MINISTRY OF EDUCATION AND TRAINING
VIETNAM INSTITUTE OF EDUCATIONAL SCIENCES

THAI THI NGA

METHOD OF FORMULATING ITEM BANK TO ASSESS PROBLEM-SOLVING COMPETENCY OF STUDENTS IN MATHEMATICS EDUCATION THROUGH ELEMENTARY ALGEBRA MODULE

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Opponent 2: ……

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Opponent 3: ……

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PREAMBLE

1. Reasons of chosing the topic

1.1. In the face of the demand for high-quality human resources to meet the socio-economic development, higher education in general and universities in particular are now proceeding to reform in the direction of formation and broadcasting the development of competency of students.

1.2. Training of education students in the direction of competency approach requires renovation of assessment in the direction of competency approach. For effective assessment, it is necessary to develop, use, manage and develop a set of items, tasks and tools - assessment tools of good quality based on modern measurement theories.

1.3. For students of Mathematics, the problem-solving competency is one of the key competencies that need to be formed and developed in the university. "Problem-solving is not only a tool but also an objective in teach mathematics "(NCTM, 1989) so ask the math teacher to be the person who has the problem-solving competency.

For the above reasons, the author chooses the topic: The method for formulation of item bank for assessment of problem-solving competency of students in mathematics education through elementary algebra.

2. Purpuse of research

Propose a method for formulation of item bank for assessment of problem-solving competency of students in mathematics education (to be illustrated in the former module) to help trainers formulate and use reliable tools in assessment of problem-solving competency of students.

3. Scope of research

The thesis is not designed but selected an available and empty item bank software (Fasttest Software), then focused research, proposed method for formulation of item bank for assessment of problem-solving competency of students in mathematics education through elementary algebra. This item bank will be managed (supplemented, adjusted, rendered for inspection, assessed, etc.) by the above software.

4. Scientific hypothesis

If the proposed method for formulation of item bank for assessment of problem-solving competency of students in mathematics education will help teachers to apply to formulate and use item bank in teaching, assess problem-solving competency of students in mathematics education.

5. Tasks of research

5.1. Summarize some of the theories related to item bank, competency assessment, problem-solving competency.

5.2. Study on the real situation for formulation of item bank for assessment of problem-solving competency in education universities.

5.3. Design of how to construct, manage and use the item bank, illustrated through the basic module.

5.4. Experimental pedagogy to confirm the feasibility of the method for formulation of item bank for assessment of problem-solving competency in education universities.

6. Methods of research

- Research theories: Gathering and analyzing studies on issues covered by the research topic: assessment of patterns, problem-solving, item bank, curriculum framework, Out of the Department of Professional Mathematics, Mathematics, Objectives, and Detailed Program of the Advanced Diploma in Computer Science

- Surveys and observations: A survey on the status of teacher assessment activities, perception and reality of constructing and using the formulation of item bank for assessment of problem-solving competency in education universities.

- Pedagogical experiments: Design the topics from the items compiled, organize the experiment to determine the parameters of the items. Experimental method of constructing item bank to verify the feasibility and effectiveness of the item bank has developed.

7. Contributions of the thesis

- Reasoning: Proposed method for formulation of item bank as a means and tool for assessment of problem-solving competency of students in mathematics education.
- In practice: Lecturers are able to use the dissertation as a reference in their teaching and assessment of the student's performance and can apply the methodology defined in thesis to develop, supplement item bank. Lecterers teaching other modules can refer to the method for formulation of item bank in the thesis to formulate the item bank for assessment of student competency by the module being taught.

8. Defended issues

8.1. Roadmap of problem-solving competency of students in mathematics education schools

8.2. Method of formulating item bank to assess problem-solving competency of students in mathematics education

9. Structure of the thesis

In addition to preamble, conclusion, references and annexes, the thesis includes three chapters:

- Chapter 1: Theoretical and practical foundation
- Chapter 2: Formulation of elementary algebra item bank to assess problem-solving competency of students in mathematics education
- Chapter 3: Pedagogic experiment

CHAPTER 1. THEORETICAL AND PRACTICAL FOUNDATION

1.1 Domestic and foreign research

1.1.1 Research in the world

1.1.2 Research in Vietnam

1.2 Competency and problem-solving competency

1.2.1 Competency

1.2.1.1 Definition

"*Competency is the combination of knowledge and skills with attitudes, emotions, values, motivations, and so on to effectively respond to a complex requirement of activity in a given context.*".

