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ORGANIZING PROJECT-BASED TEACHING IN ADVANCED MATHEMATICS FOR UNIVERSITY STUDENTS OF ENGINEERING

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THE AUTHOR'S PUBLICATIONS
RELATED TO THE DISSERTATION TOPIC

1. Nguyen Van Tuan (2016), "Constructive teaching in teaching some problems applying Dirichlet's principle", Journal of Educational Management, Academy of Educational Management, No. 85, June, p. 33 -35.
2. Nguyen Van Tuan, Tran Viet Cuong (2018), "Designing the learning project "Extreme extremum of a function of two variables" in teaching advanced mathematics to university students of engineering", Journal of Education, Ministry of Education and Training, Special Issue, March, pp.194-197.
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INTRODUCTION

1. Rationale for choosing the research topic

1. The cause of industrialization and modernization of the country in the context that Vietnam has been integrating deeply with the world in all fields; meanwhile, the global influence of information and communication technology and the knowledge economy have posed new challenges and opportunities for education and training.

The orientation for fundamental and comprehensive renovation of education and training in the face of new challenges and opportunities is clearly stated: "Strongly shifting the educational process from mainly equipping knowledge to comprehensive development of competencies and qualities for learners" at all levels of education, from general education to higher education. That orientation requires a fundamental change from the traditional education and training method – content-based approach (mainly equipping knowledge) to modern education - competence-based approach (mainly developing competencies and qualities for learners) in the entire national education system.

2. In recent years, the teaching of Mathematics for students of universities in general and application-oriented universities (engineering, economic) in particular has completely shifted to credit-based training. The training under the credit system requires a high degree of positivity and initiative of students. However, in practice, the implementation faces many difficulties, so the traditional teaching styles (presentation, explanation, illustration, etc.) are still widely applied.

3. Project-based teaching is an advanced, modern, innovation-oriented form of teaching organization, which aims to approach and develop learners' competencies and qualities. This form of teaching considers the development of learners' competencies and qualities as the central goal of the teaching process in universities, and is widely applied in many advanced countries around the world.

In the process of project-based teaching, learners are given complex learning tasks, with a continuous combination of theory and practice, creating recommendable products. Learning tasks are carried out with high self-discipline throughout the entire learning process, from defining goals, planning to project implementation, checking and evaluating performance.

In recent years, on the basis of inheriting international successful experiences and lessons, a number of researchers have been studying and looking for specific measures to apply the organizing project-based teaching in different subjects from high university to university, in line with the reality of Vietnamese education and they have obtained positive results.

For the above reasons, on the basis of inheriting those theoretical lessons and practical experiences, we choose the research topic: "Organizing project-based teaching in advanced mathematics for university students of engineering" with the desire to contribute to developing learners' competencies and qualities, meeting the outcome standards of the subject and discipline.

2. Research aim

Propose a plan to organize project-based teaching in advanced mathematics for university students of engineering in order to develop learners' competencies and improve the quality of advanced mathematics training in universities.

3. Research tasks

- Study the theoretical basis of project-based teaching.

- Investigate the current situation of teaching advanced mathematics to university students of engineering and the situation of project-based teaching in advanced mathematics in universities.

- Propose the process of organizing project-based teaching and illustrate by some specific projects in advanced mathematics for university students of engineering.

- Test the feasibility and effectiveness of the proposed measures by pedagogical experiment.

4. Research subject and object

- Research subject: The process of teaching advanced mathematics in universities.

- Research object: The process of project-based teaching in advanced mathematics for university students of engineering.

5. Scientific hypothesis

If project-based teaching in advanced mathematics is organized on the basis of selecting topics and following appropriate procedures, it will contribute to the development of competencies to meet the outcome standards of the subject for university students of engineering.

6. Research methods

6.1. Theoretical research methods

- Research, analyze and synthesize domestic and foreign documents within the scope of the topic.

- Research and analyze the goals, outcomes, and contents of the advanced mathematics program for university students of engineering.

6.2. Practical research methods

- Investigation-observation method: to find out the current situation of teaching advanced mathematics in engineering universities and find out the situation of applying project-based teaching in general and in teaching advanced mathematics in particular.

- Get expert opinions on the appropriateness of materials and projects as well as the effectiveness of project-based teaching in advanced mathematics.

- Statistical methods and data processing.

- Method of summarizing experience: summarizing experience through teaching activities, through practical surveys and inheriting lessons learned from project-based teaching in advanced mathematics.

