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Internet of Things for Project-Based Learning in "Vocational High School Building Village Program"

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Abstract
This study aims to map the setup of an Internet of things-based project-based learning model as a learning medium in the VHS program to develop communities at SMK Negeri 2 Kuningan in West Java. The research technique is a qualitative and quantitative approach engaging class X-XII students in the field of software engineering competence at SMK Negeri 2 Kuningan via exploratory and in-depth observations. Gunungmanik Village, Kuningan, West Java Province was the location of the internet of things-based learning initiative being implemented. The analysis strategy employs Aiken's formula, and the success factor is confirmed by a panel of experts using an analysis interactive model approach that includes data collecting, data reduction, data presentation, and conclusion drawing. According to the finding of the study the internet of things, project-based learning model in the Village Development Vocational School program was classified into three model configurations, namely: 1) Project based learning based on the internet of things as a medium for developing students' vocational skills in completing student work projects by 69%; 2) Project based learning based on the internet of things serves as a learning medium to place theoretical and practical knowledge in the classroom by 73%; 3) Project based learning based on the internet of things as a medium for integrating theoretical-practical learning, collaborative learning solutions to contextual problems providing more autonomy to students in the decision-making process by 74%. The result of this PBL was successful to meet the desired outcomes.
Keywords: Project Based Learning; Internet of Things; Vocational School Program to Build Villages; Vocational High School (SMK).

INTRODUCTION

In the face of increasingly complex job fragmentation as it is today, what is needed in the development of the workforce is no longer just the proficiency or automation of the skills of special units, but what is more important is the ability to adapt to current and future changes, an ability to accommodate contextual changes (Almulla, 2020). In order this adaptability to be formed in students, it is not enough to teach components of professional expertise separately from other components

but requires learning of work skills with a holistic and contextual perspective. In many literatures, contextual learning is learning that allows students to use their academic understanding and abilities in various contexts inside or outside school to solve real-world or simulative problems, either alone or in groups (Welsh et al., 2020).

The Ministry of Education and Culture (Kemendikbud) created the Vocational High School (SMK) Developing Villages initiative as a significant driver of the scope of vocational school revitalization. In essence, the Village Development Vocational School is expected to serve as a discussion forum to enforce the policies of the two essential programs previously issued by the Directorate of Vocational High Schools, namely the link and match between Vocational High Schools and global commerce, as well as the improvement of Vocational human resources (Wahjusaputri et al., 2021). Given that most vocational schools are located in rural regions, the role of SMK in village development is critical today and in the future. Vocational schools can help drive rural development by innovating and nurturing rural communities to become contemporary societies (Direktorat Sekolah Menengah Kejuruan, 2018). Furthermore, SMK graduates can develop into teams of new rural workers with current and practical technology skills, creative and innovative abilities, critical thinking and complicated problem solving, discussion, teamwork, and entrepreneurship. This ensures that SMK graduates become a new generation of rural area leaders who understand how to enhance justice, prosperity, and village welfare (Wahjusaputri et al., 2019).

According to study of Tripathy & Anuradha (2018), the advancement of internet of things (IoT) technology has influenced changes in rural communities' socioeconomic activities. The Internet of Things (IoT) technology helps vocational students and rural working communities perform better. The Internet of Things (IoT) model is a village builder model that attempts to increase the benefits of always-on internet access to exchange information and coordinate village builder choices. According to Kumar, Tiwari, and Zymbler (2019), The Internet of Things (IoT) is a new paradigm transforming traditional lifestyles into high-tech ones. As a result, Kaur (2019) revealed that the Internet of Things describes a worldwide network of billions or trillions of objects that can be collected from the physical environment around the world, deployed via the Internet, and transmitted to end users. Services are available for users to interact with these smart objects over the Internet, inquire about their status and related information, and even control their actions. Another definition put forward by Villamil, Hernández, and Tarazona (2020) is that the Internet of things is a new technology now present in most processes and equipment, allowing individuals to better their quality of life and access specific information and services. The Internet of Things technology stands out as a commercial and industrial performance facilitator, but most importantly in increasing people's quality of life. As long as improvements in other technologies follow the predicted path, the internet of things can overcome security, processing capacity, and data mobility hurdles. Efendi (2018) says that the Internet of Things, often known as IoT, is a theory in which all real-world things may interact as part of a cohesive, integrated system using the internet network as a connection. As

