DEVELOPING STUDENTS’ MATHEMATICAL COMPETENCE THROUGH EQUIPPING THEM WITH NECESSARY KNOWLEDGE ABOUT METACOGNITION- AND ACTIVITIES IN TEACHING MATHEMATICS IN SECONDARY SCHOOL

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INTRODUCTION

Metacognition (awareness): Flavell (1979) conceptualized metacognition consisting of three closely related components: Metacognitive knowledge: A person’s understanding of cognitive processes, his or her sense of self or other people’s cognitive abilities. Metacognitive knowledge helps learners have an overview and comprehensive view of the learning process, their own strengths and weaknesses, and methods to overcome or support conditions for learning. Therefore, metacognitive knowledge plays an important role in task performance. It can help learners select, evaluate, rethink or cancel cognitive tasks, goals and strategies, thereby limiting difficulties or missteps in problem solving.

Metacognitive experiences: These are the experiences obtained from the cognitive process or the influencing factors accompanying the cognitive process. It is the experience of success or failure when solving a task and the learner’s awareness of it before, during, or after performing a new task. According to Flavell (1979), metacognitive experiences often appear in important and complex situations that require the learner to be seriously conscious, pondering to make decisions. Metacognitive skills: Including executive skills such as planning skills, adjusting and monitoring skills, and evaluation skills.

Super cognitive skills

Along with the concept of metacognition, authors around the world have had in-depth research on metacognitive activities and skills. According to Veenman et al (2014) metacognitive skills are associated with process metacognitive knowledge. Metacognitive skills are understood as the ability to monitor, direct, and adjust an individual’s learning or problem-solving behavior. Metacognitive skills are demonstrated through orientation, goal setting, planning, monitoring, and evaluation skills. Metacognitive skills directly shape learning behavior and thus influence learning outcomes. Veenman and colleagues estimate that metacognitive skills determine 40% of an individual’s success in problem solving. The researchers wanted to find out what learning activities are typical for metacognitive skills. For example, Pressley and Afflerbach (1995) distinguish about 150 different metacognitive activities carried out while reading, while some researchers have come up with a list of 65 metacognitive activities for problem solving. physical problem. Veenman (2011) has attempted to present a general description of the type of activity that is considered representative of the metacognitive skill, that is, to spot the difference between activities and to apply them in a systematic way, proactive, appropriate at 3 times: at the beginning, during the implementation and at the end of the task performance.

At the start of the task, the individual can perform activities, such as reading and analyzing the task, activating prior knowledge, setting goals, and planning. The individual conducts these activities in preparation for performing the assigned task. Activities that characterize metacognitive skills during task performance include planning, monitoring and controlling plan execution, recording, and managing time and resources. These activities help individuals to orient and control task performance smoothly. At the end of the task process, activities such as assessing the individual’s performance against the set goals, drawing conclusions, summarizing and reflecting on the learning process. The function of these activities is to evaluate and interpret the results of the individual’s task performance, thereby
helping the individual to learn from his/her own activities to conduct similar activities in the future. According to Veenman (2011), metacognitive skills in different domains are different.

**METHODOLOGY**

Authors mainly use experience in math teaching together with description, synthesis and explanatory methods to present this study.

**FINDINGS**

By equipping them with necessary knowledge about metacognition and organizing application activities in theoretical teaching of high school mathematics. Basis In order for students to be able to perform metacognitive activities in learning Mathematics, before organizing students to practice these activities, the first thing is that they need to have the necessary understanding of metacognition (in relevance). Therefore, in the process of teaching Math, teachers need to pay attention to implicitly equip students with metacognitive knowledge, which is cleverly “integrated” in math learning activities.

