Using 4MAT Teaching Model to Enhance Students'Achievement and to Maintain Retention in Mathematics[*]

การใช้รูปแบบการจัดการเรียนรู้แบบ 4MAT เพื่อส่งเสริมผลสัมฤทธิ์ทางการเรียนและคงความคงทนทางคณิตศาสตร์

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Abstract

　　The objectives of this classroom action research were to enhance students' achievement and to maintain students' retention in mathematics by using 4MAT teaching model. The participants were 30 grade 10 students who enrolled in the first semester of academic year 2017 at a secondary school in Bangkok, Thailand. The topic used in this study was elementary sets. To enhance students' achievement and to maintain students' retention, 7 lesson plans integrated 4MAT teaching model were developed. Teaching and learning lasted 14 periods with 50 minutes in each period. There were three cycles of action plan (plan, act, observe, and reflect). Data were collected from summative test and teacher's reflections. Summative test was used to measure students' achievement. The results showed the students' mathematics achievement was enhanced to the levels required by the researcher. That was at least 70% of students passed 70% total score. After 14 days, the summative test was also used again to measure students' retention. The results showed the students still maintained their retention.

Keywords: 4MAT teaching model/Students' mathematics achievement /Students'retention

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อาจารย์ประจำสาขาคณิตศาสตร์ศึกษา วิทยาลัยนานาชาติ มหาวิทยาลัยราชภัฏสวนสุนันทา

บทคัดย่อ

การวิจัยเชิงปฏิบัติการในชั้นเรียนนี้มีจุดมุ่งหมายเพื่อส่งเสริมผลสัมฤทธิ์ทางการเรียนของนักเรียนและศึกษาความคงทนทางคณิตศาสตร์โดยใช้รูปแบบการจัดการเรียนรู้แบบ 4MAT   โดยมีผู้เข้าร่วมในการวิจัยคือนักเรียนระดับชั้นมัธยมศึกษาปีที่ 4 จำนวน 30 คน ในภาคเรียนที่ 1   ปีการศึกษา 2560 หัวข้อเรื่องเซตเพื่อส่งเสริมผลสัมฤทธิ์ทางการเรียนของนักเรียนและคงความคงทนทางคณิตศาสตร์ ผู้วิจัยพัฒนาแผนการจัดการเรียนรู้ที่เน้นหลักการใช้รูปแบบการจัดการเรียนรู้แบบ 4MAT จำนวน 7 แผนการจัดการเรียนรู้ใช้เวลา 14 คาบ คาบละ 50 นาที โดยผู้วิจัยเป็นผู้จัดการเรียนรู้ด้วยตนเองและประเมินผลสัมฤทธิ์ทางการเรียนของนักเรียนจากแบบวัดผลสัมฤทธิ์ทางการเรียน ผลจากการทดสอบปรากฏว่าผลสัมฤทธิ์ทางการเรียนของนักเรียนผ่านเกณฑ์ที่ผู้วิจัยตั้งไว้ กล่าวคือ ร้อยละ 70 ของนักเรียนทั้งชั้นสอบได้คะแนนสูงกว่า ร้อยละ 70 ของคะแนนเต็ม หลังจากการวัดผลสัมฤทธิ์ทางการเรียนของนักเรียน 14 วัน ผู้วิจัยได้ใช้แบบวัดผลสัมฤทธิ์ทางการเรียนชุดเดิมเพื่อทดสอบความคงทนทางคณิตศาสตร์ของนักเรียน ผลการสอบพบว่าคะแนนผลสัมฤทธิ์ทางการเรียนของนักเรียนยังมีความคงทนไม่แตกต่างจากการสอบในครั้งแรก

คำสำคัญ : รูปแบบการจัดการเรียนรู้แบบ 4MAT/ ผลสัมฤทธิ์ทางการเรียนคณิตศาสตร์ / ความคงทน

Statement and Significance of the Problems

Mathematics is highly important to develop human mind. It enables a person to acquire skills in systematic, logical and creative thinking, and allows one carefully and thoroughly analyze various problems. It also helps a person to anticipate, plan, make decisions, solve problems and apply mathematics in daily life. Mathematics serves as a tool for learning science, technology and other disciplines. Therefore, it is useful to one's life and it enhances quality of life and enables a person to live in harmony with others (The Institute for the Promotion of Teaching Science and Technology (IPST), 2008).

Moreover, mathematics is essential to human intellectual development. Creative thoughts provided by mathematics can help them solve problems precisely and make them predict and plan accurately. Mathematics can be used with science to understand natural phenomena. In addition, mathematics skills are necessary in order to improve quality of life. So, mathematics teachers play important roles in making those facts realistic. They can enhance students' critical thinking and creativity which leads to analyze and solve problems thoroughly (Narong Punnim, 2013, p.1).