stated by (Tripathy and Anuradha, 2018), The term "Internet of Things" (IoT) refers to everything around us, including machinery, buildings, gadgets, animals, and humans. Today, this technology is more recognized for smart healthcare, smart home, smart traffic, and smart home gadgets. The Internet of Things (IoT) is a new paradigm that permits connection between electrical gadgets and sensors over the internet to improve our lives. According to Kumar et al. (2019), the Internet of Things (IoT) is a breakthrough that combines intelligent systems, frameworks, smart devices, and sensors. Furthermore, the Internet of Things (IoT) can exploit quantum and nanotechnology in hitherto inconceivable storage age, sensing, and processing speed.

This research was conducted at SMKN 2 Kuningan, Jawa Barat. SMK Negeri 2 Kuningan Regency, West Java Province is a vocational school majoring in computer networks and software engineering that can drive rural development by innovating and educating the surrounding village community to become a modern and technologically advanced society. In addition, SMK graduates can become a new rural workforce who master modern and effective technical skills, creativity and innovation skills, critical thinking and complex problem solving, communication, collaboration, and entrepreneurship in realizing a just, prosperous, and prosperous Indonesia (Hanif et al., 2019).

Based on observations, the learning process at SMKN 2 Kuningan in the software engineering department continues to employ traditional techniques, notably the lecture approach and direct presentation by the teacher in charge. A teacher plays a significant role in the learning process using this technique. Students are merely present to listen. Passive pupils and their thinking abilities suffer as a result of this situation. The employment of the tedious lecture approach does not encourage student participation in the learning process. As a result, kids become lethargic, bored, sluggish, and less passionate in learning. The lecture technique also contradicts the goals of adopting the 2013 Curriculum, which is built on active learning. These circumstances are detrimental to student learning results.

One alternative learning model that can provide context for students' daily lives is the Project-Based Learning (PjBL) model (Chen & Yang, 2019). Project assignments are built by students based on observations of real-world problems around them, thus giving meaning to themselves. The Project Based Learning (PjBL) learning paradigm is one of the suitable learning scenarios for students to grasp the information and be actively involved in the learning process (Carpendale & Cooper, 2020). PjBL is a project-based learning methodology in which students learn subject matter via project work.

The project-based learning approach as a contextual learning model includes teaching and learning, which are problem-based, project work, developing self-regulation, occurring in multi-setting and multi-context, and reaching learning in different life contexts. -different students, using teams or collaborative learning group structures that depend on each other so that students can learn from other students, and using authentic and multi-method measurements for measuring student learning achievement (Carpendale & Cooper, 2020).

Project-based learning models can be employed when educators wish to create active learner-centred learning in which students have a more fascinating learning experience and generate work based on actual (contextual) problems that arise in everyday life (Permana et al., 2021). This learning paradigm may also be utilized by instructors who want to emphasize science abilities such as observing, utilizing equipment and materials, interpreting, organizing projects, applying concepts, asking questions, and communicating effectively. Project-based learning has successfully enhanced learning practices in vocational education, allowing students' academic, occupational, and employability skills to grow optimally. Furthermore, educators may utilize the PjBL approach to help students strengthen their creative thinking abilities by establishing and developing a project that can be used to solve issues (Yunita et al., 2019). So that this PjBL approach may develop high-order thinking skill (HOTS) in scientific learning (observing, associating, attempting, discussing, and communicating) and 21st-century learning (4C: Critical thinking, Collaboration, Creative, Communication)(Gultom et al., 2021). If the following requirements are fulfilled, project-based learning can be applied: a. educators must identify essential competencies that focus on skills or knowledge at the application, analysis, synthesis, and evaluation; b. educators must be capable of selecting materials or topics that will be the theme of the project in order for it to be interesting; c. educators must be proficient at motivating students to work on projects; d. the availability of suitable learning facilities and resources; d. educators must ensure that the project timeframe fits within the academic calendar so that project activities may be carried out (Yunita et al., 2019).