1.2.1.2 Structure of competency

1.2.1.3 Classification of competency

1.2.2 Problem-solving competency

1.2.2.1 Some related definitions

Problem-solving competency is the competency of an individual to effectively utilize cognitive processes, actions and attitudes, motives, and emotions to solve problem situations where process, conventional, conventional solution.

1.2.2.2 Structure of problem-solving competency

1.3 Assessment of competency

1.3.1 Some definitions

Assessment is the process of collecting information and considering the appropriateness of collecting the information obtained with the appropriate set of objective criteria determined to make a decision for a given purpose.

1.3.2 Assessment of competency

Competency assessment is the process of collecting, analyzing, processing, and explaining evidence of student competency development.

1.3.2.1 Purpose of assessment

1.3.2.2 Requirements of assessment

1.3.2.3 Methods and forms of assessment

1.3.2.4 Assessment tools

1.3.3 Formulation of competency roadmap

1.3.3.1 Theory of development region (Lev Vygotsky, 1896-1934)

1.3.3.2 Theory of competency roadmap (Robert Glaser, 1921-2012)

1.3.3.3 Item Response Theory, IRT

1.3.3.4 Process of formulation competency roadmap

Step 1: Definition of competency assessment

Step 2: Determination of components of competency

Step 3: Determination of behaviours, quality standards of each behaviour

Step 4: Draft competency roadmap

Step 5: Design of assessment tools (composition of competency assessment items)

Step 6: Item test

Step 7: Processing data of item test

Step 8: Adjustment of competency roadmap

1.3.4 Assessment of problem-solving competency of students in mathematics education

1.3.4.1 Characteristics of students in mathematics education

1.3.4.2 Problem-solving competency of students in mathematics education

Structure of problem-solving competency of students:

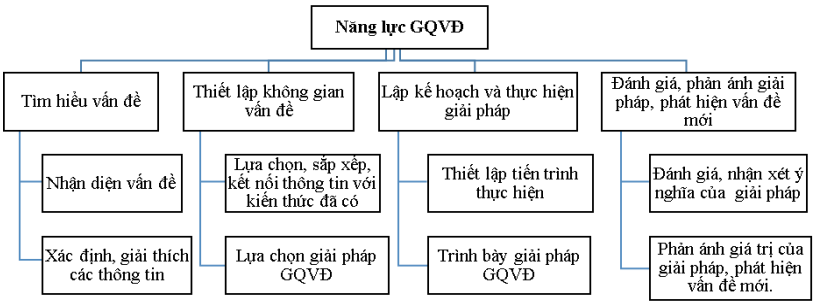

Figure 2.2. Structure of problem-solving competency of students

1.3.4.3 Purpose of assessment of problem-solving competency of students in mathematics education

The assessment is aimed at determination of problem-solving competency of students on the roadmap of problem-solving competency to obtain pedagogic impacts to help students develop their competency in the next time.

1.3.4.4 Assessment contents

Assessment of competencies: competency of understanding problem; competency of setting problem space; problem-solving competency; Competency of assessing, reflecting the solution value and detecting new problems.

1.3.4.5 Methods and forms of assessment

- Method: Essay or practice
- Form: Criteria-based assessment

1.3.4.6 Assessment tools

- Tools of information collection: Items, tasks, tests.
- Tools of measurement: assessment scheme and competency assessment standards shown in roadmap for problem-solving competency

1.4 Item bank

1.4.1 Concept, functions of item bank

1.4.1.1 Concept:

The item bank is a collection of coded items by areas of expertise, objectives to be measured, calibrated in degree of difficulty, discrimination, and managed by software on a computer..

1.4.1.2 Functions:

- Update and record items
- Print out items for review, correction, formatting of tests; correct and update items.
- Remain history of items

1.4.1.3 Advantage of item bank for teaching

1.4.2 Theory for formulation of item bank

1.4.2.1 CTT (Clasical Test Theory)

1.4.2.2 IRT(Item Response Theory)

- Apply IRT for formulation and development of item bank
  + Determine parameters of items, tasks of test
  + Determine competency of students by test results
  + Develop tests: formulate tests under given criteria

1.4.3 Requirements of item bank

- Items in item bank must be scientifically managed.
- Print out tests with different items but still measure equivalence of students.
- Items cover all knowledge of subjects.

