THAI NGUYEN UNIVERSITY UNIVERSITY OF EDUCATION

NGUYEN VAN HUNG

BUILDING AND USING SOME EXPLORATORY SITUATIONS IN TEACHING MATHS AT HIGH SCHOOL WITH THE SUPPORT OF HANDHELD CALCULATORS

Major: Theory and Methodology of Mathematics Teaching Code: 9140111

DISSERTATION SUMMARY

THAI NGUYEN - 2022

The dissertation was finished at: University of Education - Thai Nguyen University

Supervisors:

1. Assoc. Prof. Dr Nguyen Danh Nam

2. Assoc. Prof. Dr Nguyen Anh Tuan

Reviewer 1:	
Reviewer 2:	
Reviewer 3:	

The dissertation will be defended in the university committee: University of Education - Thai Nguyen University At....., 2022

The dissertation can be read at:

- 1. National Library of Vietnam.
- 2. Digital Center Thai Nguyen University
- 3. Library of University of Education.

INTRODUCTION

1. Reason for choosing the research topic

In the 1970s, the calculator technology revolution turned to handheld devices. With the advantages of compact size but capable of performing many mathematical functions, handheld calculators quickly became popular in math classrooms in countries around the world. Nowadays, most countries around the world use handheld calculators to support the process of teaching mathematics from primary school to university.

In Vietnam's high schools today, the combination of teaching theories and practical calculation has not been promoted yet. This is not entirely because of the lack of calculation tools, but because the popular use of computing tools has not been really interested in. Instructing students to use calculators creatively during math learning is still limited. In general, the majority of students only use handheld calculators at the level of performing simple calculations but have not applied them to higher levels such as predicting results, creative reasoning to solve problems, and algorithmic thinking based on handheld calculators.

Stemming from the above reasons, I chose the research title: "Building and using some exploratory situations in teaching Mathematics at high school with the support of handheld calculators".

2. Research Aim

On the basis of analysing exploratory teaching, teaching situations and the use of handheld calculators in teaching

Mathematics, the research aims to build a number of exploratory situations to foster problem solving competence for students in learning Mathematics in high school.

3. Research tasks

Study the theoretical basis of teaching Mathematics in high schools; investigate the current situation of teaching and learning mathematics with the support of handheld calculators in high schools; propose some exploratory situations in teaching Mathematics at high schools with the support of handheld calculators.

4. Objects, subjects and scope of research

The process of teaching Mathematics at high schools with the support of handheld calculators.

4.3. Research scope

- Contents and methods of teaching mathematics at high school.

- The reality of teaching math with the support of handheld calculators in some high schools.

5. Scientific hypothesis

If some exploratory situations in teaching Mathematics at high schools with the support of appropriate handheld calculators can be designed and used, they will contribute to fostering students' problem-solving competence, improving the quality of teaching mathematics in high schools.

6. Research Methods

The thesis uses a number of research methods such as theoretical research; observation; survey; expert method; experiment; statistics and data processing.

7. Viewpoints to be defensed

- The calculator is not only a calculation tool but also a tool to support students in exploring and solving math problems.

- Using exploratory situations with the support of handheld calculators in teaching mathematics at high schools will contribute to fostering problem-solving competence for students, improving the quality of teaching Mathematics.

8. Contributions of the dissertation

The research has:

- Made an overview of some research issues in the world and in Vietnam on the use of handheld calculators in teaching.

- Clarified the role of handheld calculators as a scientific basis for the widespread deployment of handheld calculators in teaching Mathematics at high schools.

- Analysed the benefits and challenges; factors affecting the effectiveness of the use of handheld calculators in fostering the competence to solve mathematical problems for high school students.

- Designed some exploratory situations in teaching Mathematics at high schools with the support of handheld calculators to foster students' problem-solving competence.

9. Dissertation layout

In addition to the introduction, conclusion and list of references, the thesis consists of four chapters:

Chapter 1. Theoretical basis

Chapter 2. The reality of teaching Maths at high school with the support of handheld calculators

Chapter 3. Building some exploratory situations in teaching Maths at high school with the support of handheld calculators

Chapter 4. Pedagogical experiment

Chapter 1 THEORETICAL BASIS

1.1. Overview of some research results on exploratory teaching 1.1.1. Some foreign research results

Research on exploratory teaching and design of teaching situations with the support of information technology is not a new issue in education in countries around the world. There have been many scientific works that have been developed through each stage; although they were approached from many different angles, they have the same goal of making teaching effective.

