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APPLYING THE 5E CONSTRUCTIVIST CYCLE TO TEACHING SOME MATHEMATICS TOPICS TO THE STUDENTS AT THE COLLEGES OF ECONOMICS AND TECHNIQUES

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DISSERTATION SUMMARY

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The dissertation can be read at:

- National library of Vietnam;
- Thai Nguyen University - Learning Resource Center;
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PUBLISHED RESEARCHES

I. Scientific articles

1. (2014), "The situation of testing and assessing the study outcomes of the study unit of advanced mathematics at College of Economics and Techniques, Thai Nguyen University", *Journal of Science & Technology*, Thai Nguyen University, No. 06/2014, pages 193-195.
2. (2014), "Assessing the self-study ability in statistical probability among the students of College of Economics and Techniques, Thai Nguyen University", *Journal of Education*, Ministry of Education and Training, special issue, No. 6/2014, pages 198-200.
3. (2015), "Teaching the study unit of statistical probability in the 5E model to the students of College of Economics and Techniques, Thai Nguyen University", *Journal of Educational Science*, Institute of Educational Science, Ministry of Education and Training, special issue, No. 4/2015, pages 65-67.
4. (2016), "Organizing exploratory teaching in advanced mathematics to the students of College of Economics and Techniques, Thai Nguyen University, *Journal of Education*, Ministry of Education and Training, No. 379-04/1016, pages 47-49.
5. (2017), "Some measures to contribute to improving the teaching quality of statistical probability through testing and assessing the study outcomes of the students of College of Economics and Techniques, Thai Nguyen University", *Journal of Educational Management*, Educational Management Institute, No. 11-11/2017, pages 112-118.
6. (2018), "Combining the 5E teaching model with active teaching methods in teaching advanced mathematics to college students", *Journal of Educational Science*, Institute of Educational Science, Ministry of Education & Training No. 01/2018, pages 68-70.
7. (2020), "The methods of teaching some mathematics topics to the students of the colleges of economics and techniques in the 5E constructivist teaching cycle", *Journal of Educational Management*, Institute of Educational Management, No. 12-02/2020, pages 45-50.

II. Scientific researches

1. Head of the institutional research (2014), *"Promoting the active teaching methods in teaching the situations of solving the exercise problems in statistical probability theory to the students of College of Economics and Techniques",* College of Economics and Techniques, Thai Nguyen University.
2. Head of Thai Nguyen University research (2017-2018), *"Applying the 5E constructivist cycle to teaching some mathematics topics to improve problem solving capacity for the students of colleges of economics and Techniques in Thai Nguyen Province",* Thai Nguyen University.

INTRODUCTION

1. Rationle

The author of the dissertation chose the topic from the following reasons:

(1) from the vocational training targets at the colleges of economics and techniques in Vietnam

(2) from the practical training at the colleges that have not met the new socio-economic requirements

(3) from the role of advanced mathematics (AM) knowledge and statistical probability (SP) for the later career of the students at the colleges of economics and techniques

(4) from several research results and application of the 5E teaching cycle in the world and Vietnam.

2. Research purposes

The dissertation proposes the pedagogical measures to teach some mathematics topics to the students at the colleges of economics and techniques in the 5E constructivist cycle to support them in building knowledge, relating knowledge to professional reality, thereby contributing to innovating teaching methods and improving training quality,

3. Research mission

The dissertation needs to answer the following research questions:

- How does an overview of the related researches relate to the dissertation topic in general and the 5E teaching cycle in particular?

- What's inadequate in teaching some mathematics topics in some colleges of economics and techniques to clarify the reason that some mathematics topics can be taught to the students at the colleges of economics and techniques in the 5E teaching cycle?

- What are the methods of teaching a number of contents of advanced mathematics and statistical probability to the students at the colleges of economics and techniques in the 5E teaching cycle?

- Are the proposed measures feasible and efficient?

4. The subject and object of the research

- The subject of the research is the teaching measures of some mathematics topics to the students at the colleges of economics and techniques in the 5E constructivist cycle.

- The object of the research is the process of teaching some mathematics topics to the students at the colleges of economics and techniques in the 5E constructivist cycle.

- The scope of the research is teaching some mathematics topics to the students at the colleges of economics and techniques in the 5E constructivist cycle.

5. Scientific hypothesis

If the measures are taken to teach some mathematics topics to the students at the colleges of economics and techniques in the 5E constructivist cycle as proposed in the dissertation, they will help the students build their knowledge and relate that knowledge to their career and learn these topics better.

6. Research methodology

The dissertation used the following research methods: Theoretical research method, methods of survey questionnaire and observation, practical research method, expert consultaion method and experimental method in pedagogy.

7. The contributions of the dissertation

7.1. Contribution to theory

The dissertation contributes to theory:

- an overview of theory and research results on the constructivist teaching and 5E teaching cycle

- clarifying how to apply the 5E constructivist cycle to teaching a number of topics of advanced mathematics and statistical probability to the students at the colleges of economics and techniques to help them build knowledge and relate that knowledge to career.

7.2. Contribution to practice

The dissertation helps the lecturers innovate the methods of teaching advanced mathematics and statistical probability at the colleges of economics and techniques, contributing to improving the quality of training at the colleges of economics and techniques.

8. Issues to be defended

The issues to be defended are:

- Teaching some mathematics topics at the colleges of economics and techniques in the **5E constructivist cycle** is necessary on theoretical and practical basis.

- The proposed teaching methods for some mathematics topics in the 5E constructivist cycle have helped the students build knowledge, relate that knowledge to career, contributing to improving the quality of training at the colleges of economics and techniques.

9. The Structure of the dissertation

The dissertation includes 3 chapters between the introduction and conclusion:

Chapter 1: Theoretical and practical basis

Chapter 2: The methods of teaching some mathematics topics to the students at the colleges of economics and techniques in the 5E constructivist cycle

Chapter 3: Pedagogical experimenting

Chapter 1. THEORETICAL AND PRACTICAL BASIS

1.1. An overview of the research problem

1.1.1. An overview of the foreign researches on constructivist theory and the 5E teaching cycle

Around 1987, Rodger W. Bybee and his associates working in the Biological Sciences Curriculum Study (BSCS) based in Colorado (USA), proposed the 5E teaching model. This model is based on the constructivism in learning. Therefore, before reviewing the researches on the 5E teaching cycle, it is crucial to include the studies on the constructivist theory.