This study explored the application of project-based learning based on the internet of things as a monitoring tool for the coffee monitoring project using Arduino by SMKN 2 Kuningan to enhance the quality of coffee beans in Gunungmanik Village. Gunungmanik Village is one of the nearest villages from SMKN 2 Kuningan. Gunungmanik Village has the best coffee-producing potential in West Java Province, even in remote mountainous areas. Besides having great potential, coffee farming in Gunungmanik Village, Kuningan Regency. Coffee farmers face various problems, one of which is the absence of standards in coffee processing, starting from planting coffee seeds and eradicating coffee pests to processing still conventional with simple work equipment so that when the coffee yields, the quality and taste of the coffee beans become less suitable. Farmers find it difficult to use technological equipment. This study also comprehensively explains the steps for implementing project-based learning carried out by SMKN 2 Kuningan.

METHODS

This research employed both quantitative and qualitative methods. The data was analyzed using Aiken's formula and an analytical interactive model technique, including data gathering, reduction, display, and conclusion drawing (Hadromi et al., 2021). Aiken's formula will describe the list of success factors (CSF) that have been developed (during the synthesis process) and evaluated in order to identify the significance (importance) of each success factor (CSF) (Putra et al., 2021). At this point, a questionnaire was created and given to several specialists in order to

analyze and appraise the significance of each success. In other words, until an agreement was reached, several experts (experts) were asked for their level of agreement on whether each success factor (CSF) for the application of internet of things-based project-based learning in the Village Development Vocational School was in accordance with the expert's opinion. The questionnaire instrument was created utilizing a Likert scale from 1 to 5, with 1 being extremely terrible, 2 being not good, 3 being poor, 4 being excellent, and 5 being very good (Soesanto & Dirgantoro, 2021).

In qualitative-descriptive research, six steps are used to implement project-based learning, namely preparing important questions related to a material topic to be studied, making project plans, making schedules, monitoring project-based learning (PjBL) implementation, conducting assessments, and evaluating project-based learning (PjBL) component using expert opinion. The phases of the Project Based Learning learning paradigm are as follows, according to (Edy et al., 2020):

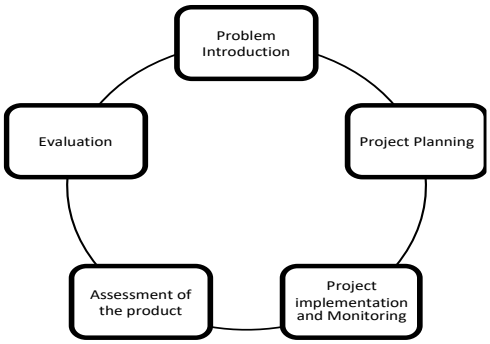

Figure 1. Project Based Learning Model

Reconstruction of the model to map variants of the internet of things (IoT)-based Project-Based Learning model, implemented in SMK, to obtain variations of the Project-Based Learning development model carried out by SMK Negeri 2 Kuningan, West Java.

Determination of basic questions

Students from SMKN 2 Kuningan headed directly to the field in this study to interview coffee farmers in Gunungmanik village and identify problems based on the outcomes of these interviews and observations (Almulla, 2020). According to the findings of these interviews and observations, there are two major issues in coffee farming in Gunungmanik Village: monitoring the temperature and humidity of coffee plants and the inability to detect pests in coffee plants.

Preparation of project design

Planning is carried out in collaboration with Software Engineering's Teachers and Students. As a result, students are intended to experience a sense of ownership over the project. The rules of the game are contained in planning, as are activities that can help answering vital questions by integrating numerous supporting themes and informing instruments and materials that can be employed to accomplish the project

(Stachura, 2021). Using the previously stated difficulties, instructors and students create solutions to solve these challenges, such as creating ~~a~~ coffee monitoring system using Arduino.

Project Implementation and Monitoring

Students begin to make coffee monitoring tools according to the designs that have been prepared previously. At this stage, educators are responsible for monitoring the activities of students while completing the project. Monitoring is done by facilitating students in each process. In other words, educators act as mentors for student activities. Educators teach students how to work in a group. Each student can choose their respective roles without overriding the group's interests (Murniarti, n.d.). Educators who become mentors are teachers in the field of computer networks and software engineering at SMK 2 Kuningan.