1.4.4 Process for formulation of item bank

Introduction of process for formulation of item bank of Harry Hsu

1.5 Actual status of formulation and use of item bank for assessment of problem-solving competency of students in mathematics education now

1.5.1 Survey of actual status

1.5.1.1 Purpose of survey

The survey aims at assessing the actual situation of the examination and assessment of the student's performance in mathematics teaching; The item of assessing the problem-solving competency of students in mathematics education university is a practical basis for proposing the method of building and managing and using item bank to assess the problem-solving competency of students in mathematics education university.

1.5.1.2 Contents of survey

- Examination and assessment for students in mathematics education at education institutions.
- Formulation of item bank for assessment of problem-solving competency of students in mathematics education.

- Teachers' perceptions of the significance of problem-solving competency development for students in mathematics education.

1.5.1.3 Subjects and time of survey

Mathematics lecturers at: Hai Phong University, Thai Nguyen University of Education, Vinh University.

1.5.1.4 Method of survey

- Survey by item notes and intensive interview.

1.5.2 Results of survey

- The assessment of learning outcomes in education institutions is mainly based on the content approach, not on the competency orientation.
- Most of lecturers have not been equipped with knowledge of item bank, most education universities are building item libraries not item bank based on the modern measurement theory.
- Teachers also recognize that problem-solving competency is an important competency for students in mathematics education. Particularly regarding the assessment of problem-solving competency of students in mathematics education, the teachers who are under the survey have said that they have not assessed such competency of students, but only investigate to gradually adjust teaching and assessment activities.

1.6 Conclusion of chapter 1

Educational activities in general and teaching in particular must be oriented towards the goal of formulation and development of learners' competency. Among the competencies that need to be developed for students in mathematics education; with the notion: "problem-solving competency is both an objective and a tool of mathematics teaching and learning", in the thesis, the author select the problem-solving competency assessment.

To assess learner competencies, the assessment approach we investigated is the *development approach*. Each competency can be represented on a continuous roadmap called competency development roadmap; assessment of one's competency at a time is to determine one's position on the competency development roadmap by comparison of their achievements with the behaviour criterion which is arranged on the competency development roadmap at different levels.

The assessment of learners' competency depends very much on the test; the scientific formulation, use and management of item bank is very necessary. However, in actually, most education institutions have not formulated a scientific item bank based on modern measurement theory. Therefore, in this chapter, the author also focuses on the measurement theories: classic and modern measurement theory and their applications in formulation of item bank.

The research results in Chapter 1 are the basis for the author to propose the method for formulation of item bank for assessment of problem- solving competency of students in mathematics education in Chapter 2.

CHƯƠNG 2: FORMUATION OF ELEMENTARY ALGEBRA ITEM BANK FOR ASSESSMENT OF PROBLEM-SOLVING COMPETENCY OF STUDENTS IN MATHEMATICS EDUCATION

2.1 Opportunities for developing problem-solving competency of students in mathematics education through elementary algebra module

2.1.1. Targets of elementary algebra module

- Knowledge: Students can obtain all knowledge of algebra in the mathematics curriculum at junior high schools and high schools.
- Skill: Students get skill of solving algebraic problems at junior high schools and high schools.
- Attitude: Students are active and take initiative in study

2.1.2. Opportunities for developing problem-solving competency by elementary algebra module

2.1.1.1 Polinomial, rational fraction:

- Content related to algebraic transformations can help students develop the competency to implement solutions.

2.1.1.2 Function:

- Functional mathematics have the advantage of being close to reality and can be applied to solve problems in daily life so there are many opportunities to help students develop all four real competencies of problem-solving competency.

2.1.1.3 Solutions of equation, system of equations, inequation, system of inequations:

- In practice, many situations have to be solved by making equations, inequalities, etc., so there are many opportunities for problem-solving competency development, especially the practical competency of understanding the problem.