Within the scope of mathematics education in high schools, students' mathematical competence will be fostered and developed in the whole process of understanding and learning Mathematics; through cognitive and metacognitive activities. Studies on metacognition show that: metacognition is considered as “cognition and cognitive process”, plays a supervisory role in the entire problem-solving process - here, the problem is “first and foremost”. The first thing that students need to understand theoretical knowledge of Math is that students need to understand theoretical knowledge of Math. Because metacognition can only have and work well when students have enough knowledge of necessary math skills, starting with learning theory to have understanding as a basis for metacognition should master the theory. Math theory is a "necessary condition" for students to perform metacognitive activities in situations that require the application of more knowledge and higher thinking ability (solution of math problems and problem-solving of difficult situations).

From the results of analysis of the influence and manifestation of cognitive and metacognitive activities on the development of mathematical competence, it can be seen that in learning Mathematics, students conduct closely linked cognitive and metacognitive activities, interweave and intertwine. In which metacognitive activity is expressed in Math learning situations, first of all, learning theoretical knowledge (including concepts, properties, theorems, rules, and mathematical methods). On the other hand, to perceive mathematical knowledge in abstract theoretical form requires students to need very important metacognitive activities - especially creativity, knowing how to choose, adjust approaches and thinking direction as well as optimizing the process of accessing, discovering and creating mathematical knowledge.

The theoretical basis can be seen that: metacognition plays an important role in thinking activities and the whole process of mathematical perception, thereby affecting the formation and development of mathematical competence; through main activities in learning and applying Math - are problem solving activities when students learn theory, solve math problems and apply it to solving practical problems. Metacognitive activities in parallel with cognitive activities are "carriers and means" for students to practice and develop the 5 components of Mathematical Competence.

From the orientation of applying metacognitive theory to develop mathematical competence for students through Mathematics, it is clear that the theoretical teaching situation (concepts, properties of theorems and rules - mathematical methods) is the "environment” school” should first be exploited to focus on affecting the components of Mathematical Competency when students acquire mathematical knowledge - as a basis for application inside and outside of Mathematics. According to Nguyen Ba Kim (2017), when approaching the teaching of Mathematics, one can divide into 4 situations of teaching Mathematics (concepts, theorems, rules - methods and problem solving). Accordingly, it is possible to see more clearly the characteristics and teaching methods in each type of Math teaching situation. However, in practice, often in each lesson and therefore, students' learning activities are
conducted in a combination of all kinds of theoretical learning activities and applying math problems.

On the other hand, in the content program of Mathematics in junior high school, four situations of teaching Mathematics have been presented in an integrated form suitable to the characteristics of students and teaching conditions. Therefore, in this thesis, we only divide (relatively) into two types of situations to apply metacognitive theory: teaching math theory and teaching problem solving (inside and outside of Math). And Hoang, N.T., Huy, D.T.N. (2021) emphasized education including math will be an advantage for students to work for foreign units in future. Refer to Tran Vui (2014) and Nguyen Anh Tuan (2002), here we approach learning Math theory from a problem-solving perspective, in which students need cognitive activities. and metacognition to detect and solve the necessary “problems”, namely: In learning “mathematical concepts”, problems for students to discover and solve are:

What is the concept of a group of mathematical objects that share those properties? How is it defined? What is internal and external? How does that concept relate to known concepts? How to identify and express this concept? In learning “mathematical properties and theorems”, the problems that students can detect and solve are:

- What phenomena do certain mathematical objects have in common? Is it a correct rule? How is it proven and stated? How is that property related to known properties? How to recognize and use this property?

In learning “mathematical rules and methods”, the problem that students can detect and solve is:

- For the “quite similar” problems encountered in some situations, is there a common way to solve them? Can a resolution process be found? What are the steps to solve? How to recognize and apply this process?

Note that: Learning theory so that students can grasp mathematical knowledge is always associated with applying that knowledge to solving math problems, solving related problems in other subjects, in practice. life. Therefore, here the division between learning theory and solving math problems is only relative.