6.3. Conduct pedagogical experiment to clarify the relevance and feasibility of the proposals

7. New contributions of the thesis

- Theoretically, the thesis has built the concept of project-based teaching and the process of project-based teaching in advanced mathematics for university students of engineering.

- Practically, the thesis has investigated and analyzed the current situation of teaching advanced mathematics to university students at some engineering universities; proposed the plan and organized the implementation of project-based teaching in advanced mathematics in order to develop a number of skills for university students of engineering (illustrated by some specific projects); and tested the feasibility and effectiveness of those proposals.

8. Arguments to be defended

- Organizing project-based teaching in advanced mathematics for university students in engineering is a form of teaching with a scientific basis, suitable to Vietnamese educational practice and the general trend in the world.

- The learning projects in advanced mathematics proposed in the thesis are feasible and initially effective.

9. Structure of the thesis

In addition to the introduction and conclusion, the thesis consists of three chapters:

Chapter 1. Theoretical and practical basis

Chapter 2. Organizing project-based teaching in advanced mathematics for university students of engineering

Chapter 3. Pedagogical Experiment

Chapter 1
THEORETICAL AND PRACTICAL BASIS

Chapter 1 studies the theoretical basis of project-based teaching, including overview of research results on project-based teaching, overview issues of project-based teaching; factors affecting

project-based teaching; survey on the actual situation of teaching advanced mathematics in universities for engineering students.

1.1. Overview of the research results

Project-based teaching started with small projects in the late sixteenth century in some European countries. With its advantages, project-based teaching is increasingly developing in the world and up to now, it can be considered as an active, modern and effective form of teaching.

Research works on project-based teaching is mainly in the direction of studying the theoretical basis of project-based teaching, building a model of project-based teaching, and studying the effectiveness and benefits of project-based teaching.

In the direction of studying the theoretical basis of project-based teaching, studies have shown that project-based teaching in universities has the following benefits:

- Encourage students to study and improve their diligence, self-discipline and active learning.

- Students are more responsible for learning compared to other traditional teaching methods; the amount of knowledge acquired is also bigger.

- Students have the conditions to develop thinking competencies, core competencies and professional competencies.

- Students can participate in social activities and create their own products.

The direction of building a model for project-based teaching and studying the effectiveness and benefits of project-based teaching has been researched and implemented at almost all levels of education from high university to professional education.

Regarding general education, the Ministry of Education and Training has coordinated with a number of international organizations to deploy and train teachers to expand and develop this teaching method. A number of projects aimed at innovating teaching methods, fostering teachers, enhancing equipment and facilities for

teaching and learning innovation, such as the Viet-Belgium Project, the Intel teaching program. These projects have taught high university teachers how to incorporate technology into their lessons, promote problem-solving skills, collaboration skills, and critical thinking for students. The above projects also encourage teachers and learners to use information technology as an effective tool in their activities, and at the same time, always put students at the center in all activities, encourage students to be active, develop self-discipline and higher-order thinking.

In addition, there are project-based teaching studies for teaching some subjects such as Physics, Chemistry, Biology, Industrial Engineering, Informatics, etc. in order to develop certain competencies for students.

Regarding professional education, research on project-based teaching is more developed thanks to the advantages of the subject nature and students' psycho-physiology.

A number of studies on project-based teaching in training pedagogical students pursued the main goal of developing pedagogical competence for students.

In another direction, research works focus on the study of organizing project-based teaching in order to develop a certain competence for students such as pedagogical competence; analytical thinking competence; professional competence; integrated teaching competence.

In the direction of organizing project-based teaching associated with professional products, the researches mainly focus on specialized subjects or professional practice. The researchers have analyzed the program framework, the appropriateness of the subject when organizing project-based teaching, outlined the steps to implement the project and specified the products achieved after the project. However, the proposed projects need a long time fund and specialized facilities.

There are a few studies on the organization of project-based teaching in Mathematics subjects such as Probability- Statistics or

Advanced Geometry. These studies have set out a number of requirements and criteria for applying project-based teaching; determined the contents, topics and implementation processes; evaluated the effectiveness; and at the same time developed a number of projects to implement in the subject. However, these studies have not clarified the difference in the organization of learning Mathematics compared with other subjects as well as the factors affecting the project-based teaching process in Mathematics for students.