1.1.1.1. A research overview of the foreign constructivist theory teaching

The constructivist theory has been built and synthesized from previous learning theories: Theory of the Near Development Area of L.X. Vygotsky (1896-1934) and Jean Piaget's Theory of Cognitive Generations (1896-1983). Our research in this work is also based on the above arguments, with a 'learner-centered' perspective.

1.1.1.2. An overview of the researches on the overseas 5E teaching cycle

In the world there are many studies on the 5E teaching cycle under many different names, for example, the 5E instructional model (Bybee R. W., 2014), the 5E learning cycle model (Campbell M. A., 2000) and (Ceylan E. & Geban O., 2009), the 5E mobile inquiry learning approach (Cheng P., Yang Y. C., Chang S. H. & Kuo F. R., 2016), the 5E learning cycle instruction (Kaynar D., Tekkaya C. & Çakıroğlu J., 2009), etc.

In this dissertation, we use the term '5E constructivist cycle' to emphasize the knowledge-building activities of students in applying the 5E teaching cycle. The learning process is an ongoing process, ending the process with a learning content is the beginning of a new process with a new learning content. The use of the term 5E constructivist cycle instead of the 5E teaching cycle is to clarify the foundations of the 5E cycle (based on the constructivist theory) and also to show the development of the dissertation in applying the research results to teaching advanced mathematics and statistical probability to the students at the colleges of economics and techniques.

1.1.2. An overview of the domestic researches on applying the constructivist theory and 5E cycle in teaching

1.1.2.1. The researches on applying the constructivist theory in teaching

In Vietnam, the researches and applications of the constructivist theory can be mentioned as the works of Tran Ba Hoanh (2002), Nguyen Ba Kim (2002, 2004, 2017), Nguyen Huu Chau (2004), Bui Van Nghi (2009, 2017), Dao Tam (2008), Do Tien Dat (2005), Cao Thi Ha (2006) and Nguyen Danh Nam (2018), etc.

1.1.2.2. A research overview of the 5E teaching cycle in Vietnam

Some domestic authors have researched and learned about the 5E teaching cycle, such as Phan Thi Bich Dao and Vu Thi Minh Nguyet (2016), Duong Giang Thien Huong (2017), Ngo Thi Phuong (2019), Tran Ba Hoanh (2002), etc. It can be seen that the domestic and overseas studies all focus on high-school students, but few published results have been conducted on the application of the 5E teaching cycle to professional students, especially in teaching mathematics at universities and colleges.

1.2. The constructivist theory and 5E teaching cycle

1.2.1. The constructivist theory

The formation of the constructivist theory continued the works of John Dewey (1958), Jean Piaget (1896-1983), Vygotsky L.X. (1896-1934) and David Kolb (1975).

1.2.2. The concepts of constructivist teaching

According to Piaget J. (2001), the learners' cognitive process is essentially the process of building their own knowledge through assimilation and adaptation of existing knowledge and skills to adapt to a new learning environment.

1.3.1. The formation and development of the 5E teaching cycle

In the 1960s, in the project 'Science Curriculum Improvement Study' (SCIS), Myron Atkin and Robert Karplus proposed a three-step model: Exploration, Invention and Discovery. Then, in the 1980s, in the project 'Biological Sciene Curriculum Study' (BSCS), Bybee's team continued the learning cycle of Atkin and Karplus (1962), adding a first step designed to derive from old knowledge, stimulate and motivate learners, and the last step to assess their understanding into a five-step model: Engage, Explore, Explain, Elaborate, Evaluate.

1.3.2. The relationship between the constructivist theory and 5E teaching cycle

According to David Kolb, "learning is a process in which knowledge is constructed through the transformation of experience". The result of knowledge is the combination of grasping experience and transforming it.

The 5E learning cycle is a learning cycle that defines the learning process based on John Dewey's philosophy of experiential learning and David Kolb's proposed experiential learning cycle. Therefore, we can say that the 5E teaching cycle is based on the cognitive constructivist theory. The learning process is an ongoing process, ending it as the beginning of a new process with a new learning content.

The five steps of the 5E teaching cycle concretize the path of forming new knowledge of learners in constructivist theory, because the cycle starts from existing knowledge, linking with new ideas, gradually forming new

knowledge. Thus, knowledge comes to learners not 'from the sky' but 'naturally'. Learners understand where this knowledge comes from, what this knowledge relates to and can be applied to their professional practice.

1.3.3. The steps of the 5E constructivist cycle

The first step: Engage
The second step: Explore
The third step: Explain
The fourth step: Elaborate
The fifth step: Evaluate

It is possible to compare in summary the presentation teaching method of lectures and the teaching method in the 5E teching cycle in opening the lesson in the topic 'Matrix - Determinants - System of Linear Equations' the at colleges of economics and techniques as follows:

Presentation teaching method	**5E constructivist cycle teaching method**
1. Matrix A matrix is a table of the following form: $\begin{pmatrix} a_{11} & a_{12} & \dots a_{1n} \\ a_{21} & a_{22} & \dots a_{2n} \\ \dots\dots & \dots\dots & \dots\dots \\ a_{n1} & a_{n2} & \dots a_{nn} \end{pmatrix}$ For example: … 2. Matrix operations: a) Matrix addition $(a_{ij})_{m.n} + (b_{ij})_{m.n} = (a_{ij} + b_{ij})_{m.n}$ For example:… b) Matrix multiplication If $A = (a_{ij})_{m \times p}$; $B = (b_{ij})_{p \times n}$, then the product AB is the matrix $C = (c_{ij})_{m \times n}$ where, the element cij is identified by the formula $c_{ij} = \sum_{k=1}^{p} a_{ik} b_{kj}$. The rule of multiplying two matrices: Multiply each term in the ith row of	*Step 1: Engage* Teacher: At high school, you learned how to solve the system of first order equations with two unknowns and three unknowns. So tell me how to solve the first order n-unknown equation system as below? $\begin{cases} a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n = b_1 \\ a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n = b_2 \\ \dots\dots\dots\dots\dots\dots \\ a_{n1}x_1 + a_{n2}x_2 + \dots + a_{nn}x_n = b_n \end{cases}$. (*) *Step 2: Explore* Teacher: To avoid having to write 'unknowns over and over', people have devised a way to write 'simpler' system (*) in the form of the equation AX = B, in which: $A = \begin{pmatrix} a_{11} & a_{12} & \dots a_{1n} \\ a_{21} & a_{22} & \dots a_{2n} \\ \dots\dots & \dots\dots & \\ a_{n1} & a_{n2} & \dots a_{nn} \end{pmatrix}, X = \begin{pmatrix} x_1 \\ x_2 \\ \dots \\ x_n \end{pmatrix}, B = \begin{pmatrix} b_1 \\ b_2 \\ \dots \\ b_n \end{pmatrix}$ are called matrices. Please apply the above writing to the