**Content and method of taking measures**

**Example:**

Cases for teaching mathematical concepts: After students have learned the concepts of "natural numbers", "integers" (Math 6), "rational numbers" (Math 6, Math 7), "real numbers" (Math 6, Math 7), Math 7, Math 9). Teachers organize a systematization to consolidate and identify relationships between sets of numbers by:

**Step 1:** The teacher makes a request to compare, distinguish, find a relationship between the numbers learned (with the necessary suggestions to guide and organize students to recognize and understand cognitive activities and metacognitive: (exposed students to situations containing metacognitive activities). Awareness:

- Activities to identify and represent each type of number when learning: natural number N; integer Z; rational number Q; real number R.

- Consider each relationship between two number concepts individually: for example, between natural numbers and integers (grade 6); integers and rational numbers (grade 6); rational and real numbers (grades 7, 9).

**Metacognition:** Revisiting the cognitive process to master and make necessary adjustments when learning a new number: N Z Q R

**Step 2:** The teacher assigns tasks (requires analysis and gives examples), organizes and guides students to practice metacognitive activities (individually or in groups): Compare, differentiate and find the relationship between each pair (N and Z); (Z and Q); (Q and R). Detail:
In grade 6: Learning and calculating situations with integers, students need to readjust the old concept of subtraction of 2 natural numbers \(a - b\) when \(a < b\). In learning and calculating situations with rational numbers, students need to readjust the old concept of division of two integers \(a/b\) when \(a\) is not divisible by \(b\).

In grades 7, 9: Learning and calculating situations with real numbers, students need to readjust the old concept of exponentiation and roots, ...

### Table 1. Orientation and adjustment activities when learning new number concepts

| Natural number → Integer | To overcome \(a - b\) \((a < b)\) | Integers have some characteristics that are different from natural numbers | Calculations with integers have some characteristics that are different from natural numbers |
|--------------------------|-----------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Integer → Rational number| To overcome \(a/b\)                | Rational numbers have some characteristics that are different from integers | Calculations with rational numbers have some characteristics that are different from integers |
| Rational number → Irrational number | To overcome \(a^2 = 2\) ... | Irrational numbers have some characteristics that are different from rational numbers | Calculations with irrational numbers have some characteristics that are different from rational numbers |

By 9th grade, students follow and review the entire process of learning numbers to have an overview of the number system learned in junior high school:

students develop mathematical communication capacity through activities of expressing implied relationships between sets of numbers in the form of inclusion formulas \(N \subseteq Z \subseteq Q \subseteq R\); as a Venn diagram; divide the concept of numbers according to the system tree, ...

**Figure 1.** Venn diagram of the relationship between the sets of numbers \(N, Z, Q, R\)

**Source:** Search data.

**Figure 2.** Number system in junior high school math

**Source:** Search data.

Step 3: The teacher gives situations (questions, exercises) for students to self-apply their understanding and metacognitive skills along with familiar cognitive activities in the problem-solving process:

- They use the same method (for the above sets of numbers) to ask questions, give examples for concepts and rules:
Group 1: equations, first-order equations, quadratic equations, equations containing implicit in the sample, equations containing roots.

Group 2: monomial, polynomial, fraction.

Group 3: functions, first order functions, quadratic functions.

Group 4: 4 operations (+; ; ; /) with natural numbers, integers, rational numbers, irrational numbers.

When done with the above cognitive and metacognitive activities to consolidate knowledge about number systems and expressions; Constan; equation; ... students practice and develop their math ability through the process of answering questions, solving exercises with the corresponding activities as follows:

- Ability to think and reason mathematically: When conducting thinking and reasoning activities.

Mathematical communication competence: When performing mathematical sign language activities to communicate with teachers and peers.

- Mathematical modeling competence: When teachers give tasks to solve problems with practical content or ask students to self-study and collect practical problems related to mathematical knowledge (such as real-life situations where negative numbers are needed).

- Capability to use Math learning tools and means: When carrying out activities using hand-held calculators, math learning aids and facilities to perform calculations.