Assessment of the resulting product

The assessment is carried out to assist educators in measuring the achievement of standards, play a role in evaluating the progress of each student, provide feedback on the level of understanding that has been achieved by students, and assist educators in preparing the next learning strategy (Guo et al., 2020). Assessment of product results is carried out by accompanying lecturer from UHAMKA, Jakarta in related fields, namely the field of software engineering and computer networks. The teacher makes an assessment using an assessment rubric which has 13 Assessment Indicator:

1. Problem Determination: Students' ability to identify problems in their surroundings.
2. Solution description: The ability of students to analyze, explain, and develop solutions to problems.
3. Preparation of Tools and Materials: Students' ability to identify the need for tools and materials in developing products
4. Design drawing: Students' ability to design and describe the product framework (Coffee monitoring using Arduino)
5. Flow and job description: The ability of students to determine schedules, project workflow and division of individual assignments effectively and efficiently.
6. Physical form: Student product results are in accordance with the design
7. Functionality: Student product results can operate according to the expected design
8. Tool Innovation: Renewal of student products
9. Presentation Making: Students' ability to make attractive presentations
10. Material mastery: students' ability to master the material and product explanations
11. Identification of obstacles and suggestions for further projects: students' ability to identify obstacles and make suggestions for further projects
12. Conclusion: students' ability to draw comprehensive conclusions
13. Report writing: students' ability to write complete, detailed, efficient, and comprehensive project reports.

Evaluate the experience.
At the end of the learning process, educators and students reflect on the activities and project results which is the coffee monitoring based on Internet of Things that have been carried out. The reflection process is carried out individually or in groups. At this stage, students are asked to express their feelings and experiences while completing the project.

RESULT AND DISCUSSION

Description of the Characteristic Project-Based Learning Model in Vocational High Schools

Software engineering expertise (RPL) programs are among the characteristics of the project-based learning model in the Village Development Vocational School program at SMK Negeri 2 Kuningan, West Java. There are 18 indicators identified to give project-based learning features in SMK, including (1) project description in connection to competency requirements, (2) project theme identification, (3) project context determination, and (4) project evaluation. (4) formation of working groups, (5) project tools, (6) working time arrangements, (7) identification of real problems, (8) formulation of alternative problem solutions, (9) design processes, (10) production processes, (11) assessment techniques, (12) assessment aspects, (13) project results presentation, (14) types of products to be produced (15) project duration, (16) measurable features of learning results, (17) methods of assessing learning results; and (18) PBP implementation approach. Project Tasks and How to Determine the Ideal Internet of Things-Based Project Learning design is always supported by a description of the project tasks. This description demonstrates the link between the topic of project work, project design, and the degree of project complexity and the learning competence criteria that must be met. It was discovered that 37.73% of students in the software engineering expertise program (RPL) at SMK Negeri 2 Kuningan, West Java, applied learning by offering project work assignments that offered entire project task descriptions with competence criteria to be fulfilled through the project work. There are 8.15% who explain the project's concept, but it is unclear how this relates to the competences to be reached. The majority of expertise programs do not give a clear definition of the project and its relevance to the attainment of the desired abilities. Project assignments are sometimes selected by the teacher, while other times they are determined by the students. When learning activities are conducted with a student focus, students can decide which project tasks to work on. Students or groups of students' interests are allowed to grow through project activities. Students have ultimate control over their learning. This is excellent. It's only that the project's topic is only sometimes chosen following the competency standards to be attained. The amount of complexity of project tasks is only sometimes proportional to the level of skill. As a result, the teacher's responsibility in monitoring and assessing the degree of task complexity and its compatibility with the skills to be acquired is required. In this scenario, no school or expertise program totally leaves the decision of project themes to students among the different project assignments that students work on at the Vocational High School. However, the subject of the project assignment was chosen by the

students in collaboration with the instructor (47.86%) or by the teacher alone (57.35%).

The learning path from the Project Based Learning learning model and associated 21st Century Competencies, namely 4C: creative, collaborative, communicative, critical, and 1Q: Taqwa with a Scientific approach according to the 2013 Curriculum (K13) integrated with ICT, namely Observing, Associating, Trying, Discussing, and Communicating, may be used to produce descriptions of the learning experiences and competencies attained by students (Thamrin et al., 2022).

Students learn during the implementation of the project-based learning model when they are encouraged to care about environmental issues in their daily lives, practice being sensitive to the environment, practice looking for key questions, practice thinking logically, critically, and in detail, think about the specifics of the work that needs to be done, and engage in associative thinking, which involves making connections between different aspects of the work (Megayanti et al., 2020). Students try to work according to their comprehension, interact and collaborate with one another, and learn from their mistakes before correcting them.