2.2 Method of formulating item bank for assessment of problem-solving competency of students in mathematics education

Process of formulating item bank for assessment of problem-solving competency of students in mathematics education:

Step 1: Definition of problem-solving competency, determination of component competencies of problem-solving competency

Step 2: Determination of behavior criteria, quality standards

Step 3: Draft students' competency development roadmap

Step 4: Compilation of items

Step 5: Item experiment

Step 6: Processing experimented data, formatting of items

Step 7: Correction of competency development roadmap

Step 8: Correction of items

Step 9: Entrance of items into item bank software

Step 10: Management of item bank (Update, printout, correction of items)

2.3 Formulation of item bank of elementary algebra for assessment of problem-solving competency of students in mathematics education

2.3.1 Definition of problem-solving competency of students in mathematics education, determination of component competencies of problem-solving competency (see 1.1.2; 1.2.4.2)

2.3.2 Determination of behavior criteria, quality standards

Table 2.1. Behavior criteria of problem-solving competency in elementary algebra module

Practical competency	**Behaviors**	**Description**
1. Problem survey	1.1. Problem identity	+ Recognize what the problem is, what kind of relationship and what the relationship between them. + Show the relationship between practical language and mathematic language.
	1.2. Determination and explanation of information	+ Determine elements, understand terminologies included in the problem. + Identify symbol, relation between quantities: variables, functions…
2. Formulate solution of problem-solving	2.1. Select, connect given information with acquired mathematics knowledge	+ Select algebraic knowledge related to tasks: which functions are used, its meanings, presentation: multinomial function, exponential function, logarite function, trigonometric function, … + Imagine the knowledge of a function to implement a solution: use a function graph, a function variation, etc. in a particular case.
	2.2. Select solution of problem-solving	+ Compare models and plans to choose the best solution.
3. Prepare plans and carry out solution	3.1. Formulate the process of implementation	+ Formulate the process of implementation, solve logically targets + Select suitable resources
	3.2. Present solution	+ Exactly perform algebraic transformations on polynomials,

		determinants, and functions. + Carry out the procedure of the function survey, assess the function to find out the maximum, minimum value of the function; Apply function knowledge in specific situations. + Solve skillfully equation, inequation problems. + Briefly and logically describe the algorithms and processes as selected.
4. Assess and reflect solutions	4.1. Assess and comment meanings of solutions	+ Assess whether the solution is optimal or not, whether there is other solution
	4.2. Reflect value of case, solution of problem-solving, detect new problem	+ What do the problem and solution mean for self (which is obtained)? + Recommend the use of solution for similar cases and problems + Detect new problem.

On the basis of component competencies of problem-solving competency as mentioned above, the author recommends quality criteria of problem-solving competency of students in mathematics education as detailed in Table 2.2.

Table 2.2. Quality criteria of problem-solving competency of students in mathematics education

Component competency	*Behaviour criterion*	*Quality standards*
1.Problem survey	***1.1. Problem identification***	1.1.1 Identify some information of the problem but not realize the problem
		1.1.2 Identify most of problem information but not understand the whole problem
		1.1.3 Identify the whole problem
	1.2. Determine and explain information	1.2.1. Determine some initial information related to the objective of the task, but not the relationship between the information.
		1.2.2. Determine the most relevant information for the purpose of the task, understand the value of the information.
		1.2.3. Determine sufficient information relevant to the purpose of the task, understand and explain the value and the relationship between the information.
2.	***2.1. Select, connect***	2.1.1. Select and connect some information of tasks with

Formulate problem space	***given information with acquired mathematics knowledge***	known mathematical knowledge.
		2.1.2. Select and accurately connect information of tasks with known mathematical knowledge.
		2.1.3. Accurately, fully and logically connect information of tasks with known mathematical knowledge.
	2.2. Select solution of problem-solving	2.2.1. Formulate part of solution of problem-solving.
		2.2.2. Formulate most of solution of problem-solving but not actually accurate and logical.
		2.2.3. Formulate specific and clear solutions to solve the problems.
3. Carry out solution	***3.1.Establish implementation process***	3.1.1. Establish an implementation process
		3.1.2. Establish most of implementation process and distribute resources relatively appropriate
		3.1.3. Establish logically process, select suitable distribution of resources
	3.2.Present solution	3.2.1. Only present some contents of solution, not fully or logically
		3.2.2. Present most of solution of problem-solving logically but not solve the problem yet
		3.2.3. Present fully, accurately and logically steps under solution of problem-solving.
4. Assess, reflect solution	***4.1. Assess solution***	4.1.1. Know to comment the solution but not accurately and centrally.
		4.1.2. Comment and assess accuracy of solution.
		4.1.3. Comment and assess the solution logically and persuasively.
	4.2. Reflect value of solution, detect new problem	4.2.1. Know to reflect and determine some knowledge obtained from process of problem-solving.
		4.2.2. Reflect and determine some knowledge obtained from problem-solving, recommend solution for similar problem.
		4.2.3. Possibly detect new problem by summarization, specialization… from solved problem.