- Problem solving capacity: through activities in each step of solving problems encountered.

Detail:

1. In order to apply metacognitive theory to the organization of mathematical learning activities, teachers need to master the theory of teaching each situation (teaching concepts, teaching properties, theorems and teaching rules - methods), research to detect cognitive and metacognitive activities included in the teaching steps mentioned above. On that basis, the teacher implements:

   - Integrating and equipping students with some necessary knowledge about metacognition - in which focus on 3 important metacognitive activities and skills: orientation and planning, monitoring and adjustment, evaluation Math learning process.

   - Implement exercises and guide students to perform metacognitive activities (when possible) in each mathematical theory learning situation.

When equipping students with some understanding of metacognition, teachers follow a three-step process as follows:

Step 1: teachers build Math learning situations containing metacognitive activities and expose them to students; teachers analyze and suggest guidance for children to recognize and understand metacognitive activities there (focusing on 3 activities of orientation and planning, monitoring and adjustment, evaluation).

Step 2: The teacher assigns tasks, organizes and guides students to practice metacognitive activities (individually or in groups).

Step 3: The teacher gives situations (questions, exercises) for students to self-apply their knowledge and metacognitive skills along with familiar cognitive activities in the problem-solving process.
Based on the theoretical framework of Artzt and Armor-Thomas (1992), we have designed the process of organizing cognitive and metacognitive activities in learning Mathematics; concretize with 5 steps of theorem teaching process. Here, referring to the teaching situation, we build a teaching situation for the Tale of Theorem to organize metacognitive activities as follows: (table 2).

Table 2. Illustrating the 5-step process of teaching Ta-Let’s theorem

| Steps | Teacher activities | Students activities |
|-------|-------------------|---------------------|
| 1: Exposure to the situation, mobilize relevant knowledge to grasp the problem (perception). Including: Read (1) and Understand the problem (2) | Ask and guide students to perform cognitive activities | Each student draws any triangle ABC, drawing the mean line MN. Identify and compare ratios $\frac{AM}{AB} \quad \frac{AN}{AC} \quad \frac{AM}{MB} \quad \frac{AN}{NC} \quad \frac{MB}{AB} \quad \frac{NC}{AC}$ |
| Problem: What if MN is not a moving average? | Each student draws another triangle ABC, takes any point M on side AB, builds a line d through M and is parallel to the base side BC, cuts side AC at N. Measure the lengths of the line segments AM, AN, MB, NC, AB, AC and compare the length ratios between them $\frac{AM}{AB} \quad \frac{AN}{AC} \quad \frac{AM}{MB} \quad \frac{AN}{NC} \quad \frac{MB}{AB} \quad \frac{NC}{AC}$ |
| 2: Problem analysis (cognitive) structuring the problem (metacognitive) by prompting students to re-evaluate the problem... | So are the obtained results sure or not? | Define the problem: If ... then the ratios ... are equal? |
| In addition to the known result (the property of the median line in the triangle), what if expanded: when MN is just a line parallel to the base edge of the triangle? | What if MN is not just a mean (variable) but some line parallel to the base of the triangle? Are the above ratios correct? |
| From those specific cases... What if a general generalization for all cases draws the parallel line MN? | Continue to test the line MN like that and then measure, predict (probe): is it true that if we just draw the line d like that ... then we always have $\frac{AM}{AB} = \frac{AN}{AC} \quad \frac{AM}{MB} = \frac{AN}{NC} \quad \frac{MB}{AB} = \frac{NC}{AC}$? |
| Hints (motivation and interest) to help students plan responses | Students ask questions, plan to find out (affirm, prove) whether the prediction is true or false? |
| 4: Perform problem solving (cognitive and metacognitive). In which, the teacher suggests to guide students: Deploy (6a). | Suggested Answer (Prove - if possible) | Prove or draw the result and admit |
| Requires re-examination of thought processes, reasoning | Step-by-step review of activities (metacognition) |
| Evaluation of true - false; rationality, optimal performance | Adjust existing limitations (metacognition) |
| Express the results obtained in the form of features, theorems | State the results in the form of theorems according to their own understanding (variety - metacognition) |
| Hiding into mathematical communication activities (with teacher and friends, in group activities) | Organize students in group activities with necessary prompts for students to perform cognitive and metacognitive | activities group study in class |