Determination of basic questions

In determining the basic questions and the problem, teachers accompany students to conduct interviews and direct observations on coffee plantations in Gunungmanik village. This activity aims to arouse students' interest in the topic to be studied. In addition, observations and interviews with coffee farmers in Gunuggmanik Village can encourage students to think critically and build their' abilities in connecting events that have occurred around them.

The results of observations and interviews with farmers in Gunungmanik Village, (1) there is no standard in monitoring coffee trees; (2) there are many pests such as termites, leafhoppers, and birds that interfere with the growth of coffee trees. Then, based on interviews with coffee tree farming experts, 3 important variables must be considered in coffee tree monitoring, namely temperature and humidity, and soil moisture. From these problems, a basic question can be proposed, namely "How to measure and monitor important variables in coffee plants?" and “How to detect pests on coffee plants?”.

Preparation of project design

Based on the basic questions that have been identified previously, students accompanied by teachers begin to develop project designs, namely making coffee monitoring. The development solution carried out by students is to create a coffee monitoring model using Arduino. This coffee monitoring device has the feature of displaying and giving warnings if environmental conditions (temperature, soil pH and pests) exceed the standard, especially if there are changes in climate and weather conditions.

Students begin the design by conducting a literature study and determining materials and equipment. Developing project designs provides several learning experiences for students, including organizing students in working groups, building collaboration among students, building communication between students,

involving students in the planning process, and determining and finding their own project designs.

After discussing with the team and mentors, namely the teachers, here is the design of the Gunungmanik coffee monitoring project:

Table 1. Component of Coffee Monitoring

No	Component	Use
1	Arduino Uno R3	Microcontroller board based on atmega328 (datasheet).
2	DHT22	Sensor package that functions to measure temperature and humidity at the same time in which there is an ntc (negative tempereture coefficient) type thermistor to measure temperature.
3	Soil moisture sensor	This soil moisture sensor module is used to measure the level of soil moisture.
3	HC-SR05 PIR	This sensor is a motion sensor made of crystalline material that can generate an electrical signal when there is heat energy in infrared radiation.
4	ESP8266	A wifi module that functions as a microcontroller enhancement such as an arduino so that it can connect directly to wifi and make tcp/ip connections.

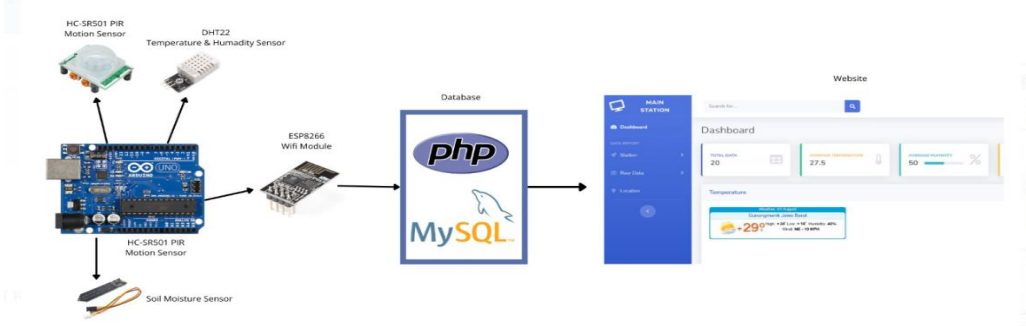

Figure 2. Project Based Learning Berbasis Internet of Things Model

Project Implementation and Monitoring

In this stage, Students make projects according to schedule, record each stage, and discuss problems that arise during project completion with the teacher while the teacher monitors the activity of students during project implementation, monitors the realization of progress and guides them if they experience difficulties. The coffee monitoring project was carried out for 4 weeks (September – October 2022). Each week, students will assemble and test the tool using 1 sensor. At the implementation stage of the coffee monitoring project design, students will investigate and analyse the assembly results for each sensor. The teacher will monitor this project's

implementation every week by holding presentations and joint discussions. At this implementation and monitoring stage, students get several learning experiences, including having the experience to conduct investigations, growing analytical skills (finding their own relationship between real conditions and the problems they face), building an attitude of sharing and collaboration, developing communication skills, developing the ability to make decisions. decisions, and utilize media and resources (ICT). During this implementation stage, most of the students had various issues while testing the sensor installation; there were several sensors that did not work owing to component quality and difficulties when programming the controller, notably the Arduino Uno R3. Furthermore, students struggle with communication and job distribution within groups; there are occasional misconceptions among members, which slows down work. These issues, however, can be remedied during weekly teacher monitoring.