2.3.3 Draft roadmap for development of problem-solving competency of students in mathematics education

Table 2.3. Draft roadmap for development of problem-solving competency of students in mathematics education through elementary algebra module

Level	Content
1	Students can identify simple situations, understand information in the matter, solve simple problems.
2	Students can detect a problem in an unfamiliar context and understand the problem in clear form, and possibly solve the problem with specific requirements.
3	Students can understand the given problem with clear or implicit information in an unfamiliar context. Select information, mathematize situations with clear issues, select solutions to solve problems, present solutions in a clear and logical way without complicated situations. Students know how to assess solutions, comment on problems without complicated problems.
4	Students can systematically understand complicated situations to find out relevant information, quickly process information for problem-solving, and think to find out good solution which satisfies given requirements. Well perform complicated solutions, good computing competency. Know to assess solution, comment problems, detect new problems.
5	Students can handle a variety of situations effectively, develop strategies during the process of situation survey, and capture all information in a disjointed, diversified, formative manner; formulate multi-step and complicated solution but flexible and monitor them during the implementation. Possibly detect new problems, new situations from the solved problem by specialization, generalization, ... of problem situation.

2.3.4 Compilation of tasks/items

2.3.4.1 Preparation of item matrix

The thesis prepares 96 tasks/items in 2 chapters: Function and graph; Equation, system of equations, inequation, system of inequations (Annex 1). Items are distributed in 4 practical competencies, each includes 24 items under the competency development roadmaps as follows: Level 1: 12 items; Level 2: 24 items; Level 3: 24 items; Level 4: 24 items; Level 5: 12 items. (Table 2.4)

Table 2.4. Item matrix

Component competency	Content	Level 1	Level 2	Level 3	Level 4	Level 5	**Total**	*%*
1. Problem investigation	Function and graph	5	4	2				
	Equation, system of equations, inequation, system of inequations	1	7	3	2			
	Total	6	11	5	2		**24**	*25*
2. Set up problem	Function and graph	2		4	4			

space	Equation, system of equations, inequation, system of inequations		7	2	3	2		
	Total	2	7	6	7	2	**24**	*25*
3. Solution implementation	Function and graph	4	4	6				
	Equation, system of equations, inequation, system of inequations		2	7	1			
	Total	4	6	13	1		**24**	*25*
4. Assessment, reflection of solution, detection of new problem	Function and graph				7	4		
	Equation, system of equations, inequation, system of inequations				7	6		
	Total				14	10	**24**	*25*
Total		**12**	**24**	**24**	**24**	**12**	**96**	*100*
	%	*12,5*	*25*	*25*	*25*	*12,5*	*100*	

2.3.4.2 Compilation of items

Each item is designed to measure a behavior indexes as outlined in the competency structure diagram; each task is designed / located in three axes:

- First axis: Practical case
- Second axis: Overview idea/mathematics content
- Third axis: Level of competency to be measured

The item difficulty is significantly influenced by four factors: type of item (closed item, open item), item context (situation in/other than mathematics), thinking level (multi-step) and level of calculation.

Example 2.3 *(Item 16, Annex 1)*

Duty: **"JOURNAL PUBLICATION"**

Thien Nam Publishing House is publishing a fashion magazine. The cost of printing x magazine (including: staff salary, employees, printing paper, ...) is given by: $C(x) = 0,001x^2 - 2x + 100000$ *unit: thousand VND. The cost per issue is VND 4,000. Expected selling price: 24,000 VND / magazine. Revenues include the sale of magazines and the $ 90 million received from advertising and media assistance.*

What is the average cost for a magazine? What is the lowest average cost, when publishing so many magazines?