Presentation teaching method	**5E constructivist cycle teaching method**
A by each term in the jth column of B, then add the result. For example: … 3. Note - The condition for two matrices to add together is that they have the same number of rows and the same number of columns. - The condition for two matrices to be multiplied is that the number of columns of the first matrix is equal to the number of rows from the second matrix.	systems of the quadratic unknowns and triple unknowns. From there please suggest a way of understanding: - What is the matrix? - How to multiply two matrices A and X - How to identify two matrices AX and B? Student(s): ....
	Step 3: Explain Teacher: Please explain your suggestions to answer the questions above. Student(s): ….
	Step 4: Elaborate Teacher: What are the conditions for the two matrices to be added and multiplied? Student(s): .... Teacher: Consider a practical issue: A gas station sells 3 types of gasoline. Table a shows the amount of gasoline sold in 2 days, table b shows the selling price for each liter of gasoline under the new management (see details in example 1.4 above). Please arrange the assumptions of the problem as follows, complete the result table of multiplying two matrices and answer: $\begin{pmatrix} 1500 & 750 & 400 \\ 2100 & 600 & 515 \end{pmatrix}\begin{pmatrix} 16032 & 373 \\ 15339 & 571 \\ 11119 & 865 \end{pmatrix} = \begin{pmatrix} \cdots\cdots & \cdots\cdots \\ \cdots\cdots & \cdots\cdots \end{pmatrix}$
	Step 5: Evaluate See example 1.5 above

Comment: The above comparison table shows that instead of teaching in explanatory presentations to make learners completely passively absorb knowledge, teaching in the 5E teaching cycle attracts learners to participate in the process of self-building knowledge. The 5E teaching cycle was developed on the basis of connecting previous teaching models with the results in teaching practice. The 5E teaching cycle will create an environment for learners to create knowledge. The above illustrations clearly show the opportunities for students to construct new knowledge and express their own thoughts. On the basis of accumulated knowledge, students discover and construct new knowledge step by step.

1.4. The mathematics topics taught at the colleges of economics and techniques

1.4.1. An overview of the training objectives and curriculum of the colleges of economics and techniques

The training programs of the colleges of economics and techniques were compiled and approved in the Circular No. 03/2017/ TT-BLDTBXH dated February 1, 2017 of the Ministry of Labor, Invalids and Social Affairs of Vietnam.

1.4.2. The objectives and contents of advanced mathematics and statistical probability in the training program of the colleges of economics and techniques

The objectives of the advanced mathematics module taught at the colleges of economics and techniques are:

- equipping the students with the system of basic concepts, such as matrix, determinant, system of linear equations, continuity, limit of functions, derivative, differential, integral, two-layer integral and linear integrating

- practising the solving skills in determinant, matrix grade, system of linear equations, derivative, limit of indeterminate form, two-layer integral, integral line

The goals of the statistical probability module are:

- equipping the students with the most fundamental knowledge of probability theory and statistics, rendering them to see the role and wide applications of probability theory and statistics in natural sciences

- helping the students intuitively form probability and statistical thinking, knowing how to use mathematical tools and critical mathematical reasoning to solve the problems of probability and statistics.

1.4. The reality of teaching and learning mathematics at colleges of economics and techniques

1.4.1. Survey objectives

The survey aims at clarifying the status of teaching advanced mathematics and statistical probability in the 5E constructivist cycle in some colleges of economics and techniques.

1.4.2. Survey objects and survey time

We have surveyed 32 teachers and 628 students at 5 colleges of economics and techniques. They are College of Economics and Techniques, Thai Nguyen University (TNU-College of Economics and Techniques), Vinh Phuc College of Economics and Techniques, Hanoi College of Economics and Techniques, Hung Yen College of Economics and Techniques, Thai Nguyen College of Economics, Finance and Technology. The survey time was from October 2015 to February 2016.

1.4.3. Survey methods and results

The methods of observation and questionnaires were used.

Following is the general assessment of the results of surveying the situation of advanced mathematics teaching and learning and statistical probability at many colleges of economics and techniques.

In general, the teachers' teaching methods are mainly presentations and lectures. In the teaching process, the teachers did not really pay attention to creating conditions for the students to participate in the activities of discovering knowledge, proposing solutions to solving problems, not paying attention to the students explaining their own ideas.

The results of learning advanced mathematics and statistical probability at the colleges of economics and techniques were generally not high. The first reason was the students' lack of self-awareness and active learning; the other reason was that the teacher didn't attract the students to the lessons, not making the lessons more attractive, not linking the lesson contents with the practical professions after the students' graduation.

Summary of chapter 1

(1) The basic of the constructivist theory is the learner's perception process which is essentially the process of building self-knowledge by themselves. Knowledge is not absorbed passively, but actively acquired by the learner.

The 5E constructivist cycle concretizes the cognitive path in the constructivist theory, which is the application of the constructivist theory in teaching.

Although there are many ways to present the 5E cycle, all agree on the five basic steps: First, teachers introduce, attract, raise problems. Next, students propose, explore problems and explain those ideas. Then the teacher validates knowledge, skills and instructs students to apply and elaborate the problem. Finally, it is evaluating and drawing from the experience on how to achieve results.

(2) Advanced mathematics and statistical probability modules at the colleges of economics and techniques have the role of providing knowledge and mathematical tools for learning professional knowledge among students.