In the above situation, through cognitive and metacognitive activities to learn and apply Talent’s theorem, students can practice and develop Mathematical competence through problem solving with activities. respectively as follows:
• Ability to think and reason mathematically: When analyzing, comparing, predicting properties, finding ways to prove, ...

• Mathematical communication ability: When conducting activities to express in mathematical sign language to state theorems, ask and answer communication questions with teachers and friends.

• Mathematical modeling ability: When teachers give tasks to solve problems with practical content or ask students to self-study and collect practical problems related to Tales theorem.

• Ability to use math tools and means: When conducting activities using hand-held calculators, measuring tools, calculating ratios...

• Problem solving capacity: through the activities shown in each step of solving the above problems.

**Example**

Teaching situation “Second congruent case of triangle”

The teacher puts on the computer screen a drawing describing the “real-life” situation:

- Students work on “mathematical modeling” to bring up the problem for triangles.
- Students (perceptual activity) answer: Measure the sides DE, DF, D'E', D'F', angle D, angle D'.

- The teacher poses a problem-provoking situation for students to think and reason:
- So, with these measured factors and comparing them to be equal, is it possible to confirm that the two triangles are congruent?
- Then how is the length of EF determined? (metacognitive activity when adjusting goals and orientations from the requirement to determine the EF length to the “indirect” problem of determining the equality of two triangles...).
- After introducing the interstitial angle, the teacher can give a few more examples of the interstitial angle, the teacher guides the students to draw a triangle when
knowing the lengths of the 2 sides and the included angle. Here, using cognitive activities, students practice skills in using tools and means to learn Math.

- The teacher gives the exercise to draw triangle ABC knowing the elements as the picture.

![Diagram](image)

- Teacher: How can we draw this triangle?
- Did you try drawing the two sides first? Students (cognitive activities) use tools and means (rulers) to construct BC, BA. But wondering about the position of the second edge?
- Teacher: When two sides BA and BC are available, how to construct angle \( \angle ABC \)?
- students (metacognitive activity): Detecting dc is difficult in that it is adjusted so that the second edge matches the requirement of angle \( \angle ABC = 85^\circ \).
- The teacher suggested guiding the students to look back and change the direction of "preconstructing the angle \( \angle ABC = 85^\circ \)" (metacognitive activity) ... from which they construct the ABC.
- Teacher: How to construct a triangle when knowing the two sides and the included angle (the activity of re-evaluating the process and drawing conclusions)?
- Teacher: Assign tasks (cognitive activities) to students to draw \( \triangle A'B'C' \) with \( A'B' = 4\text{cm}; B'C' = 5\text{cm}, \) angle \( B' = 85^\circ \) (with 2 sides and the included angle is equal to \( \triangle ABC \))

![Diagram](image)

The teacher suggests that students measure the sides and remaining angles of two \( \triangle ABC \) và \( \triangle A'B'C' \), then comment on the congruence of the two triangles? (cognitive activity)
• Teacher: So can we answer the question raised at the beginning of class? (Mathematical modeling competence).

• The teacher suggests and guides students to draw conclusions and state properties: If 2 triangles know 2 pairs of sides and the pair of included angles are equal, then those 2 triangles are congruent (Mathematical communication ability).

• Continue the teaching steps in the lesson (proof, apply the properties learned) (Problem solving ability).

CONCLUSION
The measure has exploited the advantages of metacognitive theory in combination with methods and techniques of teaching Mathematics to influence the 5 components of mathematical competence that need to be developed for junior high school students through Mathematics with Typical situation: Teaching theory.

