การพัฒนารูปแบบและการเรียนการสอนตามแนวคิดการถ่ายโยงการเรียนรู้เพื่อส่งเสริมทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผล และการเชื่อมโยงของนักเรียนมัธยมศึกษาปีที่ 1

ณัฐิกานต์ รักนาค
อัมพร ม้าคนอง

บทคัดย่อ

การวิจัยและพัฒนาครั้งนี้มีวัตถุประสงค์เพื่อ 1) พัฒนารูปแบบการเรียนการสอนตามแนวคิดการถ่ายโยงการเรียนรู้เพื่อส่งเสริมทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผลและการเชื่อมโยง ของนักเรียนมัธยมศึกษาปีที่ 1 2) ศึกษาผลการใช้รูปแบบการเรียนการสอนตามแนวคิดการถ่ายโยงการเรียนรู้เพื่อส่งเสริมทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผลและการเชื่อมโยงของนักเรียนมัธยมศึกษาปีที่ 1 การวิจัยประกอบด้วย 2 ขั้นตอน ขั้นตอนแรกเป็นการพัฒนารูปแบบการเรียนการสอน และขั้นตอนที่ 2 เป็นการทดลองใช้รูปแบบที่พัฒนาขึ้นในชั้นเรียน โดยใช้แนวคิดของการถ่ายโยงการเรียนรู้ การวิเคราะห์และการสังเคราะห์ทฤษฎีและแนวคิดที่เกี่ยวข้องกับการเรียนการสอน แล้วนำไปทดลองใช้กับกลุ่มตัวอย่างซึ่งเป็นนักเรียนชั้นมัธยมศึกษาปีที่ 1 โรงเรียนอนุบาลวังม่วง จังหวัดสระบุรี จำนวน 2 ห้องเรียน ห้องเรียนละ 43 คน โดยเป็นห้องทดลอง 1 ห้อง และห้องควบคุม 1 ห้อง ระยะเวลาในการดำเนินการทดลอง 18 สัปดาห์ เครื่องมือที่ใช้ในการทดลอง คือ แบบวัดทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผล และการเชื่อมโยง วิเคราะห์ข้อมูลแบบผสมทั้งเชิงปริมาณและเชิงคุณภาพโดยวิเคราะห์ค่าเฉลี่ยเลขคณิต ค่าเบี่ยงเบนมาตรฐาน ค่าสถิติที (t-test) การวิเคราะห์ความแปรปรวน และการวิเคราะห์เนื้อหา

ผลการวิจัยสรุปได้ดังนี้ 1) รูปแบบการเรียนการสอนที่พัฒนาขึ้น ประกอบด้วยขั้นตอน 4 ขั้นตอน ได้แก่ 1.1) ขั้นการสร้างประสบการณ์การเรียนรู้ 1.2) ขั้นการฝึกปฏิบัติการใช้ความรู้ 1.3) ขั้นการถ่ายโยงการเรียนรู้ และ 1.4) ขั้นสะท้อนความคิด 2) รูปแบบการเรียนการสอนที่พัฒนาขึ้นมีประสิทธิภาพ สามารถพัฒนาทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผล และการเชื่อมโยง ดังนี้ 2.1) ทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผล และการเชื่อมโยง หลังเรียนของนักเรียนกลุ่มทดลองสูงกว่าก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ระดับ .05 2.2) ทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผล และการเชื่อมโยง หลังเรียนของนักเรียนกลุ่มทดลองสูงกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติที่ระดับ .05 2.3) ผลการวิเคราะห์ข้อมูลเชิงคุณภาพพบว่า นักเรียนกลุ่มทดลองมีการพัฒนาทักษะและกระบวนการทางคณิตศาสตร์ด้านการแก้ปัญหา การให้เหตุผล และการเชื่อมโยงอย่างชัดเจน นักเรียนค่อย ๆ เปลี่ยนแปลงพฤติกรรมการเรียนรู้ในทางที่ดีขึ้น สามารถเชื่อมโยงและนำความรู้ไปใช้แก้ปัญหาในสถานการณ์ ที่เกี่ยวข้องกับชีวิตประจำวันได้มากขึ้น