Assessment of the resulting product

After the students completed coffee monitoring using Arduino, then an assessment of student product results is carried out. At this stage, the teacher discusses the project prototype, monitors student involvement, measures the achievement of standards. In this assessment, students make presentations that explain problems, solutions, coffee monitoring designs, product results, and constraints and suggestions for further projects. After making presentations, students and teachers conduct questions and answers and discussions related to the results of coffee monitoring products. In this assessment stage, students get various learning experiences, namely compiling presentation materials, delivering project results (presentations using media/ICT), answering questions during discussions, developing the ability to display work (using media/ICT), packaging products, documenting project stages (utilizing ICT), and displaying products (using media/ICT).

The results of the assessment showed that SMK 2 Kuningan students can identify problems in the community and can propose solutions to these problems. The design of the coffee monitoring device and product results are also very good. Coffee monitoring devices can operate properly displaying the size of related variables such as temperature, humidity, and soil moisture. In addition, the device is also capable of detecting movement around the device which is expected to detect pests such as birds or termites.

Evaluation

The evaluation stage is the final stage in the Project based learning model. At this stage, students reflect on the activities that have been carried out and the products that have been produced. The reflection process can be done individually or in groups. Students should be allowed to express their feelings and experiences while completing the project.

Table 2. Evaluation of Project Based Learning Based on Internet of Things (IoT) in the Vocational School Building Village Program

No	Indicator	Success Factor (%)
1	Proficiency in applying academic knowledge to practice.	60,9
2	Express ideas clearly	74,9
3	Creating quality products.	66,9
4	Clearly construct assignments	64,4
5	Students can design products, calculate technical, materials and costs, and create production tools to solve problems	63,8
6	Make plans effectively	63,2
7	Use important sources	67,3
8	The ability to understand the context of the problem where their knowledge and skills are useful in solving the problem	73,0
9	Design appropriate new tools or technologies to solve real problems	65,1
10	Evaluate own Actions effectively	48,4
11	Sensitive to feedback	44,7
12	Find accuracy	69,0

The evaluation results show that project-based learning in the software engineering major is going well. However, some things need to be improved in the future, such as not all students being actively involved and participating in group work to complete project assignments. Students need to be more active in asking and responding to other groups presenting in front of the class.

In response to the assessment results, the Project Based Learning learning model may be utilized by instructors as an alternative learning model to promote student activeness and learning outcomes. Furthermore, teachers can create presentation guidelines for students to ensure that presentation activities are directed and feel more alive. The last stage of project-based learning basically met the criteria of learning objectives, meaning that PjBL can be implemented in various learning context. The findings are reinforced by (Edy et al., 2020; Megayanti et al., 2020; Soesanto & Dirgantoro, 2021; Stachura, 2021; Thamrin et al., 2022; Usmeldi, 2019)

CONCLUSION

The Project Based Learning (PjBL) learning paradigm is one of the suitable learning scenarios for Student of Software Engineering Major in SMKN 2 Kuningan to grasp the information and be actively involved in the learning process. This study employs six steps for implementing project-based learning: preparing important questions related to a material topic to be studied, making project plans, making schedules, monitoring the implementation of project-based learning (PjBL) implementation, conducting assessments, and evaluating project-based learning.

The study results show that SMK 2 Kuningan students are able to identify problems in the community and can propose solutions to these problems. The design of the coffee monitoring device and product results are also excellent. Coffee monitoring

devices can properly display the size of related variables such as temperature, humidity, and soil moisture. In addition, the device is also capable of detecting movement around the device which is expected to detect pests such as birds or termites. the internet-of-things-based project-based learning model has the ability to increase students' job abilities. The reconstruction of the model is founded on three primary pillars: (1) contextual, (2) collaborative, and (3) learning autonomy.

It can be concluded that project-based learning in the software engineering major is going well. However, there are some things that need to be improved in the future, such as not all students being actively involved and participating in group work to complete project assignments. Students being less active in asking and responding to other groups who are presenting in front of the class. Instructors may utilize the Project Based Learning model as an alternative learning model to promote student activeness and learning outcomes. Lastly, for further research, the same design of project-based learning activities is highly suggested to be implemented in other learning contexts.

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