However, the reality shows that the teaching of these modules at some colleges of economics and techniques still revealed limitations: The method of presentation still accounted for a large proportion in teaching. The students did

not have a favorable environment to create knowledge and practise mathematic application skills in their career. This situation requires the teacher to change the teaching method to better meet the goals and graduation standards of the colleges of economics and techniques.

Applying the 5E teaching cycle to advanced mathematics and statistical probability teaching is suitable for the training objectives, helping overcome the situation of 'students only listening and writing'. Instead of imposing knowledge on students, it is organizing activities for students to create knowledge, relate and apply knowledge to their professional practice.

Chapter 2. THE MEASURES IN TEACHING SOME MATHEMATICS TOPICS TO THE STUDENTS AT THE COLLEGES OF ECONONICS AND TECHNIQUES IN THE 5E CONSTRUCTIVIST CYCLE

2.1. The orientation to propose the measures

Orientation 1: The pedagogical measures should be suitable for the receptive ability and cognitive level of the college students.

Orientation 2: The pedagogical measures need to clarify the meaning and role of the topics of advanced mathematics and statistical probability taught at the colleges of economics and techniques through problem-raising to choose the derivative application problems associated with the students' future career activities.

Orientation 3: The pedagogical measures need to support the mathematics teachers at the colleges of economics and techniques on how to apply the steps of the 5E teaching cycle in teaching advanced mathematics and statistical probability at the colleges of economics and techniques.

Orientation 4: The activities compatible with the steps of the 5E teaching cycle in the process of teaching a number of topics of advanced mathematics and statistical probability at the colleges of economics and techniques must be suitable for the students' age physiology and permissible teaching conditions.

Orientation 5: Among the measures, it is necessary to specify the objectives, bases of the measures, how to implement the measures, and especially, there must be illustrative examples from teaching the contents on some topics of advanced mathematics and statistical probability at the colleges of economics and techniques.

2.2. Some measures

2.2.1. Measure 1: Exploiting the specific activities applied to each step of the 5E cycle in teaching some mathematics topics

2.2.1.1. The purpose of the measure

This measure is to show the specific activities applying each step of the 5E cycle in teaching some mathematics topics at the colleges of economics and techniques.

2.2.1.2. The basis of the measure

In addition to the theoretical and practical basis as presented in chapter 1 of the dissertation, this measure is also based on the concept of the activities and component of activities in teaching mathematics and Kolb learning cycle.

2.2.1.3. How to take the measure

Method 1.1 bases on the students' existing knowledge as a prerequisite for starting, asking problems, leading students to approach the problem, organizing a series of activities to experience, explore, explain, and apply in teaching new knowledge.

Method 1.2 bases on the history of formation and development of a certain mathematical content in advanced mathematics and statistical probability to lead and attract the students to the problems in the 5E teaching cycle.

Method 1.3 exploits and designs the situations with many solutions to solve for the students to propose, exchange, discuss and evaluate the problems in the solving options.

Example 1: Teaching the lesson 'Total Probability - Bayes Formula'. The activities of teachers and students in the 5E teaching cycle can be as follows:

Step 1: Engaging

Activity 1: The teacher asks students to repeat the concept of probability, the event of product AB and solve the following problem: In a closed box, there are 3 red marbles and 2 blue marbles. Take 1 marble at the first time, no return, and take 2 marbles at the second time. Calculate the probabilities of the following events:

a) Event A: At the first time, the red ball is obtained

b) Event B: At the second time, the red ball is obtained

c) Event AB

d) Event C: At the second time, the red ball is obtained when the first red ball is obtained.

Results:

P(A)	P(B)	P(AB)	P(C)
$\frac{3}{5}$	$\frac{4}{5}$	$\frac{3}{10}$	$\frac{1}{2}$

Activity 2: Involving students into the problem:

Call event C “the 2nd time you got red balls when the first you got red balls” a conditional event; C is the event “happening B in the condition of happened A”. The symbol is C = B/A. What is the relationship among the events A, B, AB and B/A?

Step 2: Exploring

Activity 3: The teacher asks students to take some more simple examples of conditional events and calculate the probability as the problem above. Students can propose based on some results. The assumptions are as follows: A closed box has 6 ATM cards of ACB and 4 ATM cards of Vietcombank. Randomly take 2 cards in turn (take no return). Call A the event “the first time you got the ATM card of ACB”, call B the event “the second time you got the ATM card of Vietcombank”.

The event of B/A is “The second time you got the ATM card of Vietcombank if you know that the first time you got the ATM card of ACB”. The results are:

P(A)	P(B)	P(AB)	P(B/A)
$\frac{3}{5}$	$\frac{3}{4}$	$\frac{4}{15}$	$\frac{4}{9}$

+ The class ‘Electrics/Electronics’ A has 95 students, including 40 boys and 55 girls. In the statistical probability exam, 23 students got excellent scores (including 12 boys and 11 girls). Randomly call the name of a student in the class book. Find the probability of calling a student with good scores in statistical probability, knowing that the student is a girl.

Call A the event ‘calling a female student’, B the event ‘calling a student getting good marks in statistical probability’, C the event ‘calling a female student with good scores, the results are:

P(A)	P(B)	P(AB)	P(B/A)
$\frac{11}{19}$	$\frac{3}{4}$	$\frac{11}{95}$	$\frac{1}{5}$

Activity 4: Teachers ask students to tabulate the results. On that basis, the formula for calculating the probability conditionally is discovered.

Table 2.1: Synthesizing the results from the above 3 problems.

P(A)	P(B)	P(AB)	P(B/A)	Exploring the formula
$\frac{3}{5}$	$\frac{1}{3}$	$\frac{3}{10}$	$\frac{1}{2}$	P(AB) = P(A). P(B/A)
$\frac{3}{5}$	$\frac{3}{4}$	$\frac{4}{15}$	$\frac{4}{9}$	
$\frac{11}{19}$	$\frac{3}{4}$	$\frac{11}{95}$	$\frac{1}{5}$	

Step 3: Explanation

Activity 5: The teacher asks students to explain the discovery results.

Student(s): In the above table, the product of two numbers in column 1 and column 4 is equal to the number in column 3.