Development of an Instructional Model Based on the Transfer of Learning Approach to Enhance Mathematical Skills and Processes in Problem Solving, Reasoning, and Connections of Seventh Grade Students

Nathigan Raknak
Aumporn Makanong

ABSTRACT

This study was a research and development which aimed to 1) develop an instructional model based on the transfer of learning approach to enhance mathematical skills and processes in problem solving, reasoning, and connections, and 2) study the effects of the developed model on students' problem solving, reasoning, and connection abilities. The study composed of two phases which were the development of the instructional model and the experiment of using the model in classroom instruction. The instructional model was developed using research framework of the transfer of learning approach. Teaching and learning theories were also synthesized and integrated into the model. The experiment of the developed model was conducted one semester with 43 seventh grade students at Anubanwangmuang School, Saraburi Province, in academic year 2009. The other 43 students in the same school were treated as a control group and were taught by traditional approach. The research instruments were problem solving, reasoning, and connection tests. Each kind of the tests had two pararell versions of pretest and posttest. The data were analyzed by using mix method of quantitative and qualitative approaches.

The research findings were as follows: 1) The instructional model developed based on the transfer of learning approach consisted of 4 main steps of organizing learning activity, namely; 1.1) Creating of learning experiences, 1.2) Practicing of obtained knowledge, 1.3) Transferring to application, and 1.4) Reflecting and looking back. 2) The developed instructional model was effective. It enabled students to develop mathematical skills and processes in problem solving, reasoning, and connections; 2.1) Problem solving, reasoning, and connection abilities, and mathematical skills and processes of students after learning from the instructional model were significantly higher than those before learning from the instructional model at .05 level of significance, 2.2) Problem solving, reasoning, and connection abilities, and mathematical skills and processes of students learning from the instructional model were significantly higher than those of students learning from traditional approach at .05 level of significance, and 2.3) The analysis of qualitative data strongly documented that mathematical skills and processes in problem solving, reasoning, and connections of students in the experimental group were much more developed. The students gradually changed their learning behavior into positive direction. They could show their capacities of relating and applying mathematical knowledge to real life situations.

Background

Mathematics is of importance for development of manpower and country. Mathematics knowledge and skills takes a crucial role in helping all people understand what happens around themselves, and effectively helps to solve problems in real life situations. Mathematics is a basic for development of reasonable and systematic thinking, and also enables people to think and work efficiently. Therefore, Mathematics is a base of growth for civilizations worldwide, especially, in science and technology. The basis for mathematics education, therefore, focuses on students' mathematical proficiency. However, the results from educational quality evaluation conducted by the Thailand Bureau of Educational Testing have indicated that mathematics learning achievement of Thai students has not met the minimum criteria in last twenty consecutive years. Students display low performances on mathematical knowledge and skills. In academic year of 2006, arithmetic mean score of mathematics from National Test (NT) was only 31.15 % for lower secondary school students. For those in upper secondary schools, they scored 29.56% on Ordinary National Education Test (O-NET), and 27.09% on Advanced National Education Test (A-NET). These results are corresponding to current research results of mathematics education in the aspect that Mathematics proficiency of Thai students needs to be developed. Mathematics instruction is in need to be improved for better mathematical competencies, especially, mathematical skills and processes.

Mathematical skills and processes are perceived as the abilities to apply mathematics knowledge to solve problems in real world situations. Problem solving is the skill in applying knowledge to solve problematic situations, reasoning is the ability of using knowledge to justify, prove, and decide in order to conclude something reasonably, while connection is the skill in relating knowledge and experiences to other problems and situations (National Council of Teachers of Mathematics, NCTM, 2000). A factor that directly affects these skills and processes is the ability to connect mathematics knowledge in class to situations outside of class. This kind of ability is bounded to the ability to transfer what they have learned in class to the similar faced problems. This process is generally perceived as a transfer of learning.

