Applying Metacognition in Teaching and Learning in Math Lessons in Secondary School a Study in Tuyen Quang Province, Vietnam

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Abstract

Research objective: This study is designed towards the goal of assessing the actual situation of applying metacognition in the process of teaching and learning Mathematics in secondary schools, then, proposing appropriate measures for developing mathematical competence.

Research method: In this study, we conducted a survey by using questionnaire, observation, in-depth interview. The survey was conducted at 5 secondary schools in Tuyen Quang province (Y La Secondary School; Phan Thiet Secondary School; Hung Thanh Secondary School, Le Quy Don Secondary School, and Nong Tien Secondary School). Survey subjects include: 7 education experts, 30 teachers of Mathematics at secondary schools, 100 students in 9th grade. After obtaining survey data, we used mathematical statistical methods to calculate the percentage for each level. From there, make comments and suggestions. Survey period: January 2020 to April 2020.

Research results: research showed that there was a percentage of teachers and students who apply metacognition in the teaching and learning process. However, the activities of applying metacognition in both teachers and students are not regular, there is no habit of using metacognition as a thinking tool. Therefore, students' results have not made significant progress in math ability, as well as low learning outcomes in Math. In the last part, the study suggested 4 measures for applying metacognition in the process of teaching and learning Mathematics, aiming to develop students' mathematical ability.

Key Words: Metacognition, Mathematical Competence, Mathematical Thinking.

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Introduction

Metacognition is increasingly attracting the research interest of psychologists and educators. Over the past four decades, research on metacognition has gone beyond the fields of psychology and pedagogy, appearing more and more in education research in general and math education in particular (Schneider and Artelt, 2010).

Metacognition is a term used to refer to an individual's understanding of cognitive functioning and strategies for carrying out cognitive activities. This term refers to the act of thinking about thinking or perceiving perception. In the cognitive process, activities such as orientation and planning, monitoring, adjustment, and evaluation are cognitive activities.

Researches on the role of cognitive skills in the development of students' competence focus on two basic components: knowledge of individual thought processes and monitoring and control of individual activities in the learning process.

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Teaching with metacognition (as a tool - a higher-order thinking method in the cognitive process) would contribute to the development of students' competencies and help promote a more positive and effective teaching environment.

The mathematical process of individual activities from study to work is taking place strongly in the early years of the 21st century, requiring learners to learn more and more mathematics than the mathematics provided by the school for them (Kuzle, 2011). Today, math topics taught in schools no longer focus only on calculation skills, but focus on developing the necessary competencies for learners.

In Vietnam, although there have been quite a few research works to improve and innovate the method of teaching Mathematics from many purposes, tools and methods at different levels of study, but it can be seen that:

In fact, in teaching Mathematics, teachers often focus on conveying knowledge content and practicing basic skills to solve math problems. The problem of developing mathematical competence - including problems in thinking, students' ability in the whole process of learning and applying Math, has limitations in both approach and implementation method... needs to be removed, fixed.

Approaching from the theory of metacognition in teaching Mathematics, there are a number of PhD theses in educational science on metacognition in Mathematics, by the authors: H.X. Binh (2019), L.B. Duong (2019), H.T. Nga (2020), P.V. Thuy (2021).... mainly focused on training metacognition skills for students, initially effective in a number of subjects and levels.

However, studying the current situation of Mathematics in secondary schools, we found that the exploitation and application of metacognition theory is still not focused in most of the math lessons in secondary schools. On the other hand, the results of interviews with Math teachers show limitations in both knowledge and skills in applying metacognition in the process of teaching Mathematics. These problems need to be paid attention and overcome, especially before the requirements of implementing the 2018 Math program, according to which, the ability to think, perceive and apply mathematics (specified in 5 components of the mathematics competency) is considered an important goal of learning Mathematics.

The learning process can be viewed as creating meaningful expressions of knowledge learned through internal learning processes; on the other hand, also through the intermediary activities including self-awareness, self-criticism, self-monitoring and self-regulation. These are the same processes at the core of metacognition, but this approach to learning is not easily transferable. Many students come to school not really ready to achieve cognition and self-cognition.

Therefore, the Math performance of secondary school students, regardless of the current level of "score and test results" achievement, is necessary and can be enhanced by combining, exploiting and using cognitive strategies and metacognition.

