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Assess the effectiveness of Project-based Learning Method in Advanced Mathematics for Engineering Students in Vietnam in the context of the Covid-19 pandemic

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Abstract. The purpose of the study is to help students apply their knowledge and practical skills to participate in solving problems "The Robot Control Design Project". Research method: we discussed with all students of the class through google meet (and zoom software) about the purpose of the project, which is the Robot Control Design Project. Due to the Covid-19 pandemic, students will communicate with teachers and classmates online. We used the google form to evaluate the results of the project. The results show that students evaluate PBL positively because this method helps students have interesting practical experiences, while developing collaborative skills, problem solving and self-control in study.

Keywords: *Project-based learning method; construction; experiment*

1. Introduction

Currently, the world is facing many difficulties due to the Covid-19 epidemic; countries are trying to control the epidemic in many ways, including measures taken in most countries, that is social distancing, moving from face-to-face work to online work. These measures have had a great influence on education; face-to-face teaching has become much more difficult, instead of direct learning methods, online learning has been introduced as a temporary solution for current education. In the past, online teaching was only an alternative for people who were often busy and did not have time to attend in-person classes. Currently, online learning has become an indispensable solution in the education industry, helping to connect students and teachers during the complicated development of the epidemic. Besides the technological difficulties, the ability to interact and manage students is much more complicated than compared to a traditional classroom. However, during these Covid-19 outbreaks, online learning also brings many great benefits (Huyen P., Que N.T., Gia L.L., Ha M.D., Tien D.V., 2021; W.R. King, J. He, 2006).

Online learning

Online learning is a method of virtual learning through a networked device to a server in another place where electronic lectures and necessary software are stored to be able to ask/request/problem for students to learn online. Teachers can transmit images and audio via broadband connection or wireless connection (WiFi, WiMAX), local area network (LAN). Expanding, individuals or organizations can create their own online school (e-school) where they still receive training, pay tuition and have tests like other schools.

Online learning allows learning anytime, anywhere, imparting knowledge on demand, responding information quickly. Students can access the courses anywhere such as at the office, at home, at public Internet spots, 24 hours a day, 7 days a week.

Online learning saves costs: reduce costs by about 60% including travel costs and venue organization costs. Students only have to pay for course registration and can register for many courses that they need.

Online learning saves time: it reduces training time by 20-40% compared to traditional teaching methods by limiting distractions and travel time.

Online learning is easy and flexible: Students can choose from courses guided by online instructors or Interactive Self-pace Course, adjusting their own learning pace according to their ability and can enhance knowledge through online libraries (F. Abdullah, R. Ward, 2016; N. Al-Qaysi, N. Mohamad-Nordin, M. Al-Emran 2018).

Online learning optimizes educational services: Consistent transmission of content. Institutions can simultaneously offer many different disciplines, courses as well as different levels of study, making it easy for students to choose.

Online learning is easy to create courses and allows students to participate in learning, easily track learning progress, and student learning outcomes. With the ability to create assessments, administrators easily know which students have attended, when

they completed the course, how they performed and their level of development (Huyen P., Que N.T., Gia L.L., Ha M.D., Tien D.V., 2021; W.R. King, J. He, 2006; N. Al-Qaysi, N. Mohamad-Nordin, M. Al-Emran, 2018).

However, online education also has some disadvantages, such as emotional and spatial limitations for learners; direct interaction with users is limited; some users do not use smartphones, computers...

Online Learning with a learning project

The term "Project", is understood in the common sense as a pilot, a draft or a plan, which needs to be implemented in order to achieve the set purpose. The concept of project is commonly used in most socio-economic fields and in scientific research. After that, the concept of project has gone from the economic and social field to the field of education and training not only with the meaning of educational development projects but also used as a form or teaching method. At the beginning of the twentieth century, American pedagogues built the theoretical basis for The Project Method and considered it an important teaching method to realize the student-centered teaching concept in order to overcome the disadvantages of traditional teaching that considers the teacher as the center. Initially, the project method was used in hands-on teaching of engineering subjects, later being used in most other subjects. There are many different conceptions and definitions of project teaching. Many authors consider project teaching as an idea or a teaching point of view. There are also people who consider it a form of teaching because when implementing a project, there are many specific teaching methods used. However, project teaching can also be considered as a complex teaching method.