Many students did not successfully develop higher-order thinking and problem solving abilities. Results from international study such as TIMSS in 2007 revealed that mathematics average score of Thai students was lower than that of the international groups (TIMSS, 2007, p.17). In addition, PISA (Programme for International Students Assessment) in 2012 revealed

that average mathematics score of Thai students was ranked 50 out of 64 countries (The Organization for Economic Co-operation and development (OECD), 2014). Accordingly, O-NET (Ordinary National Education Test) revealed that the average mathematics score was not satisfactory. The averages of the mathematics scores on grade 12 were 21.74%, 26.59%, and 24.88% in 2014, 2015 and 2016 respectively (The National Institute of Educational Testing Service, 2016).

In the pre-practicum course, the researcher observed grade 10 mathematics class and found that students did not like learning mathematics and mathematics did not interest them, but they did like subjects that were interesting and enjoyable on class activities and class competition with classmates. Mathematics was not interesting enough for students in learning because it was difficult and boring. So, it decreased students' mathematics achievement. In talking with mentor, the researcher found that students' achievement scores in mathematics were not high to the expected level. Most students could not remember the contents studied in previous classes. Hence, they failed to understand the concepts and content knowledge in the next class. From above problems, the researcher tried to find out various teaching methods in order to solve above problems. The method found were flipped classroom (Bergmen & Sams, 2014), cooperative learning (Johnson & Johnson, 1989), 5E model of instruction (Biological Sciences Curriculum Study (BSCS), 2006), and 4MAT teaching model (McCharthy, 1980).

The 4MAT (4 Mode Application Techniques) teaching model developed by McCharthy. It was based on learning style theory developed by David Kolb. From his research, the theory identifies four learner styles as follows: concrete experiencer (feeling), reflective observer (watching), abstract conceptualizer (thinking), and active experimenter (doing) (Kolb, 1974). Applying learning style theory, Dr. McCharthy constructed the 4MAT teaching model which were composed of eight steps. The steps were: 1) connect, 2) attend, 3) image, 4) inform, 5) practice, 6) extend, 7) refine, and 8) perform (McCarthy, 1980). All steps were designed to be appropriate for the four learner styles of students. In addition, this model identifies the four major elements of learning (meaning, concepts, applications and creations). This model provides teachers with a structure for planning learning experiences for the four style learners. The researcher expected that the 4MAT teaching model would help the researcher solve the above problems during practicum course because this model supported four learner styles and the eight steps in teaching also supported and engaged students in learning.
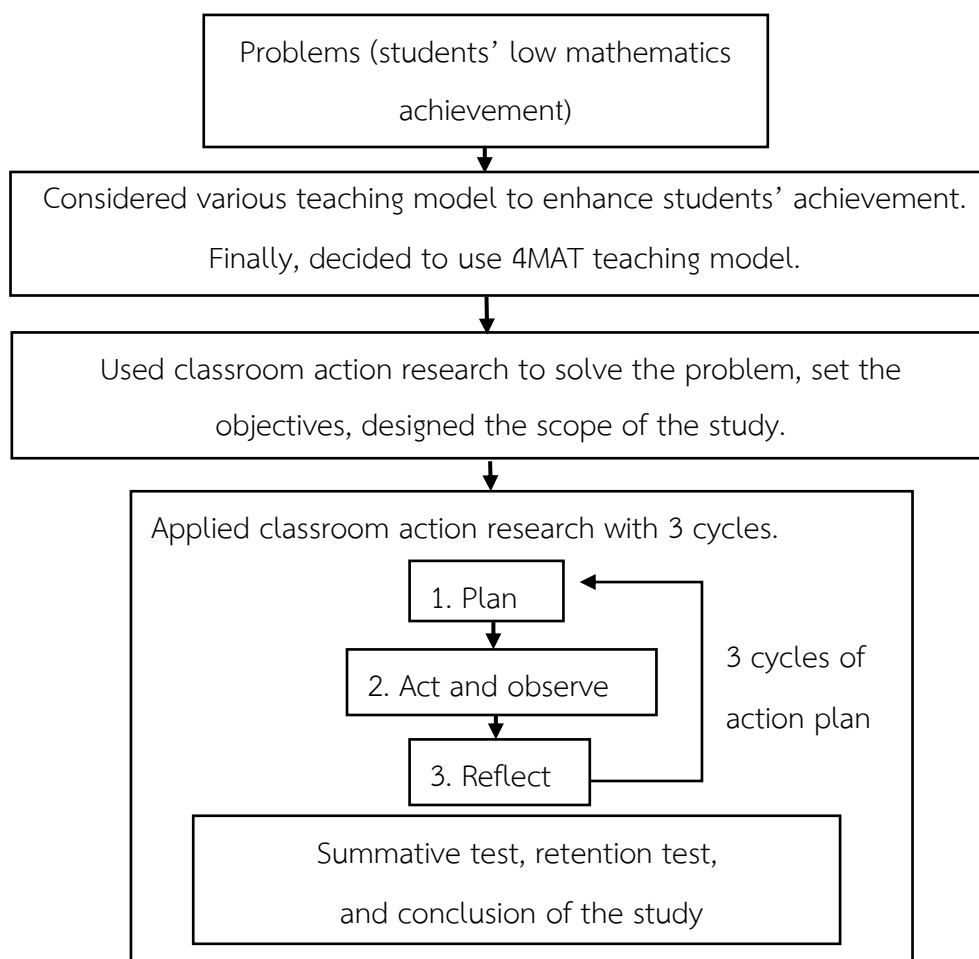
From the above problems and the study of 4MAT teaching model, the researcher used the 4MAT teaching model to enhance students' achievement and to maintain students' retention.