Approaching and exploiting metacognition in this aspect can help students actively participate in the process of discovering and mastering knowledge and skills in Mathematics, forming and developing necessary competencies (especially mathematical competence and cognitive abilities and metacognition) for success in lifelong learning and application of Mathematics.

In this study, the author focuses on assessing the actual situation of applying metacognition to teaching and learning activities of Mathematics in secondary schools. From there, make suggestions for the development of mathematical competence of secondary school students.

Methodology

Research Objectives

This study is designed with the aim of assessing the actual situation of applying metacognition in the process of teaching and learning Mathematics in secondary schools, then, proposing appropriate measures for the development of students' mathematical competence.

Subject and Period of the Study

Survey Period: January 2020 to April 2020.

Survey location: 5 secondary schools in Tuyen Quang province (Y La Secondary School; Phan Thiet Secondary School; Hung Thanh Secondary School, Le Quy Don Secondary School, Nong Tien Secondary School)

Survey subjects: 7 education experts (currently Professor, Associate Professor and PhD who have been working and doing research related to the field of education), 30 teachers of Mathematics at secondary schools participated in the survey; 100 students in grade 9 (due to the Covid-19 epidemic situation, the survey subjects and sample sizes

were considered to ensure reliability and ensure epidemic prevention and control).

Content of the Research

Find out about the understanding of teachers and students about the theory of metacognition, as well as the situation of exploiting metacognition in teaching Mathematics.

Find out the limitations in applying metacognition to developing mathematical competence for students today.

Search for effective measures to apply metacognition in developing students' mathematical competence.

Tools and Methods of Surveying

- Survey method by questionnaire: Using survey form with closed and open questions to collect feedback from teachers and students. The form is designed to be used for face-to-face and online surveys. The number students responded was 118, and 100 answers were collected (after removing invalid answers).
- Observation method: Observation through time attendance, class participation (online form) (from each school randomly chooses to attend 1 period); see a random student's graded test (choose any 20 papers/school).
- In-depth interview method: To capture more information for survey work, we conduct in-depth interviews and discussions with education experts, teachers and students. The results of the in-depth interviews complement the statements.

Implementation

This study was carried out to determine the current status of secondary mathematics subject and requirements for the development of mathematical competence for students today; and the reality of applying metacognition in the process of teaching and learning mathematics in secondary schools. The research process is shown in the following steps:

Step 1: Form a research team

Step 2: Research, find out the content related to secondary math and requirements to develop math capacity for students today; applying metacognition in the process of teaching and learning mathematics in secondary schools.

Step 3: Discuss the contents of the questionnaire to be used in the survey; discuss group issues of concern when discussing and consulting with teachers and education experts. Unify the contents for the survey.

Step 4: Conduct a survey on the application of metacognition in the process of teaching and learning mathematics in secondary schools.

Step 5: Consult with educational experts and teachers on related issues during the implementation of the case study.

In the survey, for each specific group, we have specific purposes:

- *For Educational Researchers*

We would like to have an answer about: at present, in secondary schools, what are the advantages and disadvantages of teaching Mathematics with the development of students' mathematical ability? In applying metacognition in the current process of teaching mathematics in secondary schools, what do we need to change?

From the assessment of the situation, next, we discuss with educational researchers about the idea of measures for applying metacognition to develop mathematical competence of secondary school students.

- *For Math Teachers at Middle School*

We discussed with teachers, as well as through questionnaires, to know more about teachers' thoughts and opinions about the current Middle School Math program, and the application of metacognition in teaching Mathematics for the development of students' mathematical ability.

To conduct the research, we conducted regular discussions, as well as participated in the process of validating the teaching practice of teachers in schools. The group of education experts includes 01 professor of educational science, 01 associate professor who directly teaches secondary school students Mathematics, 01 associate professor who manages the training program for pedagogical students. Reviews of these experts are conducted regularly, improving the efficiency of the research process, helping the author to have reliable and scientific judgments for the research problem. This process allows experts to assess the accuracy of the research process and ensure the reliability of the results.

Data Analysis

We had interviews with 7 education experts, 30 teachers of Mathematics at secondary schools participating in the survey; 100 students in 9th grade. During the research, we used digital devices to support image and sound recording. Analysis through inductive classification to analyze the answers of educational experts, teachers. Interview documents of research participants are divided by questionnaire for each group of respondents.