According to (Jason Ravitz, Nate Hixson, Mary English, John Megendoller, 2012), PBL provides opportunities for students to learn deeply content knowledge and 21st century skills. While PBL practices vary depending on grade level and subject area, projects should allow some level of student voice and choice, and must be planned, managed, and evaluated carefully to connect rigorously academic content to the 21st century Skills (such as collaboration, communication, and critical thinking) through students' products and presentations (Tseng, KH., Chang, CC., Lou, SJ. et al. 2013; Lih-Juan ChanLin, 2008).

PBL method can meet the requirements of learners for the process of building knowledge and practical experience; however, this method is still quite new and is not yet popular in teaching and learning technical majors in Vietnam. Therefore, this article applies project-based teaching methods in Advanced Maths for students in engineering to help students not only have theoretical understanding but also practical experience, develop collaboration skills, problem solving skill and self-regulation in learning, thereby improving autonomy in learning.

Characteristics of project-based learning method

Thomas (2000) raised 5 criteria of PBL including: (1) centrality; (2) motivation; (3) tectonics; (4) autonomy in learning and (5) reality. The uniqueness of PBL is the construction of a final product that shows the learners' knowledge, understanding and attitude towards the problem being researched and that the problem is presented by the learner in many different forms such as videos, pictures, reports, models and other artifacts (Holubova, R., 2008).

According to (Cocco S., 2006), PBL is a learner-centered approach, based on three constructivist principles: context-specific learning, active learning, and sharing knowledge and understanding. During the PBL process, learners are given the opportunity to "build knowledge by solving real world problems through questioning and discussing, designing and conducting investigation, gathering, analyzing and explaining information, data, draw conclusions and report results " (Blumenfeld, P., Fishman, B.J., Krajcik, J., Marx, R.W. & Soloway, E., 2000). Teaching in this form of questioning allows learners to gain meaningful learning experiences and achieve a common goal through collaborative development and presentation of a final product (Kokotsaki, D., Menzies, V. and Wiggins, A., 2016). PBL is also a form of experiential learning, in which learners participate consciously and actively think about the learning process (Helle, L., Tynjälä, P. & Olkinuora, E., 2006; Adrian Stoica, 2015). The Robot Control Design projects in this experimental study demonstrate the above characteristics of PBL.

3. Research Methods

In order to promote PBL's preeminence in teaching and learning engineering, an empirical study on PBL was conducted with 48 third-year engineering students of Hanoi Industrial University. The Robot Control Design Project was selected as an experimental research for the following reasons: (1) the survey subjects were third-year students with knowledge of theory and practice from a basic level or higher; (2) The author of the article who is also a lecturer of this module can evaluate his own teaching method through research on his own teaching activities.

3.1. Implementing project

To achieve the goals of PBL, the robot control design project consists of 4 specific implementation steps. We recommended a number of steps to implement a project because "when the projects are structured to help students actively plan projects early, students gradually develop a sense of ownership and pride in project". Therefore, students are instructed in detail about 4 steps to implement a robot control design project, topic selection to information research on topic and correct the trainer's responses, present the final product and evaluate the project.