Transfer of learning is defined in term of outcome as the effect of previous learning on the next related learning (Elliot and others, 2000; Marini & Genereux, 1995; Woolfolk, 1998). It is also defined in term of process as the application or connection between obtained knowledge and new knowledge (Haskell, 2001; Klausmeier, 1985). However, transfer of learning is conceptually understood as the process of using previous knowledge to learn or understand something new or to solve some new problems. It is of importance for students' thinking process and ability (Hunter, 1995). Students with good ability of transfer of learning should be able to understand mathematics concepts and algorithm, develop mathematical skills and processes, as well as connect mathematics knowledge and reasonably solve problems in real life situations. Current mathematics instruction, therefore, should emphasize on developing students' ability of transfer of learning in order that they can develop skills and processes effectively. This research hence aims to develop an instructional model using the transfer of learning approach and some related grounded theories about teaching and learning. The process of teaching and learning is designed to help students develop mathematical skills and processes in problem solving, reasoning, and connecting.

Objectives

The purposes of this study are to:

1. develop an instructional model using the transfer of learning approach in order to enhance mathematical skills and processes in problem solving, reasoning, and connections, and

2. study the effects of the developed model on students' problem solving, reasoning, and connection abilities by:

2.1 compare mathematical problem solving, reasoning, and connection abilities of students learning through the developed model to those of students learning by the traditional approach.

2.2 study the learning development related to problem solving, reasoning, and connection abilities of students learning by the developed model.

Hypotheses

The hypotheses of the study are as below:

1. Problem solving, reasoning, and connection abilities of students learning from the developed instructional model were significantly higher than those of students learning from traditional approach.

2. Mathematical skills and processes of students learning from the developed instructional model were significantly higher than those of students learning from traditional approach.

Methodology

This study is a research and development using mix method of quantitative and qualitative approaches. It composes of two main phases which are 1) the development of an instructional model in order to obtain effective model of teaching and learning, and 2) the experiment for trying out the developed model in order to study the effectiveness of the model. The process of each phase is as the following.