2.2. Result of the Research

2.2.1. The Current Situation of Applying Metacognition to Develop Students' Mathematical Ability

- *Review from Students*

In applying metacognition, the data shows that the percentage of students who think that it is necessary to plan before solving math problems is 19%, while 68% of students consider it unnecessary, 13% of students think that depending on the problem, they decide to plan or not.

Ask students about having teachers guide to plan before solving math problems. As obtained, 45% of students said that their Math teachers had instructions on how to plan math solutions regularly, 26% of students said that teachers sometimes guide them to plan math problems, 21% of students said that teachers rarely guide them planning. 8% of students said that they were not guided by the teacher to make a study plan, problem solving, asked in-depth questions about the students who were not guided by the teacher, the students had a common opinion that the main reason was that their teacher was not interested in planning before solving.

Using metacognition in monitoring and adjusting cognitive activities, 46% of students said that it is necessary to think about their own math-solving activities, only by doing so can avoid many mistakes and efforts; 29% of students said that they sometimes look back at the thinking steps and the math solving steps; 25% of students said that they almost didn't review the problem solving steps, didn't think about whether the solving steps were done wrong, did not intend to check to modify to avoid mistakes.

Using metacognition in assessment, the obtained data shows that 53% of students think that evaluating the process of solving math problems and solving math problems is necessary; 27% of students regularly self-assess their math learning and problem solving; 6% do it sometimes; 14% of students are not interested in evaluating the results of math problems or the process of solving math problems.

In order to be able to monitor, follow and adjust their own thinking during the problem solving process, 32% of surveyed students said that they would check each step of the solution and recheck the entire solution after solving the problem; 41% of students need the support of others to be able to monitor and adjust their own thinking in the process of solving math problems. After solving the problem, 57% of students will check the rigor and accuracy of the solution, 17% of students will find another solution, 5% of students intend to relate the problem solution to reality and they would see if the problem and the solution are consistent with reality or not; 5% of students said they would expand the problem. Most students will learn knowledge and experience of solving math problems from the process of solving problems that teachers require. However, only 80% of students have learned lessons for themselves even though they have thought about how to learn Math and their ability to solve math problems.

The data obtained from the study showed that, although metacognition was not mentioned and did not appear explicitly, but metacognition was applied by students in the process of learning Mathematics at secondary level.

Most of the children are aware that activities including orientation and planning, monitoring and adjustment, and assessment have an important influence on their ability and results in Mathematics. Students have applied the components of metacognition in the process of solving math problems.

- *Reviews from Educational Experts and Teachers*

Question about teachers' understanding of cognitive impairment: we received, 18/30 (60%) teachers said that they understood metacognition as higher-order perception, rethinking their own thinking; 9/30 (30%) teachers answered that they have learned and understood that metacognition is a form of higher-order thinking, but cannot explain or describe more specifically; Meanwhile, up to 3/30 (10%) teachers expressed surprise because of the term metacognition, they themselves do not understand about metacognition. Thus, it can be seen that, among the 30 teachers asked, there are still some teachers who know about metacognition but not fully, while up to 6/30 teachers do not know and are not interested in this issue. However, after we described more carefully about

metacognition, as well as its functions and components, then, all the teachers said that, although before, they did not give a complete concept about metacognition, but the application of metacognition in the teaching process has been done by teachers.

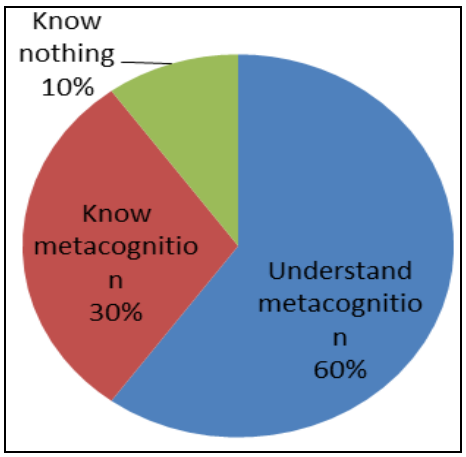

Diagram 1. Teacher's level of understanding about metacognition

Find out how teachers think about the influence of metacognition activities on students' thinking and cognitive processes? We got the results:

Table 1. Teachers' opinions on the influence of cognitive skills on students' thinking and cognitive processes

Opinion	Percentage %	Quantity
Monitor cognitive process	37	11
Adjust cognitive processes	30	9
Evaluate thought process	20	6
Evaluate ways of thinking	13	4

After that, the research team had discussions and shared with teachers about metacognition, especially its components and influences. At that time, all teachers recognized and understood more fully about metacognition. This will help us in the later stages of conducting pedagogical experiments.