To solve this problem, students firstly have to understand the information in the situation; however, this information is relatively simple and easy to understand. In order to find a solution, students need to mathematize the information: the average cost for a magazine = the cost of publishing a magazine + the cost of publishing.

Find the lowest average cost corresponding to finding the smallest value of the function representing the average cost.

So, this item selects the assessment of competency of setting problem space.

2.3.4.3 Formulation of item assessment rubric

2.3.5 Item test

2.3.5.1 Purpose of test

Collect data to determine important parameters: difficulty, distinguishing… of items. đ

2.3.5.2 Subjects of test:

160 second and third-year students in mathematics education of 3 universities: Hai Phong University, Thai Nguyen University of Education, Vinh University

2.3.5.3 Content of test

The thesis gives 32 items for students in mathematics education through knowledge of Function and Graph. Test structure: each test includes 8 items consisting of 4 practical competencies (level 1: 1 item, level 2: 2 items, level 3: 2 items, level 4: 2 items; level 5: 1 item). Duration: 120 minutes

2.3.5.4 Organization of experiment

- Provide instruction for lecturers to make coded rubric of marks.
- Collect coded data, enter data in CONQUEST software for analysis of items of assessment scheme of problem-solving competency.

2.3.6 Processing experimented data, formatting of items

After experiment, the author processes data by CONQUEST software, prints out results: parameters of items, estimated competency of every student, specific function graph of items, function of item information, …

2.3.7 Modification of roadmap for competency development

The roadmap for problem-solving competency is modified as follows:

Level	Content
1	Students can: detect, understand problem-contained information in a practical situation with information given in a clear, familiar context; solve the problem with simple algebraic model.
2	Students can: detect problems in practical situations with clear information, unfamiliar contexts; find out the corresponding algebra model to describe the problem, select the solution to solve the problem; Know the use of algebraic knowledge to implement the solution but not flexible, when the problem is difficult, there is no solution or solution is

	often incorrect.
3	Students can: detect problems in practical situations with unclear information, unfamiliar contexts; be proficient in using algebraic models in mathematical problems; Point out the solutions and choose the optimal solution to solve the problem; present logical solutions, close argumentation; Know to comment, assess the completed solution.
4	Students can: investigate complex situations to find out relevant information; Quickly process information to find out a problem solution, assess to choose a good solution to solve the problem; When facing with difficulties or mistakes, it is possible to adjust the plan to suit the current context; Assess the solution taken, the meaning of the problem situation.
5	Students can: systematically learn complex situations to find out relevant information, quickly process all information when information is given sporadically, diversify form to find out solution; formulate multi-step and complex but flexible plans, and monitor them during implementation; assess comprehensively the problem, detect new problems from the problem just resolved by specialization, generalization, ... of the solved problem.

2.3.8 Modification of items

Within the time frame and content of the thesis, the author formats 4 items: 11, 12, 19, 20 by testing 40 students of Hai Phong University, including 8 sentences, in which four items have been formatted and remain its numeric value b, connected to such four items (Test No. 2).

Upon such formatting, 32 items are recorded and managed by FASTTEST software.

2.3.9 Enter items into item bank software

The items shall be recorded in Workspaces, with the item bank named by the author as DSCSPT, divided into 4 folders: COMPETENCY 1, COMPETENCY 2, COMPETENCY 3, COMPETENCY 4, each included sub-folders as: CONTENT 1, CONTENT 2, CONTENT 3. Such sub-folders shall consist of items with the following parameters:

- Identify items (*Identifier*):
- Contents of items (*Text*): Enter items.
- Information of items (*information*): author, item source, date of creation, response to items.
- Data statistics (*statistics*): record item parameters

2.3.10 Management of item bank

2.3.10.1 Modification, addition or deletion of items

- **Addition of items:**

To update a new item into the software, the item must first be tested to analyze, calibrate, specify the required parameters.

After analysis of the items, continue to update the items in the software under the Workspaces \ Items bank \ Item \ New item and enter the necessary data into the software.

2.3.10.2 Output management: printout test forms

From the item bank, it can print out the tests based on the matrix to be used for testing and assessment. The software allows creation and printout of test in forms such as .text or .pdf files for editing and printing.

