Implementation of Project-Based Learning Using Online Virtual Lab Media in the Interfacing and Peripheral Course

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ABSTRACT

The Interface and Peripheral course is one of the Computer Systems Study Program elective courses. This particular course, related to the computer architecture field area, is offered in the sixth semester for two credits. This study aims to analyze the differences in students' creativity before and after implementing the Project-Based Learning (PjBL) method based on virtual lab media. During the online PjBL process in the Interfacing and Peripheral course, various learning applications were used to facilitate the learning process. Several applications provide virtual practice spaces and can be easily accessed for free by users, such as the Tinkercad application. In this study, the Tinkercad application was used because it was suitable for the needs of the course. In the Tinkercad application, various electronic equipment, sensors, and embedded systems such as Microcontrollers are needed for device interfaces simulations. This case study involved sixty-two students of the Computer Engineering Department in the 2020/2021 academic year. Students' creativity data were measured from their assignments through projects and questionnaires to students. The results show a significant increase in students' creativity: while it is classified as medium, with an average of 55 scores, before implementing PjBL, it significantly increased to an average of 71 after PjBl implementation. The results suggest that students have the basic ability to think creatively, but they are not yet facilitated with a learning process that can optimize the achievement of student creativity.

Keywords: Interfacing and Peripheral, Project-based Learning, Virtual Lab, Students' Creativity

1. INTRODUCTION

Creative thinking is a stage of thinking at the highest cognitive domain [1]. There are four essential characters in education: collaboration, communication, critical thinking, and creativity. One of the higher-order thinking skills is creative thinking, leading to creativity [2]. Creativity refers to the ability to find and use new ideas that may be unconventional or even breakthrough but remains rational in the context of learning. Creativity is gained from an interaction between individuals and their environment [3]. Creativity can also be interpreted as an ability to create new products, although not entirely new. Creativity is not genetic but acquired through habit. In other words, creativity is a skill that can be trained, and it is has become the task of formal education as an important factor in being creative to produce creative students.

One of the learning models that allows students to develop their creativity is a Project-Based Learning model (PjBL) [4]. PjBL is a learning model that organizes classes using a project(s) [5]. The PjBL model enables students to carry out practical activities freely, look for various learning resources suitable with assigned topics on the internet or other places, and collaborate with other students [6]. PjBL model has been developed with the hope of achieving an instructional impact in the form of (1) increasing students' abilities in mastering learning materials, (2) developing students' abilities in critical, creative, and innovative thinking, and (3) fostering students' productive creativity. The accompanying impact is in terms of (1) developing students characters, including discipline, carefulness, hard work, life skills in students, (3) improving scientific attitudes, and (4) fostering students' abilities in communicating, arguing, and collaborating/cooperating [7]. Therefore, PjBL is a constructivist-based learning model that encourages students to design a project to master the concepts being studied.

During the online virtual PjBL process in the Interfacing and Peripheral course, various learning applications are needed to facilitate the learning process. Several applications provide virtual practice space and can be easily accessed for free by users, such as the Tinkercad application. In this study, the Tinkercad application was used because it was considered suitable for the needs of the Interfacing and Peripheral course. In the Tinkercad application, various electronic equipment, sensors, and embedded systems such as Microcontrollers are needed when simulating device interfaces. Users can design and try independently according to the project created. This application is available for free on the internet and can be accessed easily. Students can build up their creativity with the help of this application. In addition, virtual experiments can make the learning process more interesting and interactive. Also, the amount of teaching time can be reduced, the quality of learning can be improved, and the teaching and learning process can be done anywhere

credits. Students' creativity data were collected by giving assignments in the form of projects and questionnaires to students. The project-based learning model applied has six learning steps [12], namely 1) start with the essential question, 2) design a plan for the project), 3) create a schedule, 4) monitor the students and the progress of the project, 5) assess the outcome, and 6) evaluate the experience. Creativity is related to fluency, flexibility, originality, and elaboration. This study includes three stages: the preparation, implementation, and final stages of the research. The relationship between the dimensions of creativity and each phase of the problem-based learning model is presented in Table 1.