The research team wants to find out more deeply, whether teachers have understanding about the role and meaning of applying metacognition in teaching Mathematics? We got:

Table 2. Teachers' opinions on the role and meaning of metacognition in teaching Mathematics

Opinion	Percentage %	Quantity
Help students orient and plan for math learning in a scientific and active way.	17	5
Help students self-assess their results and adjust their math learning.	23	7
Help students track the math learning process to choose appropriate learning methods.	13	4
Another opinion	47	14

The results show that only 5/30 (17%) teachers think that metacognition helps students orient and plan for scientific and active math learning; with 7/30 (23%) said, thanks to metacognition, students will know how to self-assess their learning activities, thereby adjusting their learning style more appropriately; With 4/30 (13%) teachers consider metacognition to help students track the math learning process and from there, students know how to choose appropriate learning methods. However, choosing the option is different from 14/30 (47%) teachers said that metacognition not only has a role in an option in the answer sheet, metacognition has an important role and meaning in the activity. In the learning process of students, metacognition not only helps students orient and make a scientific study plan, metacognition also helps students improve their ability to self-assess their own learning process, from which, students know they need to change the way of learning, to choose the appropriate learning method.

Evaluation of the current situation of applying metacognition in teaching Mathematics. We got the following survey results:

Table 3. Actual situation of applying metacognition in teaching Mathematics

Metacognition activities	Often		Occasionally		Rarely		Never	
	Qty	%	Qty	%	Qty	%	Qty	%
Help students orient their math learning activities	17	56.7	8	26.7	4	13.3	1	3.3
Help students make a plan to study Math	16	53.3	7	23.3	5	16.7	2	6.7
Help students monitor and adjust math activities	13	43.3	9	30.0	5	16.7	3	10.0
Help students evaluate the results of learning Math	10	33.3	12	40.0	7	23.3	1	3.3

The results showed that teachers often used metacognition to help students orient their learning activities with a high rate (56.7%), sometimes (26.7%), (13.3%) rarely. Only 1/30 (3.3%) teachers have not used metacognition in this activity.

For the content of applying metacognition to help students make study plans, there are (53.3%) regular teachers, (23.3%) occasional teachers. However, there are still (16.7%) teachers saying that they rarely use metacognition to help students make study plans, and (6.7%) teachers ignore this activity.

As for the application of metacognition to help monitor and adjust students' Math activities, we found that there are (43.3%) teachers regularly helping students use metacognition to monitor their own learning process, as well as students themselves will discover inappropriate problems about the way they learn Math, through which students will find ways to change and adjust their own learning style. With (30%) teachers sometimes answer; (16.7%) Teachers give options rarely. And there are 3/30 (10%) teachers did not do this activity.

With the content of applying metacognition to help students evaluate the results of their math learning, we found that there are (33.3%) teachers regularly using metacognition as an effective tool to help students know how to self-assess and evaluate their peers. These teachers added that, they see the role of metacognition as very important for the way students learn, assessment is no longer an activity separate from the learning process but it becomes an integral part of the whole learning process, assessment is also learning; with the rate (40%) teachers only guide the use of metacognition for this activity at an occasional level, we understood that this is a limitation that needs to be overcome soon. In-depth questioning of this group of teachers, we learned, many teachers said that it is not that they are not interested in this issue, basically the group of students they teach has a good sense of learning, they have trained students regularly. In the past and now, many students in the class they taught already know how to apply metacognition in learning activities, especially in assessing learning activities, so teachers sometimes need to help students in this activity. Thus, it can be seen that, although the teacher's assessment is at an occasional level, the nature of the teacher and student has performed this activity relatively well. However, there are still 7/30 (23.3%) teachers answering rarely and 1/30 (3.3%) teachers saying never.