Steps to implement robot control design project (Diagram 1)

Steps:

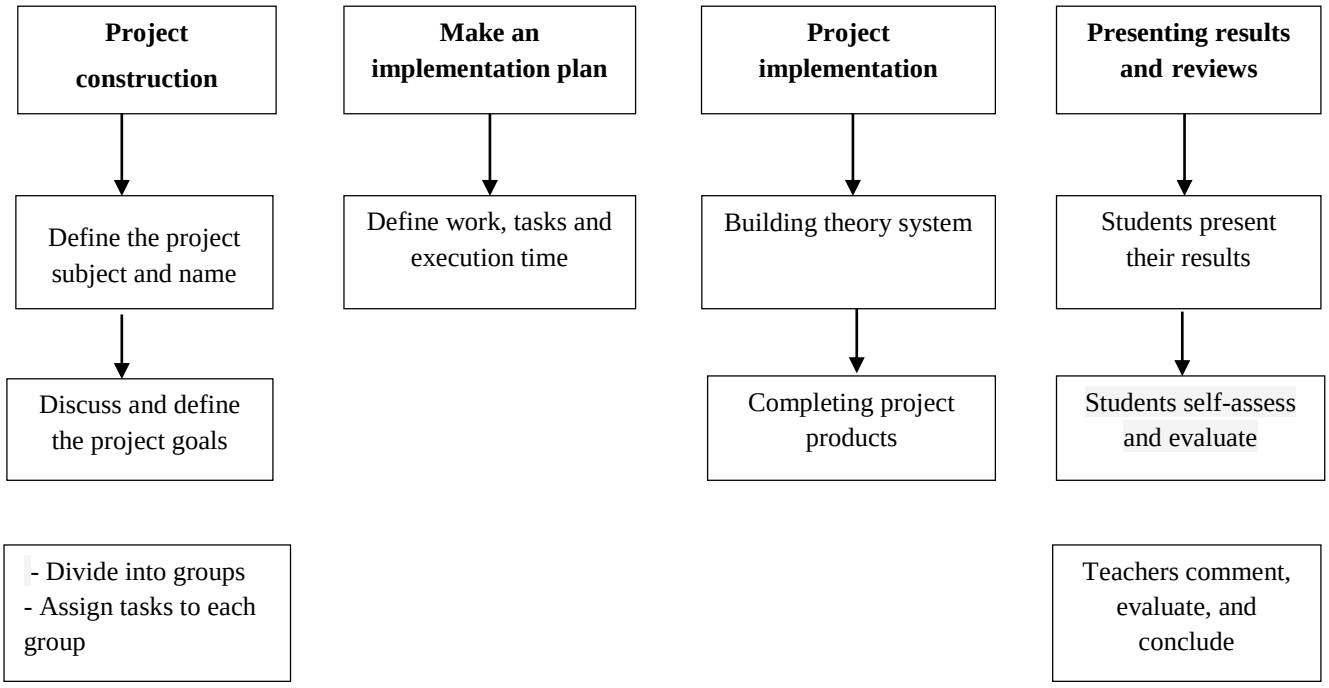

Diagram 1. Project implementation process

Step 1: Project construction

Teachers and students propose ideas on the topic of Robot Control Design for a learning project by presenting a situation with a real problem or a task to solve. The project can be proposed by a teacher, student or student group, but it is the student who decides to choose, however, it should be ensured that the content is suitable for the purpose of learning, the content of the program and the facts, in accordance with the capacity of students. The teacher can also recommend a number of topics for students to choose from.

Students clearly define the goals of the Robot Control Design project, the requirements to be achieved of the project.

Step 2: Make an implementation plan

Students actively discuss project goals, tasks to be performed in the project. Basing on project goals, project implementation time funds and student deployment plans teachers give comment, and correct to help students implement in the right direction.

Step 3: Project implementation

During this period, student positively and actively perform assigned tasks by applying the knowledge learned and self-researching.

With the feature of Advanced Math for engineering, in order to carry out the Robot Control Design project, students need to know about other basic knowledge related to the project such as mechanics, electricity. Therefore, acquiring relevant specialized knowledge is an important task in project implementation. While working on a learning project, students need to increase communication between students, between student and teacher. Strengthen cooperation and exchange among students, teacher. Especially, when doing projects, students always have to review the goals for timely adjustments.