Activity 6: The teacher asks students to prove the general formula:

P (A.B) = P (A). P (B/A) (*)

Step 4: Elaborating and applying

Activity 7: Teachers ask students to verbalize the formula (*)

Student(s): The probability of the product of two events A and B is equal to the probabilistic product of one of those events with the conditional probability of the other event: P (AB) = P (A).P (B/A) = P (AB) = P (B).P (A/B)

Activity 8: The teacher asks students to state the general formula of (*) for n events.

Student(s): P (A1. A2… An) = P (A1).P (A2/A1)… P (An/A1. A2… An-1)

The probability of a product of n events is equal to the probabilistic product of the events in which each subsequent event occurs provided that all the previous events have occurred.

Activity 9: The teacher asks students to detect the consequences of the above general formula when the events are completely independent.

Student(s): The probability of the product of n fully independent events is equal to the probabilistic product of those events: P (A1.A2… An) = P (A1).P (A2)… P (An)

Activity 10: Elaborating

+ Assuming that A is any event and B1, B2 ..., Bn establish a complete system of events and P (Bi)> 0, then: P (A) = and if P (A) > 0, then:

$$P(B_k / A) = \frac{P(B_k)P(A/B_k)}{\sum_{i=1}^{n} P(B_i)P(A/B_i)}$$

Step 5: Evaluating

Teachers can allow students to exchange, evaluate suggestions, problem-solving options, detect mistakes in the problem solving process, or teachers can evaluate the learning results of students in the process of building and creating knowledge.

2.2.2. Measure 2: Combining the 5E constructivist cycle with some other teaching methods based on the foundation of the constructivist theory in teaching some mathematics topics at the colleges of economics and techniques

2.2.2.1. The purpose of the measure

This measure aims to increase the applicability of the 5E in teaching some mathematics topics at the colleges of economics and techniques through

combining the 5E with some other teaching methods (including some methods suitable for teaching characteristic advanced mathematics and statistical probability to the students of the colleges of economics and techniques) to help them construct knowledge and apply it in solving the problems of professional practice.

2.2.2.2. The basis of the measure

The 5E teaching cycle consists of 5 steps, but we need to apply specific the teaching methods to perform those steps effeciently. With the goal of helping the students build knowledge and apply it into professional practice, it can be seen that some of the following teaching methods can be used to concretize each step of the 5E teaching cycle.

2.2.2.3. How to take the measure

Method 2.1: Combining the 5E with collaborative learning method

Method 2.2: Using teaching facilities in the process of combining the 5E with discovery teaching method

Example 2: Teaching the lesson 'Properties of Determinants' (period 3, 4) at the colleges of economics and techniques. The steps can be as follows:

Step 1: Engaging

Teacher: In this lesson we continue to explore some properties of determinants, which helps to calculate determinants more quickly and smoothly.

Step 2: Exploring

Activity 1: Teachers ask students to discover some more properties of determinants through the following handouts:

HANDOUT NUMBER 1
Study and propose the following properties of determinants. (1) If the determinant has a complete row of zeros, what is the property of the determinant? (2) If the determinant has two identical rows, what is the property of the determinant? (3) If the determinant has two rows or columns in proportion to each other, what is the property of the determinant? (4) If the determinant has the terms of a row with common factors, what is the property of the determinant? (5) If the determinant has a single row that is a linear combination of several other rows, what is the characteristic of the determinant? (6) When we add or subtract two determinant rows together, replacing one of those rows, how does the determinant change?

Note: Teachers can suggest students to explore the above properties through some specific determinants.

Activity 2: Students report their discovery results (expected) as follows:

1) If the determinant has a complete row with zeros, then the determinant is 0.

2) If the determinant has two equal rows, then the determinant is 0.

3) If the determinant has two rows or columns proportional to each other, the determinant is 0.

4) If the determinant has the terms of a row with common factors, then we can remove that common factor from the determinant.

5) If the determinant has a single row that is a linear combination of some other rows, then the determinant is 0.

6) When we add and subtract two determinant rows together, substituting for one of those rows, how does the determinant change?

Step 3: Explanation

1) If the determinant has a complete row with zeros, then we expand on the elements in that row, resulting in the determinant of 0.

2) If the determinant has two identical rows, then we expand on the elements in the other row, the determinant result is 0. For example, if the determinant has row 2 and row 3 which are the same, then:

$$\begin{vmatrix} a & b & c \\ m & n & p \\ m & n & p \end{vmatrix} = a \begin{vmatrix} n & p \\ n & p \end{vmatrix} - b \begin{vmatrix} m & p \\ m & p \end{vmatrix} + c \begin{vmatrix} m & n \\ m & n \end{vmatrix} = 0.$$

3) If the determinant has two rows or columns proportional to each other, then the determinant is 0: similar explanation.

4) If the determinant has the terms of a row with common factors, we expand the determinant as the elements in that row, such as:

$$D = \begin{vmatrix} a_1 & b_1 & c_1 \\ ka_2 & kb_2 & kc_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = ka_2 \begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix} - kb_2 \begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix} + kc_2$$

$$\begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix} = k\,(a_2 \begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix} - b_2 \begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix} + c_2 \begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix})$$

$$= k \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}.$$

Therefore, we can put the common factor out of the determinant.

5) Suppose we have a tertiary determinant where the first row is a linear combination of the other two rows, we decompose that determinant into the sum of two determinants and then take each of the common coefficients out of the determinant.

$$\begin{vmatrix} ka_2 + ha_3 & kb_2 + hb_3 & kc_2 + hc_3 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}$$

$$= \begin{vmatrix} ka_2 & kb_2 & kc_2 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} + \begin{vmatrix} ha_3 & hb_3 & hc_3 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}$$

$$= k \begin{vmatrix} a_2 & b_2 & c_2 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} + h \begin{vmatrix} a_3 & b_3 & c_3 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = 0.$$

Each determinant on the last line above has two equal rows, so the determinant is 0; thus, when the determinant has a row that is a linear combination of some other rows, the determinant is 0.

6) When we add and subtract two determinant rows, that is, multiplying the second determinant by k = ± 1, and then adding up the first row, the determinant does not change.