Currently, research on discovery teaching follows the following main trends: (1) Research on the role of teachers in organizing discovery learning for students, (2) Research on the benefits of learning exploration learning, (3) Exploration level research, (4) Exploratory learning research in special needs education, (5)) Studying exploratory teaching with the support of information technology (IT).

1.1.2. Some research results in Vietnam

a) Regarding exploratory teaching:

In Vietnam, the issue of exploratory teaching has been interested in, researched and applied by the researchers at many different levels and aspects such as research at the methodological level or exploratory teaching research at the level of teaching techniques.

b) Regarding the design and use of teaching situations:

In scientific works and researches on exploratory teaching methods, many researchers assert that if teachers know *how to create situations suitable* for students' cognitive levels, on the basis of their existing knowledge, then students can investigate the situations, explore and discover new knowledge, and exploration learning will bring better results than many other forms of learning. Specifically, many researchers are interested in designing and using different teaching situations to solve relevant problems in teaching mathematics.

In addition, in recent years, the application of IT in teaching mathematics at all levels, especially at the high school level, has been researched and applied. Many researchers have done research works on building and using software to support teaching. Some studies have confirmed that IT can help students explore and solve problems on their own.

From those works, the following issues are drawn:

- *First*, the theory of exploratory teaching and teaching situations have been studied by many researchers; however, there is no research work on exploratory situations, the characteristics of exploratory situations in teaching Mathematics.

- Second, the use of handheld calculators to support exploratory activities in learning among students has not been studied in recent research.

- Third, there has not been any systematic research on exploratory teaching of Mathematics in high schools with the support of handheld calculators. Therefore, the issue of

building and using exploratory situations in teaching Mathematics at high school with the support of handheld calculators has theoretical and practical significance. This is the main content that the thesis will continue to research and elucidate.

1.2. Overview of some research results on the use of handheld calculators in teaching

Handheld calculator is a tool to support mathematical exploration; handheld calculator helps teachers and students solve math problems by exploiting and using available functions of calculators, combined with building appropriate teaching situations. Some studies abroad (Dunham & Dick, 1994; Demana & Waits, 1990; Fey & Good, 1985) suggest that the introduction of handheld calculators has profoundly affected the teaching and learning of Mathematics. Regarding the benefits of using handheld calculators in teaching mathematics, a number of studies have confirmed the benefits that can arise from the mathematical functions installed in the calculator and the rational use of handheld calculators in the teaching process. They can help teachers innovate teaching methods, have a positive impact on the attitudes of teachers and students in the process of teaching and learning, and improve the effectiveness of math learning.

The challenges of using handheld calculators in teaching are also mentioned by some studies. For example, challenges may arise from inappropriate and abusive use of handheld calculators; from situations where students are not uniformly equipped with calculators in the classroom; or from situations where students do not regularly use calculators for long periods of time. In addition, a number of studies also pointed out the challenges such as lack of teaching materials, lack of teacher training in the use of handheld calculators, and lack of time for planning lessons. All of these factors influence the effectiveness of using handheld calculators.

In Vietnam, there have not been many studies on the use of handheld calculators in teaching mathematics; there are only some tutorials on using handheld calculators and some documents refer to techniques of using handheld calculators to solve math problems.

In the process of studying the use of handheld calculators in teaching Mathematics, the researcher of the thesis found that basically the previous studies only focused on affirming the benefits or challenges that handheld calculators could bring about in the teaching process. These research works left behind "open issues" about the role of handheld calculators in teaching mathematics without much in-depth research on how to use handheld calculators to achieve high efficiency in teaching, or how the teaching situations can be designed to be able to use the handheld calculator as a means of helping to explore, discover and solve mathematical problems more conveniently and effectively.