Step 4 : Presenting results and reviews

The result of the Robot Control Design project is a product that students can introduce and present to the online class.

Evaluation of results can be made by individuals self-assessing the results of themselves, of groups, other individuals, or among groups of each other on the project implementation process, on the achieved products. The teacher is the last person to evaluate and make general comments on the project implementation and resulting products.

3.2. Assessment tools

After presenting the robot control design project to class in week 10, all students fill out a self-assessment survey of the project. This self-assessment consists of 10 questions, of which 8 closed questions refer to the student's experience with PBL on a 5-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree), and 2 open-ended questions about students' problems and suggestions about PBL.

Table 1 contains questions for the purpose of studying self-assessment of student participating in experimental research on project-based learning methods. Circle your opinion on questions 1-8 following the instructions below and state your opinion in sentences 9-10.

Table 1. Self-assessment questionnaire

I. Closed questions					
	Scale				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
1. I have found that the project-based learning method helps students be more excited, confident and effective in learning than the traditional presentation method.					
2. I can develop autonomy in learning through team goal setting, project planning and implementation.					
3. I can improve my knowledge and creativity by presenting projects in a variety of attractive and diverse formats.					
4. I can develop collaboration skills, teamwork skills and responsibilities during project implementation					
5. I can improve self-regulation and have better learning control during the project.					
6. I can improve the team's problem solving and critical thinking abilities during project implementation.					
7. I want the project-based teaching method to be replicated in many other modules					
8. I have the opportunity to delve deeply into the topic of the project.					
II. Open-ended questions					
9. What difficulties did you encounter during the project implementation? ……..					
10. Do you have any suggestions for better project-based learning method? ……..					

1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree

3.3. Data analysis

Regarding data analysis, descriptive methods are used to characterize robot control design projects. Quantitative analysis with calculation (one sample t-test) combined with qualitative analysis is applied to students' self-assessment of PBL.

4. Main activities of the project

Part I. Develop a set of directional questions related to the robot control design project

Essential Question: Laplace transforms and their applications?

Unit Question: What is Laplace transform? What is the purpose of the Laplace transformation? What Laplace transformations are there? How to apply Laplace transforms in real problems?

Content question:

Question 1: What is the concept of the Laplace transformation?

Question 2: What are the basic Laplace transformations?

Question 3: Applying to Laplace of electrical circuits?

Question 4: An electrical circuit in the robot control contains 1 R element and 1 L element in series with a source as shown in the figure. When the switch is closed = 0, $u_C(0) = 1V$. Find the current i (t) in the circuit above to control the normal operation? (Figure 1)

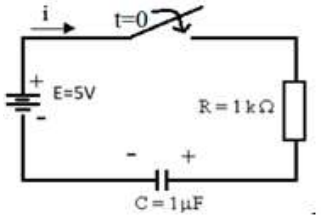

Figure 1.

Question 5: Apply the Laplace transform to find the current i (t), t> 0 in the circuit of the controlling robot and design and assemble the robot control that know the parameters E = 10.sin(5t) (V), R=4 Ω và L=2 H. Suppose at t = 0, when the lock is closed, there is no current, that is $i_0 = i(0) = 0,\ t = 0$. (Figure 2).

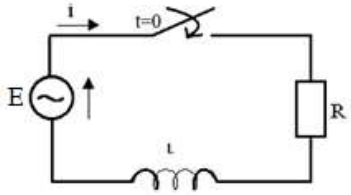

Figure 2.

Question 6: What is a practical problem that leads to Laplaceization?

Question 7: (Question of navigation) How is the Fourier transform applied in some areas such as signal processing, cryptography, frequency?

Part II. Implement a robot control design project

Task 1: Students research theory-driven theory

Task 2: Research and answer content questions

Task 3: Present results and evaluation

Figure 3. Product pictures

5. Results and discussion

After implementing related projects on robot control design, generally all groups of students have a positive assessment of PBL with an average value of 4 or more, which is statistically significant difference with p <.05. (Table 2).