To meet the urgent requirements of education and training reform, first of all, teaching methods must be renewed. With the outcome standards in each subject determined by the content of knowledge, skills and attitudes, project-based teaching has many advantages over other forms of teaching organization although there are still certain difficulties such as short course duration, large content, large class size or lack of facilities. At universities that train engineering students, a great advantage is that students have access to a lot of real-life problems and require solving those problems from life. Due to the characteristics of project-based teaching and the requirements for standard outcomes for students, we find that if we choose appropriate topics and provide a reasonable process to organize project-based teaching for students in advanced mathematics, there will be great significance and effect. However, up to now, there have been no research on theory as well as practice and implementation of project-based teaching in advanced mathematics for university students of engineering in a complete way. The factors affecting the organization of project-based teaching in advanced mathematics for university students of engineering have not been mentioned in any research. Therefore, we want to clarify those issues in this study.

1.2. Theoretical foundations of project-based teaching

The thesis studies the issues of project-based teaching, including:

- The concepts of project and learning project. The author of the thesis believes that *a project is a plan to achieve a*

predetermined goal, implemented in certain conditions, limited by time, human and material resources.

A learning project is a project under the guidance of a teacher, where learners actively perform complex learning tasks to create recommendable products.

- The concept of project-based teaching: It can be said that *project-based teaching is an active form of teaching; under the guidance of the teacher, learners perform complex learning tasks that link theory with practice, with self-discipline and initiative from setting goals, planning for implementation, testing, assessing and introducing products. In the process, learners experience and develop basic personal competencies.*

- Characteristics of project-based teaching

The characteristics of project-based teaching can be summarized as follows:

- Learner-centered;

- Practice-oriented;

- Promote self-discipline, self-reliance and sense of responsibility of learners;

- Excite learners with real-life situations;

- Product-oriented;

- Information technology-oriented;

- Improve soft skills;

- Learning in an open environment;

- Orientation to develop skills, core competencies and professional competencies.

- Classification of learning projects that can apply project-based teaching

According to previous research, there are several classifications as follows:

- Classification by time budget.

- Classification by project content and tasks.

+ Survey project: is a project to survey the actual status of the object

+ Research project: is a project aimed at solving problems, explaining phenomena and processes.

+ Practice project: is a project that focuses on creating physical products or performing practical activities to perform social tasks.

In addition, there can be mixed projects that combine the content of the above projects, or interdisciplinary projects that combine different subjects or modules.

- Process of project-based teaching

Project-based teaching is a teaching method, so project-based teaching is a teaching process, and it must be based on teaching theory; At the same time, it is a learning project, so it should be based on the structure of the overall project implementation progress.

With the view that students are the subject of project-based teaching, the author believes that the four-stage process of project-based teaching in advanced mathematics for engineering students is appropriate.

Phase 1: Build the project

Stage 2: Make an implementation plan

Stage 3: Project implementation

Stage 4: Presentation of results and evaluation

- Evaluation in project-based teaching

Evaluation in project-based teaching is the task not only of teachers but also of students. This is the peer review process. For students, the assessment process includes self-assessment and peer-assessment. For lecturers, assessment aims to guide students' activities, edit and improve the process of organizing learning projects, and report on students' learning outcomes. In order to develop skills and competencies for students, the design of assessment processes and tools must be appropriate to confirm the positive impact and effectiveness of project-based teaching. The assessment must take place regularly and include a summative assessment of the student's project-based learning.

- Advantages and challenges of project-based teaching in advanced mathematics for university students of engineering

**** Advantages:***

- Meet the requirements set forth for education, which is linking theory with practice, university with society, learning with practice;

- Project-based teaching enables teachers to combine different teaching methods, and at the same time facilitate a variety of learning styles of students.

- Project-based teaching establishes the connection between real life in the society and the lesson, relating the lesson to the real world

- For students, project-based teaching helps them increase motivation and interest in learning and promote self-reliance and responsibility for work.

- Project-based teaching helps students develop basic skills and competencies such as problem solving, evaluation, communication, teamwork, presentation, planning, compromise...

- Project-based teaching also helps students develop and perfect life skills that are difficult for students to access and practice with traditional teaching methods.

- One of the outstanding advantages of project-based teaching is to associate advanced mathematics with vocational fields, and to develop professional competence through practical situations.

**** Challenges:***

- Each learning project needs a time fund, so not every lesson and every content is effectively project-based.