This research was conducted for eight weeks, from March 2021 to May 2021. Lecture materials on standard interfaces and interface design were given at the beginning of the semester until the midterm exam. Students then work on group projects independently in

Table 1. PjBL Phase Relationship and Creativity Dimension

No	PjBL Model Phase	Dimensions of Student Creativity that Can Be Developed	Week
1	Determination of basic questions	Fluency, Flexibility	1
2	Design project planning	Fluency, Flexibility, Originality	1-2
3	Schedule	Fluency, Flexibility	1-2
4	Monitor student and project progress	Fluency, Flexibility, Originality	2-5
5	Test results	Fluency, Flexibility, Originality, Elaboration	6
6	Evaluating experience	Fluency, Flexibility, Originality, Elaboration	7

and anytime [8]. In addition, the use of virtual labs can inspire students' creativity because they can experiment repeatedly and deepen the concepts being studied [9].

PjBL model with virtual laboratories provides flexibility for students to design projects independently or in groups so that learning resources are needed to guide and at the same time encourage students to produce creative ideas. It is expected to build student creativity to design and make discoveries. The creative process always produces something new, original, and meaningful. A significant increase in creativity can also be done by implementing a virtual laboratory [10]. In addition, the application of a project-based learning model assisted by virtual media has succeeded in increasing students' creativity in learning in the Interfacing and Peripheral course.

2. METHOD

This research is classified as a case study [11]. In this study, sixty-two students were involved. All of them are from the Computer Engineering Department of the 2020/2021 academic year, sitting in semester VI and taking the Interfacing and Peripheral course for two

the second period of the semester. Research activities were divided into two stages: the first two weeks were used as a period before the implementation system, the next six weeks were used as a period when implemented with project-based learning models using virtual lab media. In the first stage, students were asked to try out the Tinkercad application to learn the device's functions, operate it, and select components to be used in group project work. In the second stage, students are asked to design an interface application project with the topic selection including 1.) The control system in hydroponics uses Fuzzy Logic control, 2). Baby incubator design, 3). Internet of Things (IoT) based enclosure temperature monitor, 4). IoT-based rice box, 5). Pond water quality control, 6). IoT-based electricity usage monitoring, 7). Soil Moisture Monitor with Zigbee, and 7). IoT-based landfill gas monitoring. Each group discusses and cooperates in designing and simulating the project and then compiling a report. At this stage, students are given six weeks to work on projects starting from designing interface designs to submitting reports. Students are divided into small groups of 7 groups consisting of 7-8 people. By giving this group project, it is hoped to motivate students to express their creativity in working on projects. The

criteria for student creativity scores are shown in Table 2.

Table 2. Students Creativity Criteria

Creativity Score (K)	Category
$85 < K \leq 100$	Very High
$70 < K \leq 85$	High
$55 < K \leq 70$	Middle
$30 < K \leq 55$	Low
$0 < K \leq 30$	Very Low

3. RESULTS AND DISCUSSION

The scores of creativity compared are students' creativity before and after implementing project-based learning. The value of student creativity is obtained at the beginning of the semester before implementing the system as a pre-test, while the value of student creativity after being given project-based learning after the midterm exam is a post-test.

and bring out students' creativity to design and try their project designs based on the material provided.

The virtual lab application used during this research is the Tinkercad application that users can easily access. Tinkercad is a free, easy-to-use web app that equips the next generation of designers and engineers with the foundational skills for innovation: 3D design, electronics, and coding. One display of a project made by a group of students is shown in Figure 1. The average value of students' creativity for the four dimensions of creativity before and after the implementation of PjBL is presented in Table 3.