Note: In order to save time, teachers can create handouts to record the results of the format change as described above or project them from the computer for students to see the results, for example:

Handout number 2
Prove property 4

$$D = \begin{vmatrix} a_1 & b_1 & c_1 \\ ka_2 & kb_2 & kc_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = ka_2 \begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix} - kb_2 \begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix} + kc_2 \begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}$$

$$= k \left(a_2 \begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix} - b_2 \begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix} + c_2 \begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}\right) = k \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}.$$

Step 4: Elaborating and applying

Activity 3: Apply the properties of the determinant to do the mental arithmetic of the following determinants:

$$A = \begin{vmatrix} -1 & 2 & -1 \\ -\frac{3}{2} & 3 & -\frac{3}{2} \\ 1 & -1 & 2 \end{vmatrix}$$

(The first row and second row are propotional)

$$B = \begin{vmatrix} 1 & -1 & 2 & 1 \\ 0 & 0 & 0 & 2 \\ 2 & -2 & 3 & 1 \\ -2 & -2 & 4 & 2 \end{vmatrix}$$

(The fourth row is twice as much as the second row)

$$C = \begin{vmatrix} 1 & -1 & 2 & 1 \\ 0 & 0 & 0 & 2 \\ 2 & -2 & 3 & 1 \\ -2 & -2 & 4 & 2 \end{vmatrix}$$

Activity 4: Prove that determinants can be separated as follows:

$$\begin{vmatrix} a_{11} & a'_{12} + a''_{12} \\ a_{21} & a'_{22} + a''_{22} \end{vmatrix} = \begin{vmatrix} a_{11} & a'_{12} \\ a_{21} & a'_{22} \end{vmatrix} + \begin{vmatrix} a_{11} & a''_{12} \\ a_{21} & a''_{22} \end{vmatrix}$$

$$\begin{vmatrix} a_{11} & a_{12} & a'_{13} + a''_{13} \\ a_{21} & a_{22} & a'_{23} + a''_{23} \\ a_{31} & a_{32} & a'_{33} + a''_{33} \end{vmatrix} = \begin{vmatrix} a_{11} & a_{12} & a'_{13} \\ a_{21} & a_{22} & a'_{23} \\ a_{31} & a_{32} & a'_{33} \end{vmatrix} +$$

$$\begin{vmatrix} a_{11} & a_{12} & a''_{13} \\ a_{21} & a_{22} & a''_{23} \\ a_{31} & a_{32} & a''_{33} \end{vmatrix}$$

Write down the general formula for your determinant of level n.

$$\begin{vmatrix} a_{11} & a'_{12} + a''_{12} \\ a_{21} & a'_{22} + a''_{22} \end{vmatrix} = a_{11}(a'_{22} + a''_{22}) - (a'_{12} + a''_{12})\, a_{21}$$

$$= a_{11}a'_{22} + a_{11}a''_{22} - (a_{21}a'_{12} + a_{21}a''_{12})$$

$$= \begin{vmatrix} a_{11} & a'_{12} \\ a_{21} & a'_{22} \end{vmatrix} + \begin{vmatrix} a_{11} & a''_{12} \\ a_{21} & a''_{22} \end{vmatrix}.$$

+ For the tertiary determinant: Expand as the third column.

+ Generalize with n-level determinant:

$$\begin{vmatrix} a_{11} & a_{12} & \dots & a'_{1n} + a''_{1n} \\ a_{21} & a_{22} & \dots & a'_{2n} + a''_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a'_{nn} + a''_{nn} \end{vmatrix} = \begin{vmatrix} a_{11} & a_{12} & \dots & a'_{1n} \\ a_{21} & a_{22} & \dots & a'_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a'_{nn} \end{vmatrix} +$$

$$\begin{vmatrix} a_{11} & a_{12} & \dots & a''_{1n} \\ a_{21} & a_{22} & \dots & a''_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a''_{nn} \end{vmatrix}$$

Activity 5: Prove that if the determinant has the lower half of the diagonal and the upper half of the main diagonal, all of which are zero, then both the upper and lower halves are zero and the determinant is equal to the product of the elements on the diagonal.

$$\begin{vmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ 0 & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & a_{nn} \end{vmatrix} = a_{11}a_{22}\dots a_{nn}$$

$$\begin{vmatrix} a_{11} & 0 & \dots & 0 \\ a_{21} & a_{22} & \dots & 0 \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{vmatrix} = a_{11}a_{22}\dots a_{nn}.$$

Instructions: Expand in rows or columns with multiple zeros.

Step 5: Evaluation

Convert the following determinant to the triangle determinant to calculate:

$$\begin{vmatrix} 0 & 1 & 5 \\ 3 & -6 & 9 \\ 2 & 6 & 1 \end{vmatrix}$$

2.2.3. Measure 3: Enhancing the situations related to professional practice in the fields of economics and techniques in the process of teaching some mathematics topics in the 5E constructivist cycle

2.2.3.1. The purpose of the measure

This measure is to help the students see the role and meaning of the contents of mathematics taught at the colleges of economics and techniques and through the knowledge-building process, the students will know how to apply mathematics in professional practice after graduation.

2.2.3.2. The basis of the measure

With the innovation in the training method, the students at the colleges of economics and techniques now have relatively early access to their career, right from the first year in terms of the lessons related to professions as well as in practice. Through reality and observations, the students have gradually shaped what will be done in the future with what contents. What issues need to have the knowledge of advanced mathematics and statistical probability in the process of solving problems. Hence, it is necessary and feasible to strengthen the situations related to professional practice in the fields of economics and techniques in the process of teaching some mathematics topics in the 5E teaching cycle.

2.2.3.3. How to take the measure

Teachers need to select the problems related to career practice that can be used in the engaing, exploring or elaborating, application and evaluation the 5E teaching cycle.

Example 3: A workshop with two special machines M1 and M2 producing two types of products, denoted A and B. One ton of product type A earns 2 million VND (Vietnam Dong); one ton of product B earns 1.6 million VND. To produce a ton of products type A, one must use the M1 for 3 hours and the M2 for 1 hour. One machine cannot be used to produce two types of products at the same time. Machine M1 works no more than 6 hours a day, machine M2 works no more than 4 hours a day. What is the maximum amount of profit this workshop can make a day?