- It is difficult to change the perception of lecturers from traditional teaching methods to project-based teaching.

- Students are familiar with the teaching form of presentation in high school; therefore, they are still passive in absorbing new knowledge, and reluctant to invest time to research and explore the content of the lesson.

- Because project-based teaching involves practical activities, it is necessary to have physical and financial facilities for implementation.

- Because advanced mathematics is usually taught in the first and second years of university, students have not learned a lot of specialized knowledge and professional skills.

1.3. The current status of applying project-based teaching in advanced mathematics for university students of engineering

1.3.1. Analysis of some factors affecting project-based teaching

When studying the components of the teaching process, we pay much attention to the four main components: teaching objectives, teaching content, teaching methods and forms, and assessment. The above factors influence each other and interact closely with each other through factors such as teachers, learners and learning environment. In this study, we focus on a number of factors affecting project-based teaching such as objectives, learning outcomes of subjects and disciplines; subject content; the influence of the teacher; learners and environmental factors.

1.3.1.1.Analysis of training goals

a. Analysis of goals by training majors

b. Analysis of training goals of advanced mathematics

The goals of advanced mathematics training is not separate from the general training goals for students. The goals of advanced mathematics training in engineering universities can be summarized in the table below:

Goals	**Description of the goal**
G1	Master knowledge, basic concepts, and contents of problem solving methods
G2	Be able to analyze and select appropriate methods for specific problems
G3	Be able to work as a team member, communicate and present effectively
G4	Be able to apply knowledge in specific technical problems.

Thus, it can be seen that the goals of advanced mathematics are not only to equip students with pure scientific knowledge, but also to

direct students to use mathematical knowledge as a tool to solve technical problems related to the field of study. Through that teaching process, students' analytical and synthesis skills, communication skills, presentation skills, teamwork skills, etc., are developed and enhanced.

1.3.1.2. Analysis of outcome standards

a. Analysis of outcome standards by technical majors

Through studies on the outcome standards of universities that train engineering, we find that although the outcome standards of the above disciplines have different forms, in general, the outcome standards are assessed through knowledge, skills, competencies, and attitudes.

b. Analyze the outcome standards of some advanced mathematics courses

1.3.1.3. Analysis of the content of advanced mathematics taught to university students of engineering

We are interested in and researched on the contents of the courses organized by many universities to teach students of engineering. Comparing the math curriculum of the universities above, we found that the math contents that these universities teach students:

- Consistent and highly focused on teaching contents; the difference in the curriculum is very little.

- There are a few universities that do not teach topics such as systems of differential equations, Z transformations, series of complex functions. However, this does not affect the logic, the science, the system and the basic knowledge of mathematics. Such content is only necessary for a few majors that those universities do not offer.

1.3.1.4. Analysis of teacher factors

The motivation of the teacher is a factor that greatly influences the teaching process. In the process of project-based teaching, the

lecturer does not play the role of the subject; instead, he/she directs and organizes knowledge acquisition activities for students. We found that:

- Lecturers still use many traditional methods such as presentation and conversation.

- Project-based teaching is rarely organized; however, some forms of teaching activities of project-based teaching are still implemented such as group teaching, discovery and problem solving, but at an irregular and continuous level. Forms of organizing such activities take place individually, not as a system of connecting activities in each specific lesson.

- Most of the lecturers realize that choosing the right teaching method has a great influence on the quality of training.

- The lecturers highly appreciate measures such as motivating students to learn, paying attention to the lesson content, or diversifying exercises.

- The lecturers have applied measures towards the goal of studying advanced mathematics, which is to apply mathematical knowledge in solving real-life problems.

1.3.1.5. Analysis of learner factors

- Engineering students are those who are 18 years old or older, so they have relatively adequate physical, health and intellectual development to study; have enough knowledge, awareness and competence to participate in learning activities, as well as the competence to evaluate, self-assess and adjust thinking and activities to suit new circumstances.

- When entering university, engineering students have good or higher grades; their competence to perceive and absorb knowledge quickly, especially subjects in the natural and technical fields.

- Engineering students are mostly male, generally healthy, prefer to exercise and participate in practical activities.

- Engineering students are dynamic and love to explore and learn new things. Students in general also have this trait, but it is more prominent in engineering students.

- In terms of cognition, engineering students have quick cognitive competence, logical thinking competence, creativity, and high independence. The thinking of engineering students is often creative, less moldy and mechanical.

