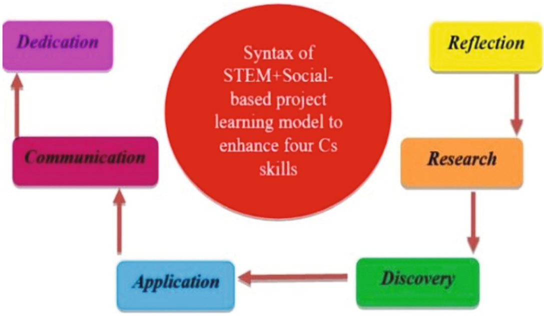

Fig. 1. Syntax of STEMS-Based Project Learning Model

Table 1. Lesson plan using stems-based project learning model

Step	Teacher's Activity	Student's Activity
Reflection (10 min)	The teacher will ask students to answer the ill-define problem regarding pollution and environmental preservation	The students need to answer the teacher's question about pollution and environmental preservation
Research (20 min)	The instructor will instruct pupils to create groups andlooking find the solutions to the problem of plastic waste	The pupils will gather together and look for thesolutions to the problem of plastic waste
Discovery (40 min)	The teacher will ask students to discuss and create the plastic waste distillator project	The students will discuss and create the plastic waste distillator project
Application (60 min)	The teacher will ask each group to test the product	Each group will test the product
Communication (20 min)	The teacher will ask each group to present the results of the project in front of the classroom	Each group presents the results of the project in front of the classroom
Dedication (30 min)	The teacher will ask students to socialize the project results to the community (environment) who experiencing problems related to plastic waste pollution	The students socialize the project results to the community (environment) who experiencing problems related to plastic waste pollution

students still have to document every step that is done when making a project as a form of accountability for activities to the teacher. The student's activity when making the project was to make a simple plastic waste distiller that was able to convert plastic waste into fuel. At the next meeting, it was continued with the syntax of application, communication, and dedication. The dedication stage is carried out by adjusting the learning time because it also takes a relatively long time. This stage can also be adjusted to be carried out outside school learning hours if possible.

We developed the last syntax in this model, namely dedication. This stage aims to socialize and dedicate the products we produce to the wider community so that people can participate in getting solutions that occur in real life. In addition, students must also motivate and persuade the community to use the results of projects made by students.

The dedication steps in the STEMS-based project learning model is in accordance with the structural functional perspective thinking. Structural functional perspective thinking states that The aim of education is to transform pupils able to socialize as members of society and can appear as part of productive citizens [11]. In this structural functional theory perspective, society is defined as a social system consisting of elements or parts that have their respective roles and are united in balance [12]. Changes that occur in one part will have an impact or change on other parts [13]. This is in accordance with the activities carried out at the dedication stage where the products produced by students must be socialized to the community in order to have a positive impact on the problems that exist in the community.

According to Dhurkheim, every element in a society has one function, namely to contribute to the survival of the system [14]. This is in accordance with the objectives at the dedication stage in the STEMS-based project learning model because students are expected to have a function as part of the system in the community by producing a product to overcome existing problems. Students are also expected to contribute to the community by socializing the products produced for the realization of social balance. The AGIL scheme aims to maintain function from various threats and meet individual needs [11]. In the application of the AGIL scheme, it is known that the pattern maintenance of a system is carried out by providing actors or elements that motivate them to act. This is in accordance with the dedication activities on the STEMS-based PjBL model where students act as actors in disseminating the project to the system (community) so that the system can be maintained.

The technology element in the STEMS approach can improve students' creativity because in their learning activities students make plastic waste processing technology in the form of a simple distillator. Students are also required to be able to use the internet to find information related to the type of technology for processing plastic waste into fuel, solving problems with plastic waste processing technology, and designing distillers. Students are also required to be able to use computers to make tables or graphs of observations.