Step 1: Engaging

The teacher asks students to find a practical situation that matches the content of the above problem, then solve the problem. One of the following hypothetical scenarios is an example:

M1 is an industrial wood cutting machine for making toys.

M2 is a wooden toy varnish machine.

A is a house jigsaw toy.

A is a garden jigsaw toy.

Step 2: Exploring

- What are the factors to look for?
- Which sub-unknowns need to be placed?

- What is the relationship between the hypotheses of the problem?

In this case, students can have different sub-implicit methods and different systems of equations and inequalities.

Step 3: Explanation

Activity 1: Teachers let students explain how to place their sub-unknown(s) and explain each equation and inequations obtained from the problem.

For example, let x, y be the number of tons of products A and B that this workshop produces per day (x, y > 0). Then the profit per day of this workshop is f (x, y) = 2x + 1.6y (million VND), the number of working hours per day of machine M1 is 3x + 2y and the number of the working hours a day of machine M2 is x + y.

Since the M1 works for no more than 6 hours every day, and the M2 works no more than 4 hours, we have a system of inequations.

$$\begin{cases} 3x + 2y \le 6 \\ x + y \le 4 \quad (*) \\ x.y \ge 0 \end{cases}$$

Activity 2: Solve the system of inequations based on graphs and solution domain.

- The problem then changes into finding the maximum value of the function f (x, y) on the root domain of the system of inequations (*). The root domain of the system of inequations (*) is the quadrilateral OABC (including the boundary). The function f (x, y) will reach the maximum value on the root domain of the system of inequations (*) when (x, y) can be the coordinate of one of the vertices O (0; 0), A (2; 0), B (1; 3), C (0; 4). We have:

f (0; 0) = 0, f (2; 0) = 4, f (1; 3) = 6.8, f (0; 4) = 6.4

Activity 3: The results obtained deduce the max f (x, y) = 6.8 when (x, y) = (1; 3). Therefore, the biggest profit that this workshop can earn in a day is 6.8 million VND.

Step 4: Elaborating and applying

Activity 4: Solve the following problem.

It is intended to use two types of ingredients to extract at least 140 kg of substance A and 9 kg of substance B. Each ton of ingredient I is 4 million VND to extract 20 kg of substance A and 0.6 kg of substance can be extracted. Each ton of ingredient II is 3 million VND to extract 10 kg of substance A and 1.5 kg of substance B. So how many tons of ingredients of each type can be used for minimal costs, knowing that the supplier can supply no more than 10 tons of type I and no more than 9 tons of type II ingredients.

Step 5: Evaluation

Activity 5: Students do the test in 30 minutes.

Problem: A family needs at least 900 units of protein and 400 units of lipid in their food each day. Each kilogram of beef contains 800 protein units and 200 lipid units. Each kg of pork contains 600 protein units and 400 lipid units. Given that this household can only buy up to 1.6 kg of beef and 1.1 kg of pork and the price for 1 kg of beef is 120 thousand VND, 1 kg of pork is 100 thousand VND. How many kilograms can the family buy each type of meat for minimal money.

CONCLUSION OF CHAPTER 2

On the basis of the theory and practice presented in chapter 1, we propose the three methods of teaching some mathematics topics at the colleges of economics and techniques in the 5E teaching cycle. The measures are based on the constructivist theory and overcome the limitations and shortcomings from the practice of teaching the contents of advanced mathematics and statistical probability to help students be confident, proactively mobilize and connect their own knowledge to create new knowledge and relate it to professional practice and solve the problems in the future career practice, specifically:

Measure 1 exploits the specific activities applied in each step of the 5E cycle in teaching some mathematics topics.

Measure 2 combines the 5E teaching cycle with some other teaching methods based on the foundation of the constructivist theory in teaching some mathematics topics at the colleges of economics and techniques.

Measure 3 strengthens the situations related to professional practice in the fields of economics and techniues in the process of teaching some mathematics topics the 5E teaching cycle.

Each measure is illustrated by one or some specific examples in the contents of advanced mathematics and statistical probability at the colleges of economics and techniques.

Chapter 3. PEDAGOGICAL EXPERIMENTING

3.1. The purpose and organization of the pedagogical experiment

3.1.1. Experimental purpose

The pedagogical experiment was conducted to evaluate the feasibility and effeciency of teaching some topics of advanced mathematics and statistical probability at the colleges of economics and tchniques proposed in chapter 2.

3.1.2. Organizing the pedagogical experimenting

The experiment was conducted in two locations:

Location 1: At College of Economics and Techniques, Thai Nguyen University (TNU-College of Economics and Techniques). We chose 2 classes of course 13 to participate in the experiment:

- The pedagogical experiment class was the class 'Electrics-Electronics' with 37 students.

- The control class was the class 'Industrial Electrics' with 34 students.

The time of the experiment was October 2018.

Before conducting the pedagogical experiment, we had conducted a quality test in two classes with a time allowance of 45 minutes (Appendix 3) for both classes and used a 10-point scale. The results were relatively equal, either in terms of the overall grade point average or each score.

Location 2: At Hung Yen College of Economics and Techniques. We chose 2 classes (course 49):

- The experiment class was the class 'Business Administration' with 23 students.

- The control class was the class 'Marketing Management' with 19 students.

The time of the experiment was November 2018.

3.1.3. The teaching method of the pedagogical experiment

Lesson 1: The system of linear equations (2 periods)

Lesson 2: Full Probability - Bayes Formula (2 periods)

The teacher taught the pedagogical experiment class in the direction of applying the 5E teaching cycle designed in the 5E cycle in section 2.2 of chapter 2). The teacher taught the control class in the teacher's self-compiled lesson plan, not the same as the pedagogical experiment class and also observed the learning activities of the students and evaluated on both qualitative and quantitative aspects.

3.2. Experimental teaching lesson plan

3.3. Evaluation of pedagogical experiment results

3.3.1. Quantitative assessment

After the pedagogical experiment, we let the students of both the pedagogical and control classes to do the same test; the author of the dissertation marked the papers in the same scale and answers.