2.4 Conclusion of Chapter 2

In chapter 2, the author proposes the method of formulating the item bank to assess students' competencies with a 10- step process and how to perform each step. The method is illustrated by the formulation of item bank for elementary algebra to assess the problem-solving competency of students in mathematics education.

As stated in Chapter 1, in order to address problem- solving competency, it is required to formulate the roadmap for problem- solving competency; therefore during the formulation of the item bank of Chapter 2, it is included the process of formulating the roadmap for problem- solving competency of students in mathematics education.

The roadmap for problem- solving competency of students in mathematics education is drafted by the author on the basis of researches, references and modified upon test of items, data processing by CONQUEST software based on the modern measurement theory.

The items in the item bank are used by the author using a variety of situations with practical elements, not just within the context of mathematics but in the direction of solving the real situation with the purpose of each situation being a problematic situation for the learner.

Through the CONQUEST software, the rendered data includes:

- Item parameters: Difficulty, Distinction, competency, etc. These parameters help assess the quality of the items, manage items and use items in the testing and assessment of the competencies of the students.
- Graphs: Function specific items, item functions, test information functions, etc., as the basis for designing the test subject with assessment objectives.
- Estimate the potential competency of the student, chart the appropriateness of the item and student competency as the basis for the corrected item, and adjust the competency development roadmap drafted.

The software for management of item bank is selected as FASTTEST 2.0 software that allows: updating, adding items; Modify item content, delete item; Test results meet the diverse needs of users: content knowledge, competency level, graph information function, ...

With the aim of proposing the method of item bank building, the tasks / items in chapter 2 are just examples of the method so the thesis only builds 96 items with the contents of two chapters: Function numbers and graphs; Equations, invariants, systems, and systems of inequality in elementary algebra. The empirical study on the feasibility of item bank building method will be tested by the author in Chapter 3.

CHAPTER 3: PEDAGOGIC EXPERIMENT

3.1. Purpose of experiment

Test the feasibility of the method of item bank building for assessing the problem solving competency of undergraduate students in Mathematical pedagogy; The impact of using problem solving item bank in the teaching process and elementary algebra assessment.

3.2. Subject of experiment

15 lecturers of Mathematics Faculty, Hai Phong University.

10 thrid-year students in mathematics education, Hai Phong University.

3.3. Contents of experiment

- Lecturers: Take a number of steps in the item bank building process: compiling items, testing items, checking results. Then, comment on the feasibility of the item bank formulation.
- Students:

  + Take 01 test at the beginning of the Function chapter.

  + Be introduced with the problem-solving competency, conduct the study as instructed by the lecturers in the direction of problem-solving competency.

  + Take 01 test of the end of the Function chapter (as required for a given problem-solving competency from the item bank formulated in Chapter 2).

3.4. Experiment organization

3.4.1. Regarding lecturers

3.4.1.1.Step 1: Provide lecturers with training method on formulation of item bank for assessment of problem-solving competency

3.4.1.2. Step 2: Some steps in the formulation of item bank

3.4.1.3. Step 3: Collect lecturers' opinions of the method on formulation of item bank for assessment of problem-solving competency of students in mathematics education by some items.

3.4.2. Regarding students

3.5. Assessment of experiment results

3.5.1. Regarding teachers

After discussion with teachers, we obtain some opinions as follows:

- **Regarding method of formulating item bank for assessment of problem-solving competency of students in mathematics education**: All the teachers said that the process of formulating item bank for assessing the problem solving competency of students in mathematics education mentioned in the dissertation is suitable and feasible in the teaching practice. University teaching, this process can be implemented with other modules and other competency assessment.

- **Regarding quality of items used for problem-solving competency through elementary algebra module:** The items are in roadmap with the principles and requirements set out. Many items are built with real-world situations that help students gain access to competency assessments, better understand the meaning of math in life, and create excitement in student learning. However, some teachers think that it is necessary to add more challenging items in order to assess students who are capable of solving problems at a high level.
- **Regarding impacts of item bank on teaching activities:** The majority of teachers concur that the item bank has a positive effect on teaching activities of teachers. Through the assessment of problem solving competency of students, teachers can identify the problem solving competency of each student, from which there is the exchange of experience in the professional team about teaching activities. To teach, to work out corrective measures in time should contribute to improve students' problem-solving competency.
- **Regarding advantage and difficulties when the item bank is formulated and used:**

Advantage: In the thesis the items were processed by CONQUEST software, the parameters of the items were determined. Difficulties, competency, etc.,. helped teachers in assessment and teaching. Item bank is managed by FASTTEST software with friendly interface, helping teachers to use easily and effectively.