1.3. Exploratory teaching

1.3.1. Some key concepts

Based on the previous research works, in the thesis, the researcher uses the concept:

"Exploration is an active and proactive activity of learners, by asking questions, collecting, investigating, analyzing data... to find and acquire new knowledge";

Exploratory teaching is a process in which, under the teacher's orientation, learners take the initiative in their own learning, form questions posed in thinking, and expand research work; thereby building new understandings and knowledge. This knowledge helps learners answer questions, find different solutions to problems, prove a theorem or point of view".

1.3.2. Features of exploratory teaching

Exploratory teaching as a teaching method has the following basic characteristics: Exploratory teaching is not about discovering things that people don't know; carried out through a series of activities; equip students with thinking techniques and creative ways to discover and solve problems.

1.3.3. Manifestations of exploratory activity

Many studies have shown the manifestations of exploratory activities are: Detect the characteristic properties of the concept; Detect, search and propose other equivalent definitions; Detect, propose hypotheses, predict properties, characteristics of events and relationships between mathematical elements; Reveal or discover internal logical relationships between objects; Transform the given problem in a way that makes the hypothesis and conclusion closer; Solve the posed task of the problem by mobilizing and selecting relevant knowledge; Discover hidden mathematical knowledge in real situations, events, and problems and apply them to solve problems.

1.4. Exploratory situations in teaching

1.4.1. Teaching situation

1.4.1.1. Perception of situation

The researcher of the thesis uses the concept "A situation is understood as a system of external events that are related to the subject and have the effect of promoting the positiveness of that subject " to agree with the content built in the thesis.

1.4.1.2. Teaching situation

From the perspective of studying situations in teaching Mathematics; on the basis of the above conceptions of situations, the researcher of the thesis agrees with the researcher Do Hoang Mai's definition: A teaching situation is a situation designed according to the teacher's pedagogical intention to transfer learning tasks to learners; when learners solve those tasks, they will achieve certain learning goals.

1.4.2. Exploratory situation

1.4.2.1. The concept of exploratory situation

The researcher of the thesis builds the concept of exploratory situation as follows:

Exploratory situations are teaching situations that make students interested or that have to create interest in learning for students, stimulate students to reason, think, have a need to learn about previously unknown issues. Students are selfdisciplined, proactive and actively explore independently or under the guidance of teachers to overcome obstacles and get results according to certain teaching goals.

Exploration in learning is not a spontaneous process but a process under the purposeful direction of teachers; students are self-disciplined, active and proactive to overcome obstacles, and they can use tools and means to support their own activities. Therefore, the researcher may conceive of a exploratory situation in teaching mathematics with the support of a handheld calculator as a exploratory situation in which students use a handheld calculator to support their thinking activities like: calculating, analyzing, evaluating, hypothesizng and making inferences in order to discover concepts and regular properties of objects or relationships between things and phenomena that students have never known before.

1.4.2.2. Characteristics of the exploratory situation

An exploratory situation should satisfy the following requirements:

(1) Exploratory situations are open-ended and generalizable; (2) The situation must make the student interested or must create interest in the student; (3) Provoke learning activities; (4) Suitable for students' cognitive level

1.5. Teaching aids

1.5.1. The concept of teaching aids

In this thesis, the researcher uses the concept of teaching aids in the sense that all means are capable of containing or transmitting information about the teaching content and the control of the teaching process, and they can be used directly in the teaching process to assist teachers and students in organizing and conducting rationally and effectively the teaching process.

1.5.2. Roles and functions of teaching aids

- Roles of teaching aids:

Teaching aids create favorable conditions for the organization of learning activities. They can follow closely and expand human senses, form environments with pedagogical intent, simulate dangerous phenomena and processes, or transcend the limitations of time, space and expenses.

- Functions of teaching aids:

Each teaching aid can help perform some of the following functions: knowledge construction; skill training; stimulating interest in learning; organizing and controlling the learning process; rationalizing the work of teachers and students.

1.5.3. Some forms of using teaching aids

Teaching aids can be used in some of the following forms: (1) teachers conduct lessons in combination with the use of teaching aids; (2) student works directly with the teaching aids under the guidance and control of the teacher; (3) student learns independently with the teaching aids through a program designed before; (4) students learn from electronic materials

1.6. Handheld calculator as a teaching aid

1.6.1. Brief history of handheld calculators

The first known arithmetic calculation tool was the abacus (Abacus) used by the Sumerians and Egyptians around 2000 BC.