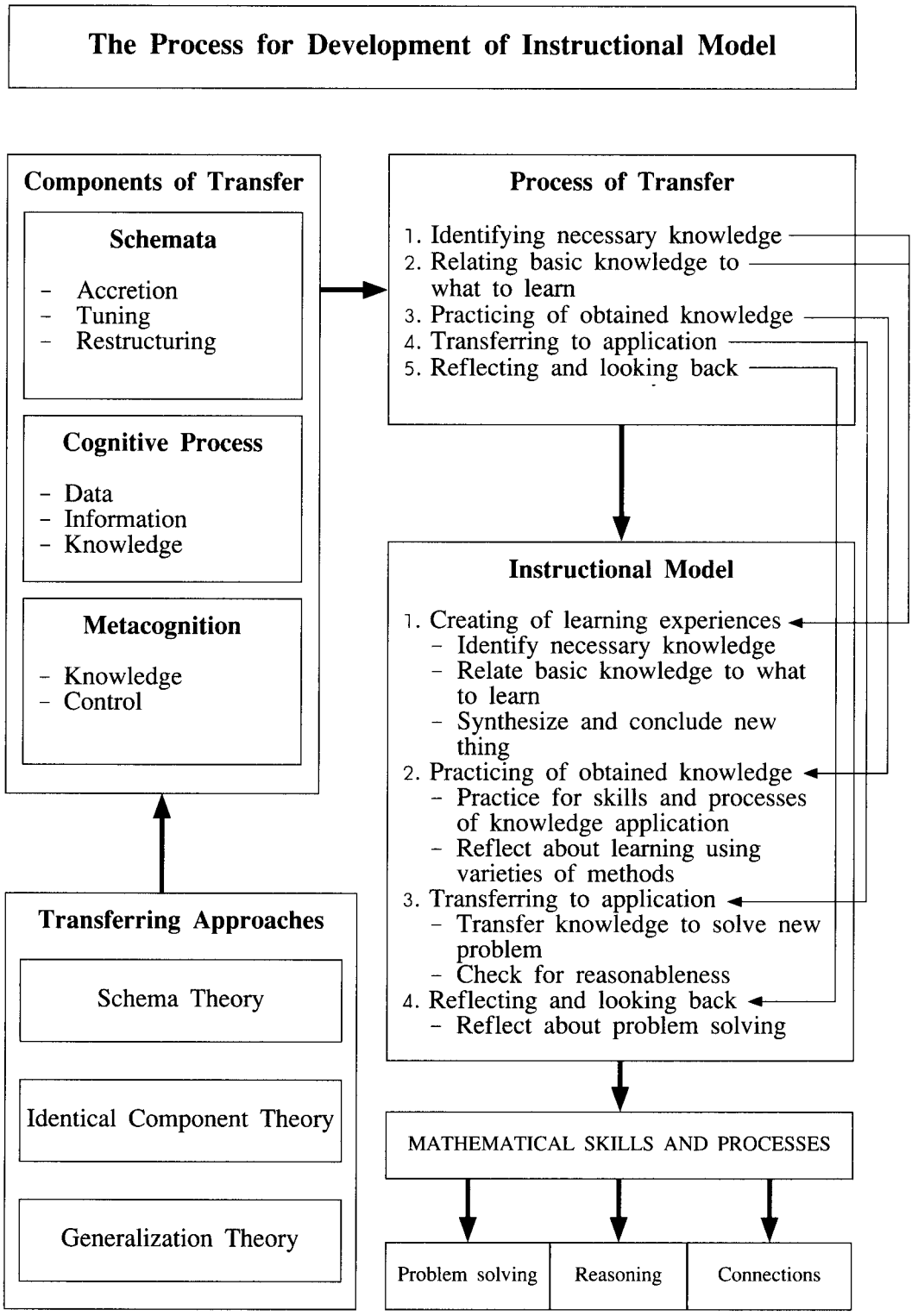
1. The development of an instructional model

The researcher analyzes and synthesizes main ideas of the transfer of learning approaches and grounded theories about teaching and learning. Three theories are used for development of an instructional model; 1) Schema theory, 2) Identical component theory, and 3) Generalization theory.

Schema theory: this theory relates its ideas in the aspect that human will transfer his or her knowledge if he or she has enough basic information to transfer, and upon the activation of learning experiences.

Identical component theory: the principle of this theory is that transfer of learning comes from the analogy of varieties of components such as facts, concepts, algorithms, and skills between previous and new situations.

Generalization theory: this theory mentions that transfer of learning will occur if people can conclude the process of transfer and generalize the conclusions to other situations.


The Process for Development of Instructional Model
Components of Transfer
Schemata
- Accretion
- Tuning
- Restructuring
Cognitive Process
- Data
- Information
- Knowledge
Metacognition
- Knowledge
- Control
Process of Transfer
1. Identifying necessary knowledge
2. Relating basic knowledge to what to learn
3. Practicing of obtained knowledge
4. Transferring to application
5. Reflecting and looking back
Instructional Model
1. Creating of learning experiences
- Identify necessary knowledge
- Relate basic knowledge to what to learn
- Synthesize and conclude new thing
2. Practicing of obtained knowledge
- Practice for skills and processes of knowledge application
- Reflect about learning using varieties of methods
3. Transferring to application
- Transfer knowledge to solve new problem
- Check for reasonableness
4. Reflecting and looking back
- Reflect about problem solving
Transferring Approaches
Schema Theory
Identical Component Theory
Generalization Theory
MATHEMATICAL SKILLS AND PROCESSES
Problem solving
Reasoning
Connections

The three theories above are analyzed and synthesized. The components of transfer are Schemata, Cognitive Process, and Metacognition (Wittrock, 1991; Cree, 2000; Elliot et al., 2000). An analysis of all components yields the process of transfer which has 5 steps, namely; 1) identifying necessary knowledge, 2) relating basic knowledge to what to learn, 3) practicing of obtained knowledge, 4) transferring to application, and 5) reflecting and looking back. The analysis of teaching and learning mathematics in real classroom together with the process of transfer is conducted to develop instructional model based on the transfer of learning approach. The applicable model is finally adjusted to 4 steps as the following.