Based on the data in Table 3, it appears that students' creativity before the implementation of PjBL was still classified as moderate, with an average of 55. It shows that students already have the basic ability to think creatively but are not facilitated by a learning process that further optimizes the achievement of student creativity. Previously, students have given the Teacher-Centered Learning (TCL) teaching system, and students received learning according to the material provided by the lecturer so that students' creative ideas
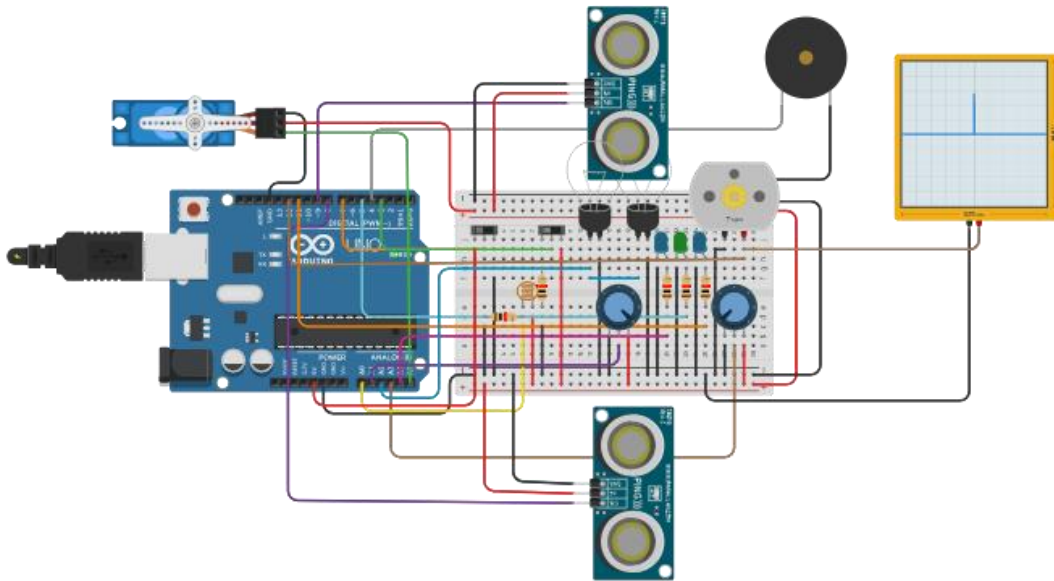

Figure 1. Interface Project in Tinkercad Virtual Media Lab

The results showed that applying a project-based learning model using virtual lab media could significantly increase students' creativity compared to the traditional teaching class [12]. The application of a problem-oriented project-based learning model could significantly increase creativity. Project-based learning models using virtual labs can provide opportunities for students to explore themselves in learning interface and peripheral concepts and to design projects independently or in groups without any time and place restrictions. In addition, giving projects can motivate

did not develop optimally during lectures. Different things happened after implementing PjBL using virtual lab media. Students had more opportunities to express creative ideas on the given project assignments. The average value of creativity increased to 81 in the high category. This increase is certainly inseparable from changes in the learning process experienced by students. When students are given the freedom to design projects according to their design problems, it allows them to develop their thinking skills.

Table 3. Average Creativity Score per Dimension Before and After Implementation

No	Creativity Dimension	Average Creativity Score		Creativity Category	
		Before	After	Before	After
1	Fluency	59	70	middle	high
2	Flexibility	56	75	middle	High
3	Originality	52	68	low	middle
4	Elaboration	54	72	low	high
	Total	55	71	middle	high

The project-based learning model can provide opportunities for students to explore thinking skills in learning in the Interfacing and Peripheral course. The four dimensions of creativity, namely fluency, flexibility, originality, and elaboration, can be developed through project-based learning. The four dimensions of creativity can be formed during the six stages of project-based learning. For example, as shown in Table 1, the first stage, namely determining the basic questions, can develop the dimensions of fluency and flexibility of student thinking. At this stage, students will be presented with problems related to problems in the surrounding environment. Students have explained the function of components and how to choose a suitable device for designing the project. After that, students can design simulations on the Tinkercad application and then compile reports on the project experiments. When explained in the first stage, some students began to express their opinions or ideas about devices such as sensors, microcontrollers, or circuits to be designed. So, students' thinking skills on the dimensions of fluency and flexibility of thinking can be assessed during the process. Each stage of the project-based learning process will significantly increase students' creativity.

4. CONCLUSION

Based on the results and discussion of the research carried out, it can be concluded that there is a significant difference in students' creativity before and after implementing PjBL model based on online virtual lab. The average score of student creativity increases from 55 (medium) to 71 (high). The results also show that the increase in creativity occurs in the four dimensions: fluency, flexibility, originality, and elaboration. This suggests that the PjBL model assisted by virtual labs can increase students' creativity. This case may not be unique to the Interfacing and Peripheral course, but other related courses.

Further research is needed so that the results obtained are more accurate and comprehensive, such as conducting quasi-experimental research. The limitation of class meetings (only through online media) prevents lecturers and students from having optimal interactions.

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