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Developing students’ mathematical competence through equipping them with necessary knowledge about metacognition- and activities in teaching mathematics in secondary school

Desenvolvimento competência matemática dos alunos através de equipá-los com conhecimentos necessários sobre metacognição e atividades no ensino de matemática no ensino médio

Desarrollo de la competencia matemática de los estudiantes equipándolos con los conocimientos necesarios sobre la metacognición y las actividades en la enseñanza de las matemáticas en la escuela secundaria.

Resumo
A teoria da metacognição tem se interessado em pesquisa desde os anos 70 do século XX no mundo. Percebe-se que o processo de pensamento, percepção e metacognição dos alunos e competência matemática é um dos focos da pesquisa sobre educação matemática. No entanto, o problema que sempre interessa aos pesquisadores da educação matemática é como desenvolver a competência matemática? Quais fatores influenciam esse processo de desenvolvimento de capacidade? Como apoiar os alunos a se tornarem melhores solucionadores de problemas matemáticos, especialmente em matemática? Para encontrar soluções para os problemas acima, uma série de estudos no mundo e no Vietnã têm focado na relação entre metacognição e resolução de problemas; Ao mesmo tempo, encontrar maneiras de aplicar a metacognição no processo de ensino de matemática. Este estudo tem como foco o objetivo de desenvolver competências dos alunos; Especialmente para o objetivo de desenvolver competência matemática para estudantes do ensino médio através da Matemática, é preciso pesquisar e explorar o pensamento e fatores cognitivos na aprendizagem de Matemática para encontrar soluções para superar esses problemas.

Palavras-chave: Metacognição. Alunos. Ensino de matemática. Métodos de ensino.

Abstract
Metacognition theory has been interested in research since the 70s of the twentieth century in the world. It can be seen that the thinking process, perception and metacognition of students and mathematical competence is one of the focus of research on mathematics education. However, the problem that is always interested by researchers in mathematics education is how to develop mathematical competence? What factors influence this capacity development process? How to support students to become better math problem solvers, especially in math? To find solutions to the problems posed above, a number of studies in the world and in Vietnam have focused on the relationship between metacognition and problem solving; At the same time, find ways to apply metacognition in the process of teaching mathematics. This study focuses on the goal of developing learners’ competencies; Especially for the goal of developing mathematical competence for high school students through Mathematics, there is a need to research and exploit the thinking and cognitive factors in learning Mathematics to find solutions to overcome these problems.

Keywords: Metacognition. Students. Teaching mathematics. Teaching methods.

Resumen
La teoría de la metacognición ha estado interesada en la investigación desde los años 70 del siglo XX en el mundo. Se puede ver que el proceso de pensamiento, la percepción y la metacognición de los estudiantes y la competencia matemática es uno de los focos de la investigación en educación matemática. Sin embargo, el problema que siempre interesa a los investigadores en educación matemática es ¿cómo desarrollar la competencia matemática? ¿Qué factores influyen en este proceso de desarrollo de capacidades? ¿Cómo apoyar a los estudiantes para que se conviertan en mejores solucionadores de problemas de matemáticas, especialmente en matemáticas? Para encontrar soluciones a los problemas planteados anteriormente, una serie de estudios en el mundo y en Vietnam se han centrado en la relación entre la metacognición y la resolución de problemas; Al mismo tiempo, encuentre formas de aplicar la metacognición en el proceso de enseñanza de las matemáticas. Este estudio se centra en el objetivo de desarrollar las competencias de los alumnos; Especialmente para el objetivo de desarrollar la competencia matemática para los estudiantes de secundaria a través de las matemáticas, existe la necesidad de investigar y explotar los factores de pensamiento y cognitivos en el aprendizaje de las matemáticas para encontrar soluciones para superar estos problemas.

Palabras-clave: Metacognición. Estudiantes. Enseñanza de matemáticas. Métodos de enseñanza.