The engineering element in the STEMS approach can improve students' creativity because in the learning activities students are asked to master the techniques in making simple distillators. Students must also be able to determine the tools and materials to make a distillator product. Students are also asked to test the optimality of the distillator through a series of experiments. In addition, students were asked to evaluate the product results in order to make improvements to the distillator.

Wu's research corroborates this finding, he says that when schools organize knowledge of creativity, they generally convey subject matter such as knowledge, and generally do not allow students to personally experience creative processes and discoveries. If pupils can actually encounter and feel imagination, it will provide the secret to inspiring

Fig. 2. Prototype of Research Product

personal imagination [17]. According to Treffinger, creative thinking can be improved by engaging in genuine creative work group creative thinking both action [18]. If the ability to think creatively is incorporated the classroom, students can form and develop creative ideas and improve their creativity in groups to foster problem solving skills [19]. Creativity is very useful for students to face changes in the future [20].

The social system describes the function and connection between teachers and students as well as the underlyingnorms. The social system designed in the STEMS-based project learning model is student-centered learning that requires students to be active in learning activities. Active learning can improve students' abilities, especially in learning biology [21]. The pattern of interaction between students is formed in a collaborative learning atmosphere so as to build interaction, communication, cooperation, exchanging opinions and mutual respect. The norms that apply during learning follow the norms of Indonesian life that apply in general, such as politeness, religion, respect, respect, and other norms.

The learning model applied in this book is based on constructivism theory where learning is student-centered so that the teacher's function is more of a facilitator, motivator, evaluator, reflector, and mentor in learning. The teacher's behavior in responding to the results of students' thoughts in the form of questions or difficulties experienced in solving problems must be directing, guiding, motivating, and encouraging student learning.

The support system in the Enhancing creativity in high school biology instruction through STEMS-based project learning are model books, teacher's book, and student's book. The research product that has been compiled is packaged in the form of a learning book. The book before being used in learning is tested for validity by experts. Figure 2 shows the prototype of the research product.

The expected instructional effect of this model is the improvement of students' creativity. While the nurturant effect that will occur with the application of the STEMS-based project learning model is that students can rediscover various biological concepts and realize how important the benefits of biology are for life so that students do not feel alienated from their environment. Biology as a science is no longer seen as the result of thinking from the outside world but is in the student's environment. Thus, a sense of belonging, attitudes, and positive perceptions of students towards their environment are

Table 2. Validation result of research product

Product	Assessment Aspect	Average	Percentage	Interpretation
Model Book	Book Format	3.75	75%	Valid
	Book Content	4.15	83%	Valid
	Language	4.12	82%	Valid
	Graphics	4.08	82%	Valid
	Syntax	3.92	78%	Valid
	Social System	4.25	85%	VeryValid
	Priciple of Reaction	3.75	75%	Valid
	Support System	4.00	80%	Valid
	Effect of model	3.75	75%	Valid
Teacher's Book	Content	3.91	78%	Valid
	Language	4.03	81%	Valid
	Graphics	4.25	85%	Very Valid
Student's Book	Content	4.47	89%	Very Valid
	Language	4.52	90%	Very Valid
	Graphics	4.42	88%	Very Valid

formed. The results of this study should thus inspire teachers to include STEMS-based project learning models into biology lessons in order to boost their students' creativity.

4.2 The Validity of STEMS-Based Project Learning Model

The STEMS-based project learning model meets the criteria. The accuracy of the STEMS-model for project based learning is actualized from the findings of the reliability of the model book, teacher's book, and student's book. Table 2 shows the validation result of the STEMS-based project learning model product.

The STEMS-based based project learning model meets the criteria. The accuracy of the STEMS-model for project-based learning is actualized from the results of the truthfulness of the a textbook and a model book, as well as a textbook. The average validation results of the three products developed were 3.98, 4.06, and 4.47.

5 Conclusion

As for the conclusion, it is proven that the STEMS-based project learning model is valid in classroom settings, especially those involving biology subjects Engaging children in high school. The results of this study should thus motivate teachers to incorporate STEMS-based project learning models in biology classes in order to foster students' creativity.

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