1) Creating of learning experiences
   - Identify necessary knowledge
   - Relate basic knowledge to what to learn
   - Synthesize and conclude new thing

2) Practicing of obtained knowledge
   - Practice for skills and processes of knowledge application
   - Reflect about learning using varieties of methods

3) Transferring to application
   - Transfer knowledge to solve new problem
   - Check for reasonableness

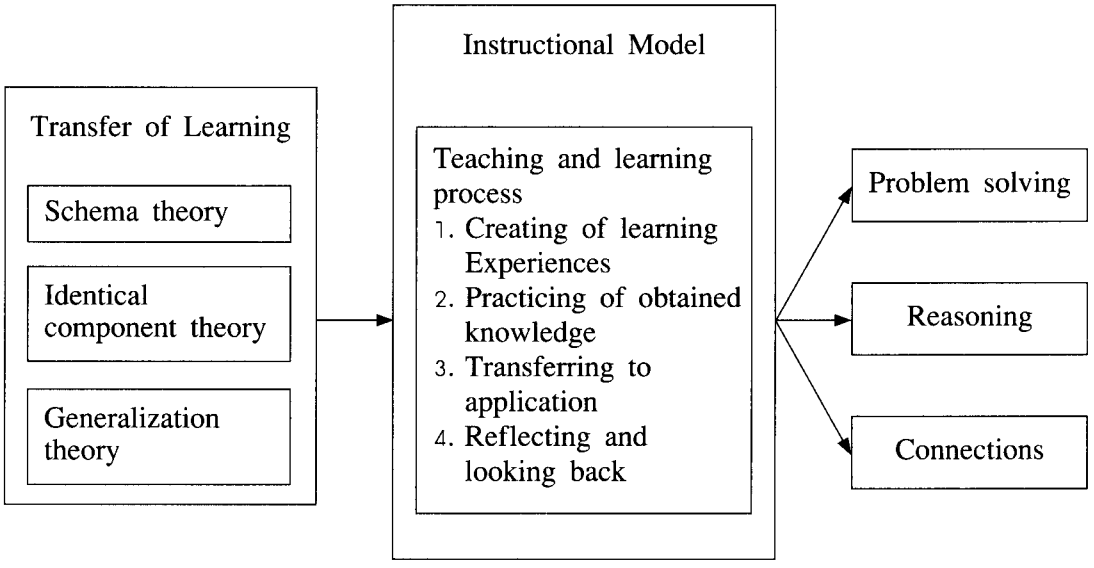
4) Reflecting and looking back
   - Reflect about problem solving

2. The experiment of the developed model

The developed instructional model is experimented in mathematics class. Learning activities are designed based on the teaching and learning steps of the model. The data from ongoing process are continuously collected along the experiment in order to study the effects of the model on students' problem solving, reasoning, and connection abilities. The researcher conducts the experiment by her own in order to strictly control confounding variables. The research and development process is applied to improve the quality of teaching according to the model.

The subjects are seventh grade students with average achievements of mathematics in academic year 2009, Anubanwangmuang School, Saraburi Province. They are divided into two groups, one experimental group with 45 students and one control group with 45 students. Students in the experimental group are taught by the instructional model based on the transfer of learning approach and those in the control group are taught by conventional approach. Both groups are tested for equality in term of basic knowledge and variables that related to dependent variables. Other confounding factors are treated in order to control the quality of teaching. The experiment lasts 18 weeks long in order to ensure that the process is repeated as many as possible. Quantitative data are collected before and after the experiment for statistical comparisons while qualitative data of students' learning, thinking, and working processes are collected all along the experiment.

The research framework of the two main phases is as the following.