2.2.2. Difficulties in Applying Metacognition in Teaching and Learning Mathematics

To find out more specifically, what are the current difficulties teachers are facing in applying metacognition to teaching Mathematics? We used questions with closed and open answer options. Results:

There are 21/30 (70.0%) teachers have the same opinion, students at secondary level have limited knowledge, thinking and awareness, so the application of metacognition in the teaching and learning process needs to be done each step by step, it is necessary to create a habit with students gradually, students cannot receive an abstract concept of cognitive problems but need teachers to transmit it through learning activities, fun activities integrated with problem solving.

With (56.7%) teachers said, the content of Mathematics was abstract and difficult for students of this age. Meanwhile, teaching content such as teaching concepts, theorems, math exercises, practical problems. Thus, in order for teachers to apply metacognition in these teaching and learning activities, each teacher himself needs to be supported such as training, referencing sample lectures, and being suggested on how to take measures facing different teaching topics.

With (21.0%) teachers said that the time for each teaching content is a limitation for teachers and students when applying metacognition, usually when applying metacognition in teaching and learning activities, there usually be more steps. For example, helping students to make study plans or problem solving, students regularly monitor their own learning activities, regularly evaluate, self-adjust... Therefore, the learning time for each content is often longer than that of traditional teaching methods.

In addition, there are also (36.7%) teachers saying that each teacher has limitations in understanding and applying metacognition in teaching, as well as limited pedagogical ability to convey ideas and learning methods to students.

Exchange and Discussion

Consulted 7 education experts and 30 teachers teaching Math during the current situation survey. In order to develop students' math competence, education experts and teachers said, we should follow the competency framework set forth by the

Vietnamese Ministry of Education and Training in the 2018 General Education Program, including: ability to think and reason mathematically; mathematical modeling competence; mathematical communication competence; ability to use tools and means of learning Mathematics; mathematical problem solving ability. However, experts also suggest that, within the framework of this research, and with teaching practice, they said that the components of mathematical competence proposed on them do not separate independently, they integrate and complement each other. In particular, it is advisable to focus only on fostering mathematical thinking and reasoning capacity and mathematical problem solving capacity, because mathematical communication capacity always supports and is present in mathematical modeling capacity, modeling capacity and ability to use tools and means are often present in problem solving activities, and mathematical reasoning ability is always necessary in activities when students study Math and problem solving.

Proposing Measures to Develop Students' Mathematical Ability

With 4 recommendations made by the research team, including: (1) Equip students in a hidden way with the necessary knowledge and skills about metacognitive activities, thereby, serving as a basis for them performing cognitive and metacognitive activities in the process of learning Mathematics; (2) Develop students' mathematical competence through organizing activities to apply metacognition in the process of equipping and systematizing math knowledge; (3) Develop students' mathematical competence through organizing cognitive and metacognitive activities in teaching and solving math problems; (4) Develop students' mathematical competence through organizing cognitive and metacognitive activities in teaching and applying mathematics to practice.

Talking to experts: We received 7/7 education experts who rated the proposals as feasible and would have a positive impact on students' math ability. However, experts also noted that, in order to implement these suggestions well, first, teachers need to be trained in metacognition theory, as well as apply metacognition theory in teaching. At that time, the new implementation proposals are really guaranteed to be implemented and effective.

Talking with teachers, about what measures should be taken to be able to apply metacognition in teaching to help develop Math skills of current middle school students, we received some comments and summarized as follows: first, there should be a training course on theory of metacognition and how to apply metacognition in teaching Middle School Mathematics; secondly, strengthen activities for students to participate in problem solving in real life, through which, teachers suggest for students to regularly use problem solving for their task solving process, creating a habit of using problem solving. Students will memorize and master when they have a lot of experience, learn with joy and excitement to find answers to problems.

Conclusion

The results of this study show similarities with previous studies of (H.X. Binh 2019; L.B. Duong 2019; H.T. Nga 2020; P.V. Thuy 2021; N.T.H. Lan 2018, 2019, 2020). The reality of math teaching shows that many teachers have applied metacognition into the teaching process, as well as students have also had metacognition activities. However, the activities of applying metacognition in both teachers and students are not regular, there is no habit of using metacognition as a thinking tool. Therefore, students' results have not made significant progress in math ability, as well as low learning outcomes in Math. Finally, suggestions on measures to apply metacognition in teaching and learning to help develop students' Math ability.

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