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USING MATHEMATIZATION TO DEVELOP STUDENT'S QUANTITATIVE LITERACY COMPETENCIES

Nguyen Thi Tan An

Department of Mathematics, College of Education,
Hue University, Hue, Vietnam
e-mail: tanan0704@gmail.com

Abstract

Quantitative literacy, an ability to apply quantitative ideas in new or unfamiliar contexts, is essential for any individual who wishes to participate fully in democratic society. The quantitative literacy competency is described in terms of six sub-competencies by Niss (2003) and Turner (2011), these are communication, representation, using symbolic, formal language and operations, reasoning and argument, ana lysing and constructing mathematical model, devising strategies. This paper reports the results from an empirical study, which has evaluated student's development quantitative literacy sub-competencies in the mathematization environment that situations have the same complexity. For this purpose, we designed mathematization situations, constructed a measure of complexity of situations and a rubric to grade student work, taught experiment, collected and analyzed data. Result shows that some group of students are in advance clearly, but some are in only a little or not clearly. In addition, the progress of sub-competencies is seen through each week.

1 THEORETICAL FRAMEWORK

1.1 What is mathematization?

The term mathematization is used in many ways. In the mathematical modeling perspectives, mathematization is a step in the modeling process, which

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transforms the real model into a mathematical model (Blum and Leiß, 2006).

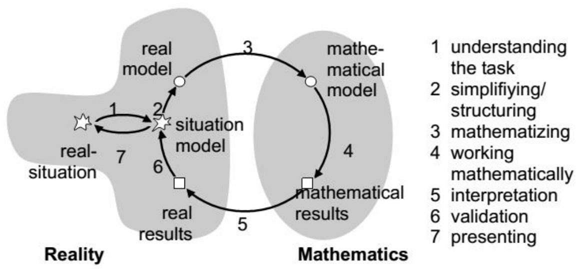


Figure 1. Modeling cycle from Blum and Leiß (2006)

Meanwhile, in the PISA mathematics framework, mathematization is the process students use the mathematical knowledge and skills they have acquired through schooling and life experiences to solve real-life problems (OECD, 2009).

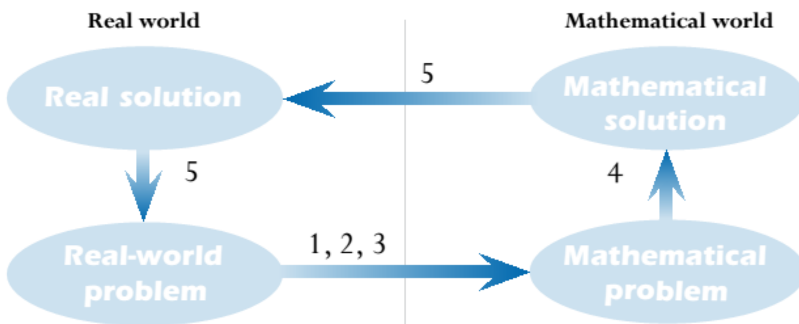


Figure 2. The mathematization cycle from PISA (2009)

This process starts with a problem situated in reality. The problem solver tries to identify the relevant mathematics, gradually trims away reality and transforms the real-world problem into a mathematical problem that faithfully represents the situation. Then solving the mathematical problem and making sense of the mathematical solution in terms of the real situation. So, in this way, mathematization was presented as the entire mathematical modeling cycle.

However, in grade 10 Vietnamese textbook, most of mathematical tasks (91,89% in Advanced series) are "purely" mathematics, not set in real-world context. In the remaining tasks, context is just a "shell", mathematical requirements set out explicitly for students to apply the knowledge have been learned. Therefore using mathematization process starting with a real-world situation will be difficult for students because they are not accustomed to solving such situations. Furthermore, theoretic and empirical researches have shown the difficulties when using real-world situations in mathematics classroom such as students lack real-world knowledge related situations and transition experience between mathematics and reality in both directions, teachers are difficult to predict students' solving and guide them in the resolution process (Blum, 2011). So to fit the program and limit the difficulties mentioned above, we are interested in the mathematically oriented real-world situations, which we call the mathematization situations.

Mathematization situation comes from extra-mathematical world which on the one hand still contains essential features of reality but on the other hand has already been simplified, idealized, specialized and provided more appropriate informations, conditions, assumptions according to teacher's intention and interests so that it allows for an approach with mathematical means.

To solve a mathematization situation, students need to select an appropriate mathematical model, work in the mathematics environment, then interpret and validate the result in the initial context, sometimes this process must be iterated until there is a reasonable result. These are the main steps of the mathematization process shown in the diagram below:

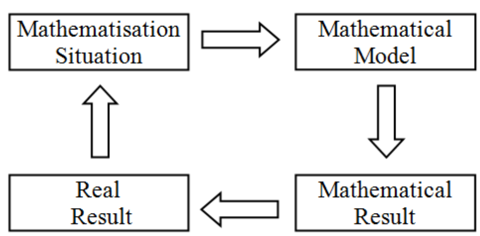


Figure 3. The mathematization process using in this study

1.2 Quantitative literacy competencies

Quantitative literacy is the ability to identify, understand, and use mathematical knowledge effectively in the quantitative situations of everyday life (Hallett, 2003). The competencies needed for QL include problem tackling, modeling, reasoning, representing, symbol and formalism, communicating (Niss, 2003 and Turner, 2011).