Especially, engineering students have technical thinking.

- The problems that engineering students are interested in or related to the lecture often stem from practice or practical problems that need to be solved.

1.3.1.6. Analysis of environmental factors

The environment has a significant impact on the process of project-based teaching. Several factors which directly influence the process of project-based teaching include course length, class size and facilities. The university can completely overcome, build and create the most favorable environment for lecturers and students to organize learning projects well.

1.3.2. Investigate the application of project-based teaching method in advanced mathematics for university students of engineering

1.3.2.1. Purpose

Find out the awareness and understanding of lecturers and students about project-based teaching, the obstacles in organizing project-based teaching and the current situation of teaching advanced mathematics to university students of engineering.

The survey results are the basis for proposing measures to organize project-based teaching activities in advanced mathematics in order to improve teaching quality and best meet the outcome standards of university students of engineering.

1.3.2.2. Survey respondents

Lecturers teaching advanced mathematics and students at some engineering universities.

+ Lecturers: We distributed 70 questionnaires to lecturers and collected 58 answer sheets.

+ Students: We randomly surveyed 236 students studying in the 3rd year of engineering major at Hanoi University of Industry, University of Electricity, University of Mining and Geology, University of Water Resources, University of Transport.

1.3.2.3. Survey tasks

- Investigate the teaching methods being implemented in some universities in teaching advanced mathematics.

- Investigate lecturers' perceptions and awareness of innovation in teaching methods towards competence development for students.

- Investigate a number of measures to organize learning activities towards the development of competencies and meet the outcome standards of students.

- Investigate difficulties when organizing project-based teaching.

1.3.2.4. Survey methods

+ Statistics, analysis

1.3.2.6. Evaluate survey results

- Teaching methods are mainly traditional methods; lecturers mainly use presentation and conversation methods.

There are two main reasons for this: large class size and limited time for the lesson, so it is difficult for teachers to organize active teaching methods.

- Lecturers also want to change to the active teaching method but they have no specific directions.

- Lecturers highly appreciate the active participation of students in the lecture.

- Some activities while teaching the subject such as dividing students into groups, asking students to present their ideas, self-

assessment and peer-assessment, presenting results are used by lecturers, but not regularly.

- Understanding and interest in project-based teaching is limited. Most of the lecturers believe that the conditions of implementation and the way of organization are the most difficult stages in project-based teaching.

- Although they do not understand much about project-based teaching, in their lectures, the lecturers have initially made innovations in teaching methods. Some contents of project-based teaching such as students presenting problems related to the lesson, grouping, self-assessment and evaluating results are organized by lecturers but they are neither organized continuously and regularly nor included in a specific teaching project.

Thus, project-based teaching has not been implemented regularly in teaching advanced mathematics for university students of engineering.

From the above survey results, it can be seen that if lecturers have a good understanding of project-based teaching, choose appropriate learning projects, and build a reasonable and scientific implementation process and plan, they can organize project-based teaching for advanced mathematics and contribute to the development of skills and competencies, meeting the outcome standards for engineering students in universities.

1.4. Summary

Project-based teaching stems from learning projects, is a teaching method that puts learners at the center of the teaching process, and has the orientation to best develop the competencies of learners. With characteristics such as practice-oriented, product-oriented, and oriented to develop core competencies and career competencies, project-based teaching also excites learners because of practical situations, which promote self-discipline, self-reliance and

sense of responsibility of learners, helping them perfect soft skills and develop their own competence.

In the process of implementing a learning project at university, students are always proactive in absorbing new knowledge, from project formulation, project implementation planning to implementation, evaluation, and report. Students' autonomy, independence, creativity and competence to work in groups as well as communication, presentation and evaluation skills are enhanced.

The survey results have shown the reality of organizing learning and organizing activities to innovate teaching methods as well as difficulties encountered in the implementation process.

In the context of fundamental and comprehensive educational innovation, orientation to develop learners' competencies and take learners as the center, project-based teaching in universities has many opportunities for implementation and development. Although there are still difficulties and challenges when organizing project-based teaching, these difficulties can be overcome if we can select appropriate topics and bulid a project-based teaching process which is reasonable, scientific and consistent with educational principles, suitable for students and practical situations.