In 1642, the mathematician Blaise Pascal (1623-1662) invented the mechanical calculator, the first device that could perform basic calculations without using human intelligence. 400 years later, from Pascal's original mechanical counter, with a series of improvements and upgrades in program as well as hardware, pocket calculators – portable calculators now occupy only a small compartment in a student's schoolbal, weigh less than 200 grams, and have many functions for not only performing calculations of addition, subtraction, multiplication, but they are also capable of performing complex mathematical calculations.

1.6.2. Concepts of handheld calculators used in teaching

A handheld calculator (also known as a pocket calculator) is a compact, easily portable (small enough to be handheld) electronic device with an independent power source, is operated by pressing keys with monochromatic or polychromatic display numbers, and is used to perform basic and complex mathematical calculations.

1.6.3. Roles and functions of handheld calculators in teaching

- a) Roles of handheld calculators in teaching mathematics
- A handheld calculator is a tool for calculating
- A handheld calculator is a data visualization tool
- The calculator is a tool for checking
- b) Functions of handheld calculators in teaching maths
- Construct knowledge
- Develop skills, consolidate and review knowledge
- Stimulate interest in learning

- Organize and controll the learning process

- Rationalize the role of teachers and students

1.7. Fostering students' competence to solve math problems through exploratory activities with the help of handheld calculators

1.7.1. The concept of competence

There are many documents that refer to the concept of competence and they have different definitions. In the thesis, the researcher uses the definition of competency given in the 2018 National Education Program, which is: *Competence is the ability to successfully perform an activity in a given context thanks to the integrated mobilization of knowledge, skills and other personal attributes such as interest, belief, and will,... The competence of an individual is assessed through the method and results of that individual's activities when solving life problems.*

1.7.2. Problem solving competence

The researcher uses the following concept: *Problem*solving competence is a combination of competencies expressed in skills (thinking manipulation and activity) in learning activities in order to effectively solve the tasks of the problem to develop and agree with the relevant contents of the thesis.

1.7.3. Components of problem-solving competence

Approaching the problem-solving process in teaching mathematics, the researcher agrees with some studies that problem-solving competence is composed of the following components: Competence to understand problems, competence to detect and implement problem-solving solutions, competence to present problem-solving solutions, competence to discover other solutions to solve problems and competence to detect new problems.

1.7.4. Fostering students' problem-solving competence through exploratory activities with the help of handheld calculators

With the approach of handheld calculators as the means used to analyze mathematical situations, the researcher of the thesis offers a number of possibilities that handheld calculators can support students to improve their competence to solve math problems with a number of exploratory activities:

• Using handheld calculators to detect and clarify problems:

• Using handheld calculators to support the formation and implementation of new ideas:

• Using handheld calculators to assist in choosing a problem-solving solution:

• Use handheld calculators to perform and evaluate problemsolving solutions:

• Use handheld calculators to detect new problems:

1.8. Levels of exploratory activity with handheld calculators

The researcher of the thesis proposes the levels of exploratory activities as follows:

- Level 1. Fully Guided Exploration (guided exploration)

- Level 2. Partially Guided Exploration

- Level 3. Free Exploration

CONCLUSION FOR CHAPTER 1

On the basis of the theory of exploratory teaching and teaching situations, the researcher of the thesis has proposed the concept of exploratory situations in teaching mathematics with the support of handheld calculators; analyzed the characteristics of the exploratory situation; and proposed the use of handheld calculators as a teaching aid in supporting students' exploration and problem-solving activities.

From the scientific basis of exploratory teaching and related research works on designing situations in teaching, it can be seen that to improve the effectiveness of math teaching in high schools, teachers need to know how to use aids in teaching math, including handheld calculators, to design teaching situations and stimulate the need to discover knowledge in learners and rationally use teaching aids in the teaching process. This is a solution to carry out educational innovation in the direction of competence development for students.

Chapter 2

THE STATUS OF TEACHING MATHS AT HIGH SCHOOL WITH THE SUPPORT OF HANDHELD CALCULATORS

2.1. Research aims

Assess the current situation of teaching and learning mathematics at high school level with the support of handheld calculators; evaluate the benefits and challenges of using handheld calculators in teaching and learning Mathematics in high schools.