Problem tackling: means to be able to detect, formulate, delimitate and specify different kinds of mathematical problems, and be able to solve such mathematical problems in their already formulated form.

Modeling: means to be able to analyse existing models and assess their range and validity. On the other hand, the competency involves building a mathematical model to situations beyond mathematics itself.

Reasoning: means to be able to think logically, explore and link problem elements in order to make inferences from them, and be able to check a justification that is given or provide a justification of statements.

Representing: means to be able to understand, choose, utilize and switch between different kinds of mathematical representation and be able to understand the reciprocal relations between different representational forms of the same entity, as well as their strengths and weaknesses.

Symbol and formalism: means to be able to translate back and forth between the mathematic symbol language and natural language; and be able to utilize symbolic expressions base on having an insight into the nature of the "rules" of formal mathematical systems.

Communicating: means to be able to interpret mathematical expressions or "texts", and be able to express oneself about mathematical matters precisely, present the solution, explanation or justification to others.

2 METHODS

2.1 Design situations

According to Steen, Turner, Burkhart (2007), a student can achieve high levels of QL when working with simple problems and low levels when solving complex problems. Therefore, to assess the QL levels of students accurately, we realized that the QL competencies should be measured in situations having the same complexity. So we developed a complexity scale of mathematization situations with 3 levels, based on 5 elements - familiarity of context, amount of given information, number of elements have to transfer into mathematics language, techniques of calculation, amount of given guidance.

After that, we designed 4 mathematization situations involving quantitative elements with medium complexity level (level 2), and relating to three contents: quadratic functions, inequalities and trigonometry in triangle. Then they were piloted in many class to check how tasks worked in practice and if it was enough time for student to solve. Based on the feedback, we improved the situations, such as adding or cutting down information, giving more instructions, replacing words or adding explanations to help students understand situations better.

2.2 Teaching experiment

The study was carried out with 46 students in grade 10A2 Dang Huy Tru High School, Huong Tra district, Hue city. Teaching experiment started near the end of the school year. At that time, students could use their existing knowledge in mathematization settings. 80.43% of the participating students had average scores on math higher than 6.5. It shows that most students grasped math knowledge and skills they had learnt. The class was divided into 12 groups of 3 to 4 students and maintained throughout the experimental period.

Teaching experiment was done in four consecutive weeks, one situation a week. Each situation was conducted within 30 minutes, groups carried out tasks independently without any assistance from teacher or researcher. Students' work was used to analyze, evaluate and compare the development of QL competencies. In addition, observation and interviews were also used throughout the experimental period to support the analysis process .

2.3 Assessment

In 2009, The Association of American Colleges and Universities (AAC&U) published a rubric which is used for assessing undergraduate student learning in Quantitative literacy as evidenced in students' electronic portfolios. In this study, our QL assessment rubric is an adaptation of the AAC&U's rubric to make it applicable to grading student work. The rubric is intended to measure achievement levels of QL competencies in a variety of mathematization assignments. To develop the rubric, we have modified the core competencies and have rewritten the descriptors so that it is more appropriate to our research's purpose. The progress of each competence expresses through four levels, at four stages of the mathematization process. Based on the rubric, we score groups' competencies for each situation, then using statistical methods to analysis. We also have made a pre-test and a post-test with mathematization situations to assess the growth in students' QL competencies across the research.

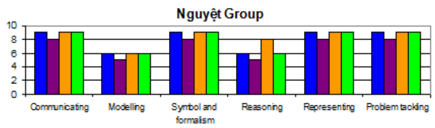
3 RESULTS

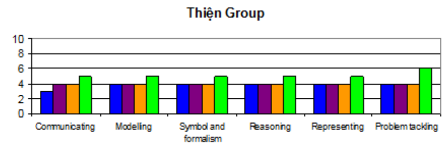
3.1 The development of the groups' QL competencies

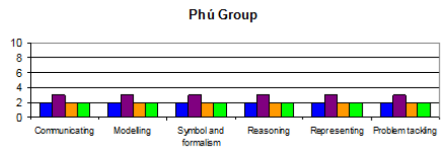
The groups' QL competencies develop in different ways, and can notice following three trends:

a. The groups with little change in the direction of development

For all situations, some groups developed a suitable mathematical model, solved math problems correctly and explained the result reasonably such as Nguyet group; some groups used a correct model with a wrong solution method, or a correct method with an incomplete mathematical model like Thien group; some groups only converted some not all informations to math languages, so they generated incorrect or incomplete models, therefore six competencies have low score such as Phu group.