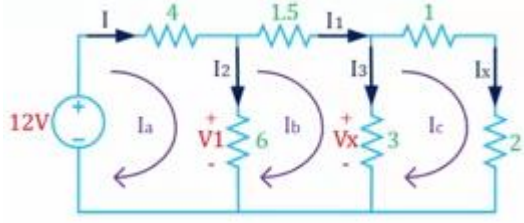
3.3.1.1. The 30-minute advanced mathematics test at TNU-College of Economics and Techniques

* Test questions (30 minutes): Advanced mathematics

Question 1. Apply the properties of determinants to get the fastest way of calculating the following determinants:

$$A = \begin{vmatrix} 1 & -1 & 2 & 1 \\ 0 & 1 & -1 & 2 \\ 2 & -2 & 3 & 1 \\ 2 & -2 & 4 & 2 \end{vmatrix}; \quad B = \begin{vmatrix} 0 & 1 & 5 \\ 3 & -6 & 9 \\ 2 & 6 & 1 \end{vmatrix}$$

Question 2. Calculate I1, I2, I3 in the following circuit:



* The pedagogical intention of the test:

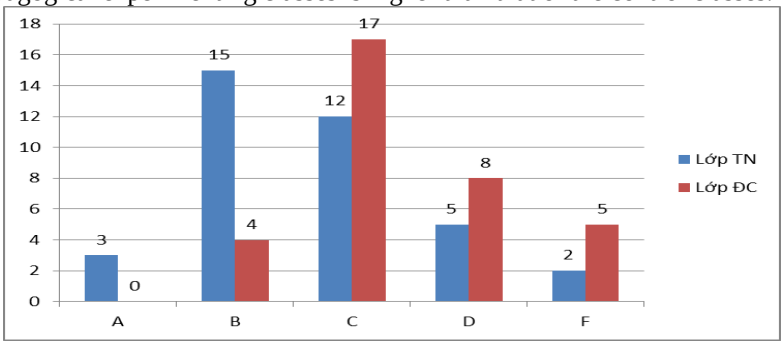
Question 1 aims to evaluate the basic knowledge and skills of determinants and applying the properties of determinants.

Question 2 aims to evaluate the ability of the students to apply mathematics to practical professional practice in the Faculty of Electrics and Electronics (calculating the intensity of circuits).

The test results are shown in the following table:

Grades of the classes	A	B	C	D	F
Experimental class: 37 students	3	15	12	5	2
Control class: 34 students	0	4	17	8	5

The graph clearly shows that the number of points A and B of the pedagogical experimenting classes is higher than that of the control classes.



3.3.2. Qualitative assessment

To evaluate the results of the pedagogical experiment qualitatively, we have implemented the following activities:

- Discussing with the homeroom teacher to grasp the psychology, situation and learning process of advanced mathematics and statistical probability among the students.

- Observing the classrooms and the way the students listen to the lectures, the students' activities during and outside class hours and the practical skills of the students.

- In-depth interviewing with some students.

The pedagogical experiment results show that if the teachers apply the 5E teaching cycle to teaching some topics of advanced mathematics and statistical probability at the colleges of economics and techniques, the students will understand the nature of knowledge and acquire practical skills to apply mathematics to better practise problem solving.

CONCLUSION OF CHAPTER 3

First of all, the pedagogical experiment has shown that we can apply the 5E teaching cycle to teach some contents of advanced mathematics to the students of the colleges of economics and techniques.

Next, through the pedagogical experiment, it is clear that immediately after approaching the 5E, especially after being supported by an expert teacher with some practical situations that need to apply advanced mathematics and statistical probability to solve, the teacher could quickly design their lectures in the steps of the 5E teaching cycle (thereby demonstrating the pedagogical measures proposed by the dissertation), and the students quickly got acquainted and actively participated in the activities in the 5E teaching cycle. Thus, it is feasible to apply the 5E cycle to teaching some contents of advanced mathematics and statistical probability.

The pedagogical experiment results show that if the teachers apply the 5E to teaching some advanced mathematics and statistical probability at the colleges of economics and techniques, the students will understand the nature of knowledge and acquire practical skills to apply mathematics to better practise problem solving.

Through the pedagogical experiment process, it can be seen that the application of the 5E teaching cycle in advanced mathematics teaching has helped the students not only grasp knowledge but also know how to find knowledge, thereby improving the efficiency and quality of teaching mathematics at the colleges of economics and techniques.

Particularly, if combining teaching in the 5E with some other positive teaching methods, such as collaborative teaching, discovery teaching, teaching with media and information technology, it will bring about better results in learning, improving the capacity to solve problems among the students at the colleges of economics and techniques.

Although the pedagogical experiment has not been conducted on a large scale, its results have shown the feasibility and effeciency of the proposed measures in the dissertation, which has really attracted the students to participate in building their lessons to create knowledge and apply knowledge into professional practice step by step. Thus, the scientific hypothesis is acceptable.

CONCLUSIONS AND RECOMMENDATIONS

I. Conclusion

(1) The cognitive constructivist theory emphasizes the student's role. Learners must be the ones who create knowledge for themselves, under the guidance of teachers.

(2) The 5E teaching cycle consists of 5 activities: Engage, explore, explanation, elaboration and evaluation, which is one of the ways to concretize the application of the constructivist theory in teaching.

(3) The survey of teaching and learning practice of some mathematics topics at some colleges of economics and techniques shows that many teachers still taught in the traditional way (giving presentation lectures), imposing knowledge which led the students to passive learning that limited the quality of training, not meeting the graduation standards of students. Although there were a few teachers who did this step or the other step of the 5E teaching cycle, none of the teachers systematically carried out the full steps.

(4) The dissertation presented and proposed the three measures to apply the 5E teaching cycle to teach some mathematics topics to the students at the colleges of economics and techniques to help the teachers attract the students to the lesson contents, creating opportunities for the students to be active, proactive, knowing how to discover knowledge, form and practise necessary skills and know how to apply those knowledge and skills to solving the problems of the subject; further, it is the professional practice to better meet the graduation standards of the vocational colleges in Vietnam.

(5) The pedagogical experimenting is to partly prove that the proposed pedagogical measures are feasible and efficient; the scientific hypothesis is acceptable.

II. Recommendations

The research direction of the dissertation is open; hence, it is possible to research and apply the 5E teaching cycle to teaching a number of other contents to the students at universities and colleges in Vietnam.