Chapter 2
ORGANIZATION OF PROJECT-BASED TEACHING IN ADVANCED MATHEMATICS FOR UNIVERSITY STUDENTS OF ENGINEERING

In order to effectively organize project-based teaching in advanced mathematics for engineering students, on the basis of the analysis and survey results of Chapter 1, lecturers need to be equipped with a system of theoretical basis for project-based teaching, especially in terms of choosing topics and building appropriate project-based teaching process.

2.1. Some orientations for organizing project-based teaching

2.1.1. The content of knowledge in the lesson need to link theory with practice and reveals problematic situations

2.1.2. Ensuring appropriateness

2.1.3. Topics need to integrate knowledge of many subjects and fields of science

2.1.4. Products need to be technical and technological

2.2. Organize project-based teaching activities in advanced mathematics for university students of engineering

2.2.1. The process of organizing project-based teaching in advanced mathematics for university students in engineering

The teaching process of advanced mathematics must ensure the general process of project-based teaching, show inheritance and development, ensure scientific and pedagogical characteristics, and at the same time have the specificity of the subject, the flexibility and creativity applied in specific cases.

Phase 1: Build the project

Step 1: Identify the topic and project name

Step 2: Discuss and define project goals

Step 3: Divide groups and assign tasks to each group

Stage 2: Make an implementation plan

Step 4: Determine the work, tasks and time to perform among the group

Stage 3: Implement the project

Step 5: Build a theoretical system

Step 6: Finalize the product of the project

Stage 4: Present and evaluate the results

Step 7: Students present their results

Step 8: Students comment and evaluate the results

Step 9: Lecturer makes comments, evaluation and conclusion

2.2.2. List of learning projects that can be organized for project-based teaching in advanced mathematics for students of engineering

a) Project-based teaching topics approaching knowledge content

In these projects, topics are built according to each content and each knowledge circuit in the program. These learning projects have a tendency to form new knowledge. The project product is a system of theory, formulas, and mathematical results according to those

contents. These products can be considered as tools to implement other more extensive projects. Simultaneously with grasping the necessary mathematical content, through activities when implementing learning projects, students will form and perfect skills, develop core competencies and professional competencies.

We recommend the following learning projects:

1) Design a traffic signal light board

2) Apply a system of linear equations

3) Apply quadratic form in optimization and extremum problems

4) The derivative of a function of a single variable

5) Integral and its application

6) Study the structure and production costs of enterprises

7) Determine the volume, surface area, center of gravity and mass of the object

8) Some applications of differential equations

b) Project-based teaching topics aim at completion and consolidation of knowledge

When implementing these projects, in addition to the product being a mathematical theory system, students also have to enter workshops and laboratories to design and manufacture products that can be physically grasped. We recommend the following learning projects:

1) Signal conversion in ICs (advanced mathematics knowledge: Fourier transform, inverse transformation)

2) Robot control design (advanced mathematics knowledge: Laplace transform).

2.3. Some recommendations when implementing project-based teaching in advanced mathematics to develop skills for university students of engineering

2.3.1. The lecture provides sufficient basic knowledge of advanced mathematics to fully meet the goals and outcome standards

2.3.2. The problems and situations in the lecture need to demonstrate the connection of advanced mathematics with specialized subjects and with basic science subjects

2.3.3. The problems and situations in the lecture need to create excitement and motivation for students to participate in learning projects

2.3.4. Encourage and create conditions for students to use information technology applications in learning activities

2.3.5. Coordinate with other departments and faculties to create conditions for facilities, factories, and laboratories for students to complete the project's products.

2.3.6. Compile coursebooks and develop curricula suitable with the training profession in a career-oriented approach

2.4. Summary

We studied the factors that affect the project-based teaching process, through which we know which factors have positive or negative influences and which factors affect more or less to take measures and organize the implementation of project-based teaching with high efficiency.

Based on the characteristics of project-based teaching, the characteristics of advanced mathematics and the characteristics of students in the engineering sector, the criteria for selecting teaching topics which we have developed are appropriate. At the same time, the process of organizing project-based teaching in advanced mathematics for university students of engineering that we have proposed consists of 4 stages divided into 9 steps. With this process, students can master the knowledge; develop and perfect skills; adopt a better attitude and sense of responsibility in learning and life; achieve the objectives, requirements, and learning outcomes of the course. We have given 2 examples to illustrate the above process.

The proposed learning projects meet the selection criteria, which can maximize the advantages of the project-based teaching method.