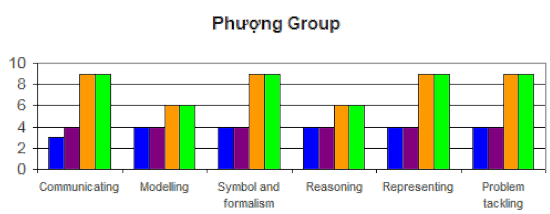






b. The groups with change in the direction of development

In the first two situations, cooperation among members of these groups was not good, students did not have much experience with resolving such situations. Therefore they could not complete their solution, even their mathematical model and method were correct so competences' score were low. But in the next 2 weeks, the progress was evident as they tried to complete the problem-solving step, explained math results in mathematization situations, but they still did not consider the reasonableness of the results and other possibilities of situations.



c. The groups with inexplicit change in the direction of development

For example in this case is Hoa group. In situations 1 and 2, they built appropriate mathematical models but not found a method to solve the problem, or used the wrong formula led to wrong results. Then, they chose a wrong model to represent for situation 3 so competencies' score went down that week. However when dealing with situations 4, this group showed improvement compared with the previous situations, by offering a suitable solution as well as recognizing the limitations of mathematical models they built.

3.2 The development of QL competencies expressed through 4 experimental situations

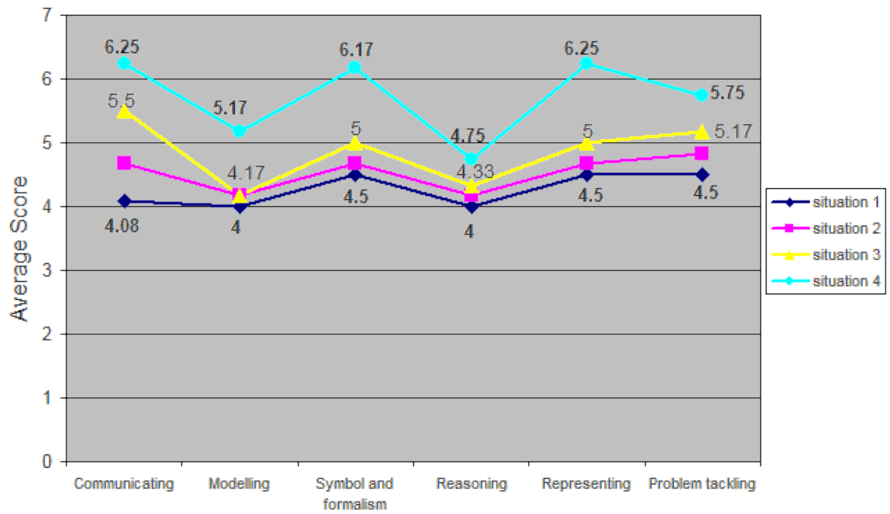


Figure 4. QL competencies expressed through 4 experimental situations

The graph shows that QL competencies develop each week, but growing trend of each is not the same. The most developed competencies are communicating, from 4.08 to 6.25, and representing from 4.5 to 6.25. These demonstrates that students' abilities such as understanding the situation, using appropriate representations to build the mathematics model, expressing solution, as well as answering the question of situation increase through this research. The least developed competencies are modeling and reasoning, because students often ignore considering the real factors affecting to results, as well as understanding the scope and limitations of the model was built. This can be explained because reflection is a rather new and difficult require for students, they often have not enough time to do this, in addition to their views are just finding out results. Symbol and formalism competence also make progress. At first, some groups have the right solution method but not go to the final results or not transfer mathematical result to real result. However, through teacher's reflection after each situation, this competence show improvement. The development of problem tackling competence is shown in selecting appropriate methods to solve the mathematical problem and checking result's satisfaction with the informations in the initial situation.

4 CONCLUSION

The following conclusions can be drawn from this study:

Four weeks is too limited for teaching experiment, however from the evaluation results it is obvious that mathematization situation are not too difficult for most students. Furthermore, experiment shows that the mathematization process using in this study is suitable and feasible because students can take the steps (1) - (3) without much explanation and guidance from the teacher, but they do not still have the habit and skills to make reflection on initial situation.

Research also show that we can use mathematization situations to develop students' QL competencies. Particularly, competencies in communicating, symbol and formalism, representing tend to grow faster than competencies in reasoning, modeling, problem tackling because they do not relate to reflection ability. In addition, the instability of progress indicates that longitudinal processes are necessary in order to provide a solid base for steady improvements.

If we really want to convince our students that mathematics is important for everyday life, students need to have chance to work with these kinds of examples on a regular. But first students need to master related mathematical knowledge and skills. Besides, situations need to put in many different contexts to reflect the diversity of life. Work in groups also support the development of QL competencies through exchange, presentation, interpretation, comments among the members.

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