2.2. Research methods

The research is based on survey results and survey data by observation - investigation methods. The collected data is then compared with the data in a number of published documents with high reliability. The study was carried out in 24 high schools in 7 provinces, representing different regions, with 260 teachers, 40 school administrators and 367 students.

2.3. Research results on the actual situation of using handheld calculators in teaching mathematics in high schools

2.3.1. Survey contents

The survey content aims to obtain information, data and evaluation from teachers, professional administrators and students about the use of handheld calculators in teaching Mathematics.

2.3.2. Survey results

Through investigating the current situation of using handheld calculators in teaching, the researcher of the thesis has obtained and analyzed the following main results regarding:

1- Perspectives on handheld calculators in teaching;

2- Approach to handheld calculators for teachers and students;

3- The use of handheld calculators by teachers and students;

4-Benefits of using handheld calculators in teaching mathematics;

5- Challenges when using handheld calculators in teaching math;

6- The design and use of teaching situations with handheld calculators.

CONCLUSION FOR CHAPTER 2

The results of investigating the current status show that handheld calculators have been used by teachers and students in teaching mathematics, especially since the implementation of the 2006 National Education Program. Based on the study of the current situation of using handheld calculators in teaching mathematics at high schools, the researcher of the thesis finds that the use of handheld calculators in teaching mathematics needs to be further researched, especially on the issue of building exploratory situations in teaching in the environment of using handheld calculators to improve the quality of teaching Mathematics. At the same time, from the difficulties and challenges as well as from analyzing the causes of the limitations of using handheld calculators in teaching mathematics, we draw some research directions for ourselves in the coming time such as proposing measures to include handheld calculators in teaching mathematics in the General Education Program, designing teaching content, and designing teaching materials for teachers and schools.

Chapter 3

BUILDING AND USING SOME EXPLORATORY SITUATIONS IN TEACHING MATHS AT HIGH SCHOOL WITH THE SUPPORT OF HANDHELD CALCULATORS

3.1. Principles for designing exploratory situations

(1) Each situation need to be designed to meet the characteristic requirements of the exploratory situation.

(2) The designed situations should pay attention to all typical situations in teaching Mathematics

(3) The exploratory situation is built so that when organizing teaching, it will create a positive learning environment.

3.2. Building and using some exploratory situations in teaching Maths at high school with the support of handheld calculators

3.2.1. The process of constructing and using the situation

- The process of building an exploratory situation: Prepare to design a situation \rightarrow Design a situation \rightarrow Check and revise a situation.

In the thesis, the researcher focuses on building content in step 2 (Situation design) to clarify the characteristics of the exploratory situation with the help of handheld calculators as follows: Create excitement \rightarrow Stimulate exploration \rightarrow solve problems \rightarrow reinforce application.

3.2.2. Situation group 1: Using a handheld calculator to support calculations, predicting rules, and analyzing problems

This group of exploratory situations is built on an experimental point of view in mathematics, that is: *Experimental mathematics is an approach to mathematics in which numerical computation is used to study Mathematical subject matters and identify properties and laws.*

The researcher has built the following situations:

(1) Exploring the data obtained through calculation

(2) Exploring by method of searching and prediction

(3) Exploring mathematical laws

(4) Using a handheld calculator to analyze the mathematical problem.

In each of the above exploratory situations, the researcher presented the purpose, scientific basis and meaning of the situation, built a situation design diagram and provided illustrative examples.

3.2.3. Situation group 2: Using a handheld calculator to support mathematical modeling activities

The purpose of this exploratory situation group is to exploit the functions of a handheld calculator for use in a variety of ways in the mathematical modeling process. For example, simulations on handheld calculator can be used to develop mathematical models so that students feel the importance of parameters in a model; data from handheld calculators create favorable conditions for data collection to validate models; handheld calculators can also be used to perform math problem-solving in the time-constrained classroom, allowing time for learners to develop skills of constructing and revising models.

Based on the results that have been synthesized and in accordance with the use of handheld calculators in performing mathematical modeling, in this section, the researcher has focused on mathematical modeling in the following two situations:

(1) Constructing and using a model given by the data set representing the change in a discrete variable.