Chapter 3: PEDAGOGICAL EXPERIMENT

3.1. Experiment purpose

The pedagogical experiment aims to test the appropriateness of the scientific hypothesis that has been set out in the thesis, and at the same time to demonstrate the feasibility and effectiveness of applying principles, processes as well as organization of project-based teaching in advanced mathematics for engineering students by answering the following questions:

(1) Are the proposed project-based teaching principles and procedures appropriate and effective?

(2) Do the lecturers design and organize their lectures according to the proposed direction?

(3) Does the proposed procedure of organizing project-based teaching have a positive effect on the students' acquisition of the required knowledge? Is it really possible to form and develop some skills through teaching advanced math?

The pedagogical experiment needs to ensures objectivity and relevance to the object and reality of the process of organizing project-based teaching in universities.

3.2. Experiment contents

The contents of the pedagogical experiment were conducted in 2 phases:

3.3. Experiment participants

The pedagogical experiment was carried out in 09 classes at Hanoi University of Industry. Based on the university entrance scores and the results of the previous semesters, we found that the experimental and control classes had relatively equal knowledge levels and similar learning results. The teaching staff participating in the experimental and control classes all have master's and doctoral

degrees, have many years of teaching experience, are experienced in organizing teaching activities, and are interested in changing and search for new teaching methods.

3.4. Experiment organization

3.4.1. Experiment procedure

After selecting experimental and control classes, we organize a pedagogical experiment including the following steps:

a) Training for trainers

b) Survey students in experimental and control classes

c) Organize experimental teaching

d) Evaluate experiment results

3.4.2. Methods of evaluating the results of the pedagogical experiment

3.4.2.1. Evaluation criteria

For students:

- Mathematical knowledge acquired by students through learning projects.

- Competence to apply mathematical knowledge to solve practical problems

- The interest and positive attitude of students in the process of implementing the learning project.

- Some skills gained by students such as teamwork skills, assessment skills, connection skills, mathematical modeling skills, skills of applying mathematics to practice, and time management skills, etc.

For lecturers:

- Skills of designing and organizing project-based teaching in advanced mathematics for engineering students.

- Lecturers' interest in designing and organizing learning projects.

3.4.3.2. Tools to evaluate the results of the pedagogical experiment

a) Written test

b) Evaluation sheet for students

c) Evaluation sheet for lecturers

d) Classroom observation

e) Interview

f) Mathematical statistics

3.5. Results of the pedagogical experiment

3.6. Summary of chapter 3

Chapter 3 presents the issues of organizing the pedagogical experiment in order to clarify the scientific hypothesis of the thesis with such contents as: purpose, contents, participants, methods of organization and evaluation of the experiment results. Analysis of the pedagogical experiment results shows that the scientific hypothesis has been accepted; the learning projects selected for the experiment are appropriate and well-grounded; and the project-based teaching process proposed for teaching advanced mathematics to university students of engineering is feasible and effective.

CONCLUSION

The thesis has investigated the reality of organizing learning and organizing activities to innovate teaching methods as well as the difficulties encountered in the implementation process. With the characteristics of engineering students, the characteristics of the project-based teaching method and the requirements of the outcome standards, the thesis has demonstrated that the project-based teaching method is very suitable for teaching advanced mathematics for engineering students in universities.

The thesis has also identified the factors that have an impact on the project-based teaching process. Thereby we know which factors

have positive or negative influences and which factors affect more or less so that we can take measures to organize the implementation of project-based teaching with high efficiency.

In teaching advanced mathematics at universities, project-based teaching is not intended to completely replace other forms of teaching. Project-based teaching is really effective when choosing the right topics, content and scientific process. The thesis has set out the criteria for choosing a project-based teaching topic, and at the same time provided a process for organizing project-based teaching in advanced mathematics for university students of engineering with the desire to help students master knowledge; develop and perfect skills; have a better attitude and sense of responsibility in learning and life; achieve the objectives, requirements, and learning outcomes of the course. The thesis has given two examples to illustrate the above process and proposed a number of learning projects that meet the selection criteria and maximize the advantages of the project-based teaching method.

The pedagogical experiment in chapter 3 aims to clarify the scientific hypothesis of the thesis with such issues as purpose, contents, participants, methods of organization and evaluation of the pedagogical experiment results. Based on the pedagogical experiment results, the researcher believes that the scientific hypothesis has been accepted. The grounds for choosing a learning project are reasonable, and the proposed process of project-based teaching in advanced mathematics for engineering students is feasible and effective.