Difficulties: The process of building a item bank closely, need to learn many complex theory, it takes a lot of time and effort.

3.5.2. Regarding students

Comparison of problem-solving competency of 10-student group after 2 assessments by similar tests is shown in figure 3.6.

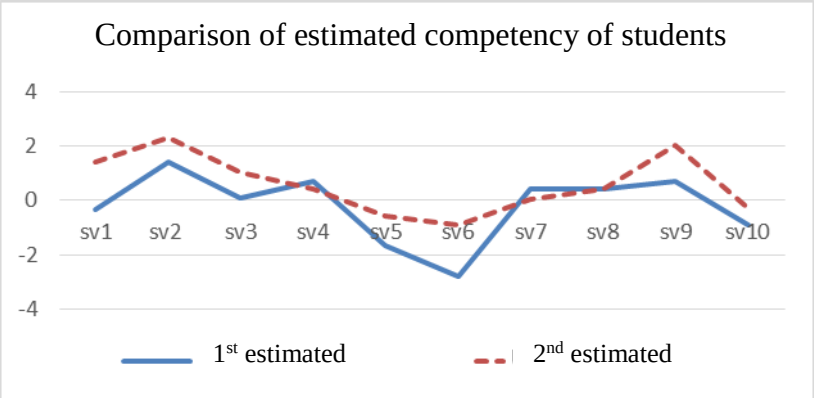

Figure 3.6. Comparison of student's estimated competencies

Thus, through the influence of some pedagogical measures, some students have higher problem solving competency than before. These are the initial results showing that the item bank assesses competency effectiveness for university teaching activities.

3.6. Conclusion of chapter 3

- The method for formulation of item bank for assessment problem- solving competency of students in Mathematical education is suitable for lecturers who teach mathematics at education universities used in practice..
- The item bank management with FASTEST software with friendly interface, save items in many levels, large storage space, has many test output options to help faculty access and easy to use for assessment purposes from time to time.

CONCLUSION

The purpose of the thesis is to design a method to build the problem solving competency of mathematical university students contributing to the process of teaching and evaluating students' competency development. Through various research methods dissertation has obtained results:

1. Clarify the thesis-related theories, including: Clarify the concept of competency, problem solving competency, competency assessment, problem- solving item bank.

2. Proposing the problem-solving competency structure, the problem-solving competency of mathematics university students as a basis for this student competency assessment..

3. Recommending 10-step process to formulate the item bank for assessment of problem-solving competency of stuents in mathematics education and method of use and management of such item bank.

4. Formulating 96 items through primary algebra of the two chapters: Functions and Graphs; Solving equations, inverse equations, systems of equations, systems of inequality; Experiment 32 items of Functions and Graphs with the sample of 160 students. Using CONQUEST data processing software to get the required parameters of the item while the correction of the roadmap for problem-solving competency development problem solving has been drafted. Items that meet the requirements of the item bank are updated and managed using FASTEST's software, which allows users to easily submit tests for use in teaching and assessment.

5. Due to the limited time frame, the author only tested and updated the item bank with 32 items solving competency of Mathematics University student. In order to obtain a complete item bank, elementary algebra instructors can apply the above procedure to further supplement and update the item. Instructors who teach other modules may apply the formulation of an item-and-answer bank in a thesis to build a item bank to assess a student's competency.

THE RELEVANT WORKS OF THE AUTHOR RELATED TO THE THESIS

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2. Thai Thi Nga (2015), *"Some measures of improving quality of advanced mathematic result assessment of students in economics under credit training system at Hai Phong University"*, Scientific Magazine, Hai Phong University, No. 10, p. 90-96.

3. Thai Thi Nga (2016), *"Establishment of problem-solving competency of students in Mathematics Education"*, Journal of Education Science, No. 132, p. 36a-38.