(2) Constructing and using a model given by the data set representing the change in a continuous variable

In each of the above situations, the researcher has built a step-by-step process, given examples to analyze and illustrate,

and built a specific teaching situation (*E.g.* 3.14. Problem Which carpark is lower in parking expenses?).

3.2.4. Situation group 3: Using a handheld calculator to explore mathematical representations

Mathematical knowledge is received by students along the way from vivid visualization to abstract thinking. Using visual a bridge between familiar real-life representations as representations and abstract symbolic representations has been recognized as an effective practice in teaching and learning Mathematics. Exploiting the functions of handheld calculators, the researcher of the thesis proposes a number of situations where a handheld calculator can be used to support representation, convert of mathematical some forms mathematical representation, thereby facilitating the process of exploration and problem solving in students to be implemented more effectively. In this group of situations, the researcher has built the following situations:

(1) Explore the mathematical representation to make judgments:

(2) Exploring the mathematical representation to describe the modeling process

(3) Exploring the mathematical representation to form concepts.

At the same time, a number of measures have been developed to use handheld calculators to support a number of activities to convert mathematical representations: From linguistic representation to symbolic representation; from linguistic representation to visual representation; from visual representation to symbolic representation; and represent an matter in various forms.

CONCLUSION FOR CHAPTER 3

Based on the results of theoretical studies on exploratory teaching and teaching situations; based on the results of the survey on the actual situation of using handheld calculators in teaching at high schools with the benefits and orientations identified for effective use of teaching aids and shortcomings that need to be overcome; in order to supplement or overcome the shortcomings drawn from the theoretical basis and research practice of the topic, the researcher of the thesis has proposed 3 exploratory situations in teaching Maths at high school with the support of handheld calculators.

The proposed situations have ensured a close connection between theory and practice; each situation contains the development of skills in using handheld calculators and, at the same time, the acquisition of knowledge in students. These situations create opportunities for students to demonstrate their own competencies at an increasingly high level after a process of learning and practicing in a learning environment which stimulats initiative and creativity in discovering and mastering knowledge and applying the acquired knowledge into practice. The proposed methods of organizing through by exploratory situations need to be implemented flexibly, regularly and continuously in the teaching process and can be extended to other teaching contents such as geometry, trigonometry, statistics. Other teaching aids can also replace handheld calculators; for example, students can use software with similar functions, or smart phones with calculator app. At the same time there should be a combination with other teaching methods depending on the needs of students. The creative application of the teachers ensures the suitability with the students and the actual conditions of the classroom.

Chapter 4 PEDAGOGICAL EXPERIMENT

4.1. Purposes, requirements, and contents of the pedagogical experiment

The purpose of the pedagogical experiment is to examine the feasibility of applying some exploratory situations in teaching Maths at high school with the support of handheld calculators; and to assess the effectiveness of using handheld calculators to assist students in exploring and solving problems in math, contributing to fostering problem-solving competence for students, and improving the quality of teaching Mathematics.

4.2. Time, process and method of pedagogical experiment 4.2.1. Pedagogical experiment time

Based on the specific requirements of the thesis, we carried out the experiment as follows:

- Experiment Phase 1: School year 2019-2020.

- Experiment Phase 2: School year 2020 - 2021.

4.2.2. The process of organizing the pedagogical experiments

The pedagogical experiment was conducted according to the following procedure:

+ Select experimental and control classes with similar learning quality of students.

+ Train and equip teachers of experimental classes with basic knowledge about handheld calculators, exploratory teaching situations and some exploratory situations designed in the thesis.

+ Organize the lesson design according to the selected content.

+ Teachers teach the experimental class according to the designed lesson plans

+ Observe the classroom, conduct interviews with teachers and students after school to verify and evaluate.

4.2.3. Methods of conducting the pedagogical experiments

a. Contents tobe evaluated

The effect of using handheld calculator-aided exploratory situations on satisfying the objectives of each lesson and topic, through conducting the lesson.

b. Method of assessment

To evaluate the above contents, we use the following tools: Written test; Student survey questionnaire; Interview; Mathematical statistical methods.