The research instruments are tests of mathematics problem solving, mathematical reasoning, and mathematical connections. Each test is constructed based upon the abilities of specific skill. All of them are tried out to verify for content and

construct validities with mathematics educators and some of non-subjects. The difficulty and discrimination indexes as well as reliability of each test are in the range of qualified instruments.

Results

The results from hypothesis testing indicated that:

1. Problem solving, reasoning, and connection abilities of students learning from the developed instructional model are significantly higher than those of students learning from traditional approach as shown in table 1-3.

Table 1 A comparison of students' problem solving abilities between experimental group and control group

Group	*M*	*SD*	t	*p*
Experimental	20.02	3.349	6.605	.000*
Control	16.19	1.816		

*$p<.05$

The result from t-test indicates that problem solving abilities of students learning from the developed instructional model are significantly higher than those of students learning from traditional approach.

Table 2 A comparison of students' reasoning abilities between experimental group and control group

Group	*M*	*SD*	t	*p*
Experimental	20.33	2.408	7.205	.000*
Control	16.72	2.229		

*p<.05

The result from t-test indicates that reasoning abilities of students learning from the developed instructional model are significantly higher than those of students learning from traditional approach.

Table 3 A comparison of students' communication abilities between experimental group and control group

Group	*M*	*SD*	t	*p*
Experimental	45.07	9.184	6.085	.000*
Control	35.02	5.734		

*p<.05

The result from t-test indicates that communication abilities of students learning from the developed instructional model are significantly higher than those of students learning from traditional approach.

2. Mathematical skills and processes of students learning from the developed instructional model are significantly higher than those of students learning from traditional approach as shown in table 4.

Table 4 A comparison of students' mathematical skills and processes between experimental group and control group

Group	*M*	*SD*	t	*p*
Experimental	85.42	13.496	7.230	.000*
Control	67.93	8.331		

*$p<.05$

The result from t-test indicates that mathematical skills and processes of students learning from the developed instructional model are significantly higher than those of students learning from traditional approach.

Conclusions and discussions

The results from the study draw conclusions and discussions as below.

1. The evidences from students' performance indicate that the instructional model developed based on the transfer of learning approach is practical and applicable for mathematics instruction. The four steps of organizing learning activity, namely; 1) creating of learning experiences, 2) practicing of obtained knowledge, 3) transferring to application, and 4) reflecting and looking back, go along well with the teaching and learning approaches recommended by mathematics educators. Each process of the model enables students to reasonably connect mathematics knowledge in class to unfamiliar problems outside of class.

2. The instructional model developed based on the transfer of learning approach is effective.

2.1 Problem solving, reasoning, and connection abilities of students learning from the instructional model are significantly higher than those of students learning from traditional approach.

2.2 Mathematical skills and processes in problem solving, reasoning, and connections of students in the experimental group are much more developed than those of students in control group.

The qualitative data from teaching and learning process strongly document that mathematical abilities in problem solving, reasoning, and connections of students in the experimental group are developed times to times. The students gradually change their learning behavior into positive direction. They show their capacities of relating and applying mathematical knowledge to real life situations. The results are in the same trace with other studies that transferring ability influences students' problem solving and reasoning abilities (Dossey and other, 2002). Each step in the instructional process promote students' thinking and doing something different from what they have ever done before. They have experiences of how to make mathematics meaningful.

Guidelines for Application and Future Research

The results from the study research suggest some useful guidelines as the following.

For teaching and learning mathematics:

Although the instructional model is practical for mathematics instruction, the teachers should be aware of students' abilities to catch up with the planned activities. Their basic knowledge and learning experiences will be an important factor affecting the transferring competencies. Teachers should be more patient to see learning outcomes and impacts of their teaching because students will take time to gradually develop their skills in problem solving, reasoning, and communicating.

For future research:

More studies integrating transferring and thinking processes should be conducted more in order to seek for model that can develop students' thinking abilities and empower students' learning for mathematical senses. This kind of research in the future should focus more on mathematical thoughts.

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