Table 2. Students make their own assessment of PBL (48 students)

	Mean value (M)	Standard deviation	t-test value
I have found that the project-based learning method helps students be more excited, confident and effective in learning than the traditional presentation method.	4,60	0,536	59,565
I can develop autonomy in learning through team goal setting, project planning and implementation.	4,29	0,544	54,642
I can improve my knowledge and creativity by presenting projects in a variety of attractive and diverse formats.	4,21	0,849	34,322
I can develop collaboration skills, teamwork skills and responsibilities during project implementation	4,17	0,630	45,806
I can improve self-regulation and have better learning control during the project.	4,10	0,627	45,347
I can improve the team's problem solving and critical thinking abilities during project implementation.	4,06	0,783	35,948
I want the project-based teaching method to be replicated in many other modules	3,94	0,633	43,119
I have the opportunity to delve deeply into the topic of the project.	3,81	0,607	43,521

Note: p*=0,000 difference with p <0.05; t = t-test value of a sample; p = probability value

According to the results in Table 2, students agree the most that PBL helps students to be inspired, confident and learn more effectively than the traditional presentation method with the highest mean (M = 4.60). With PBL's learner-centered approach, students find they have the opportunity to develop autonomy in learning through goal setting, group project planning, and implementation (M = 4.29).

The students all agreed on the benefits that PBL brought them through improving their ability to build knowledge and creativity (M = 4.21; SD= 0.849; t = 34,322 and p <0.05), develop collaborative skills, teamwork skills and responsibilities (M = 4.17; SD= 0.630; t = 45,806; p <0.05), improve self-regulation and control learning (M = 4.10; SD= 0.627; t = 45,347 and p <0.05) and improve problem solving abilities and critical thinking during project implementation (M = 4, 06; SD= 0.783; t = 35,948 and p <0.05). The students also agreed to propose that the PBL should be replicated in many other modules (M = 3.94; SD= 0.633; t = 43,119 and p <0.05). The average value of the opportunity for in-depth research on the project topic is the lowest (M = 3.81; SD= 0.607; t = 43.521 and p <0.05) due to the difficulties students face in project implementation process.

Based on the above survey results, we find that, even though, in the situation of the Covid-19 epidemic, face-to-face learning in the classroom is not possible, the project-based learning method has been applied flexibly through the support of information technology, exchange activities during project implementation, idea presentations, and product presentations are still well done by the students.

We have received positive feedback from students implementing the project. TDK and NVH student said that the project-based learning method helps them to be more excited, confident and learn more effectively than the traditional presentation method. Meanwhile, NTH student said, because of the school closure period, this project and the way it was implemented helped me develop academic autonomy through setting good personal study goals, setting project planning and execution.

In addition, many students share the same opinion that, by implementing the project, they themselves improve their knowledge and creativity, after having the product "control robot", students themselves see very proud, thereby promoting the passion for creativity even more.

Although they cannot directly work with classmates, they still regularly exchange ideas to help each other during project implementation, so each student improves his ability to self-regulate and control his learning during the project. The majority of students say that the project-based teaching method should be replicated in many other modules.

6. Conclusions

This study provides empirical evidence on the use of PBL by student robot control design projects. Despite certain difficulties during project implementation, as it was the first-time students were working on robot control design projects, the results showed that PBL offers many practical benefits and interesting experience for students, especially help students build knowledge, improve self-regulation, control and develop autonomy in learning.

These skills are very essential for learners and should be focused on developing so that students can integrate internationally in the age of globalization. In order to fully develop a learner-centered approach in PBL, teachers need to be more aware of the role of an instructor in student projects rather than as transmitting or imposing knowledge.

From the practical benefits that PBL brings to students through robot control design projects, this study shows that PBL needs to be replicated and more popular in schools from high schools to universities in Vietnam to meet the increasingly high learning needs of learners for international integration.

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