4.3. The process of pedagogical experiment

4.3.1. Pedagogical experiment Phase 1

- Time: From October 2019 to December 2019

- Research Design: Quasi-Experiments and Nonequivalent Groups

- Results of the pedagogical experiment phase 1

a) Qualitative results: Initial assessment of the effectiveness and benefits of using handheld calculators in teaching activities.

b) Quantitative results: Organized for students to take a quality test to assess the learning quality of the two classes; the results have been fully synthesized in the thesis.

4.3.2. Pedagogical experiment Phase 2

- Time: From October 2019 to December 2019

- Research Design: Quasi-Experiments and Nonequivalent Groups

- Results of the pedagogical experiment phase 1

a) Qualitative results: For teachers, the design of exploratory situations in teaching has closely followed the objectives of each lesson and applied according to the proposed measures.

b) Quantitative results: Organized for students to take a quality test to assess the learning quality of the 2 classes; the results are fully summarized in the thesis.

CONCLUSION FOR CHAPTER 4

Through the two phases of the experiment, some conclusions are drawn as follows:

1. There is a change in the awareness of teachers and students about the use of handheld calculators in teaching and learning mathematics.

2. The use of handheld calculators to support normal calculations in math learning activities will help students get

fast and accurate results; therefore they can spend more time on activities of detecting, exploring and solving math problems.

3. About the design of exploratory situations in teaching of teachers: through analysis and discussion after reviewing the teacher's lesson design and classroom observation, the obtained results are found to be effective.

4. Students receive learning situations naturally, actively use tools, and solve problems well in each situation.

5. We can affirm that designing and using exploratory situations with the support of handheld calculators can bring about benefits for students and teachers. However, the abuse of handheld calculators can bring about negative effects such as reducing basic calculation skills in students, or making students become too dependent on calculators in the learning process.

CONCLUSION

1. The requirement for using teaching aids to support math teaching in high schools is an urgent issue in the context of current fundamental and comprehensive educational innovation and a trend in teaching in countries around the world. Handheld calculator becomes a tool to access knowledge, a means to analyze mathematical situations, so it is necessary to design and use teaching situations in the environment using handheld calculators.

2. The researcher has given the concept of exploratory situations in teaching mathematics with the support of handheld calculators and has identified the characteristics of exploratory situations.

3. The research has presented 3 exploratory situations in teaching mathematics with the support of handheld calculators and proposed the process and principles of teaching organization with exploratory situations in teaching Mathematics.

4. The proposed situations have ensured the close connection between theory and practice; each situation contains the training of skills in using handheld calculators and the acquisition of knowledge in students, creating opportunities for students to demonstrate their own abilities, stimulating initiative and creativity in discovering, mastering knowledge and applying learned knowledge into practice.

5. Experimental results have confirmed that the exploratory situations and teaching organization process proposed in the thesis have brought practical effects and confirmed the correctness of the proposed scientific hypothesis.

LIST OF THE RESEARCHER'S PUBLICATIONS RELATED TO THE THESIS

- Nguyen Anh Tuan, Nguyen Van Hung (2017), "Explore math problems with the help of handheld calculators". Proceedings of the International Scientific Conference: Developing pedagogical competence of natural science teachers to meet the requirements of reforming general education, Hanoi University of Education, December 2017.
- 2. Nguyen Danh Nam, Nguyen Van Hung (2018), "Graphic handheld calculators A means of supporting Mathematics

teaching in high schools". Vietnam Journal of Education, No. 423, February 2018.

- 3. Nguyen Van Hung (2018), "*The trend of using handheld calculators for teaching and learning mathematics at school.*" Vietnam Journal of Education, Vol. 3, 2018, pp. 43-47
- Nguyen Van Hung (2018), "Benefits and challenges of using electronic calculators for teaching and learning Mathematics in high schools". Vietnam Journal of Education, Vol. 5, 2018, pp. 82-87
- Nguyen Van Hung (2019), "Some measures to exploit and use handheld calculators in teaching mathematics in high schools". Vietnam Journal of Education, No. 460, August 2019.
- Nguyen Van Hung, Nguyen Danh Nam (2021), "Using handheld calculator in teaching mathematics in high schools". Technology and Education, Hanoi National University Publishing House, pp. 249-280.