Research Objectives

1) To enhance students' achievement in mathematics by using 4MAT teaching model For research objective 1, the researcher aimed to compare 70% of all students to pass summative test. The criterion for each student to pass summative test was to gain at least 70% of total score.

2) To maintain mathematics retention of students taught by 4MAT teaching model For research objective 2, the researcher applied the same summative test again to compare students' retention. To analyze students' retention, t-dependent test was used.

Conceptual Framework of the Study

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┌─────────────────────────────────────────┐
│   Problems (students' low mathematics    │
│              achievement)                │
└─────────────────────────────────────────┘
                    ↓
┌─────────────────────────────────────────────┐
│ Considered various teaching model to enhance  │
│ students' achievement. Finally, decided to    │
│ use 4MAT teaching model.                      │
└─────────────────────────────────────────────┘
                    ↓
┌─────────────────────────────────────────────┐
│ Used classroom action research to solve the   │
│ problem, set the objectives, designed the     │
│ scope of the study.                           │
└─────────────────────────────────────────────┘
                    ↓
┌─────────────────────────────────────────────┐
│ Applied classroom action research with 3      │
│ cycles.                                        │
│        ┌──────────┐                           │
│        │ 1. Plan  │←──────┐                   │
│        └──────────┘        │   3 cycles of    │
│             ↓              │                   │
│    ┌──────────────────┐    │   action plan     │
│    │ 2. Act and observe│   │                   │
│    └──────────────────┘    │                   │
│             ↓              │                   │
│       ┌────────────┐       │                   │
│       │ 3. Reflect │───────┘                   │
│       └────────────┘                           │
│   ┌─────────────────────────────────────┐     │
│   │ Summative test, retention test,     │     │
│   │ and conclusion of the study         │     │
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Research Methodology

This research took model of action research with three cycles. Each cycle has four steps: plan, act, observe and reflect. The participants in this study were 30 grade 10 students from a classroom in the first semester of academic year 2017 at a secondary school in Bangkok, Thailand. The contents used in this study were about elementary sets. Ideas of sets are important in mathematics because sets is a basic language of mathematics and many lessons in mathematics used sets as to describe definitions, examples, theorems, and proof.

Research Instruments

The instruments used in this study were consisted of 7 lesson plans, tests (summative test and retention test), and teacher's reflections.

1. Lesson plans: There were 7 lesson plans on sets integrated the 4MAT teaching model. The contents on sets were 1) introduction of sets, 2) set notations, finite and infinite sets, and equality of sets, 3) subsets and power sets, 4) set operations (union and intersection), 5) set operations (complement and difference), 6) venn diagrams, and 7) problems solving about sets. The 4MAT teaching model comprised 8 steps: 1) connect, 2) attend, 3) Imagine, 4) inform, 5) practice, 6) extend, 7) refine, and 8) perform. At the end of periods 2, 4, and 6, the researcher reflected teaching and students' behaviors for improving in the next periods. Lesson plans were validated by using face to face validity and iterations of systematic design cycles to improve and develop teaching process instructions with the approval of the host of practicum supervisor and two experts.

2. Tests: Summative test and retention test in mathematics were the instruments the researcher used in the study. All tests were developed by the researcher. Summative test was composed of 20 multiple-choice items for 20 points. This test covered all the topics used in this study. After 14 days, summative test was used again as retention test to measure students' retention. The Index of Item Objective Congruence (IOC) was used to measure the congruence between learning objectives and the test items. The value of IOC of summative test between 0.60 – 1.00 as rated by three expert teachers.

From 6 cognitive domains presented by Benjamin S. Bloom and others, the researcher considered to test students only 4 cognitive domains (recall, comprehension, application, and analysis) as presented by James W. Wilson (Bloom et al. 1971).

3. Teacher's reflections: There were three reflections to improve teaching and learning activities. In each reflection, the researcher reflected the following points: 1) students' problems in classroom, 2) teaching, 3) students' homework, and 4) improvement plan.

Data Collection

The data were collected and analyzed in the following steps.

1. The data collection of this study was performed during 14 periods of instruction in elementary sets, as described in the previous section. During the intervention period, the participants received learning instruction based on 4MAT teaching model. The steps are in the following:

Step 1. Connect: remind personal experiences that relate to the concepts being taught.

Step 2. Attend: analyze and reflect the experiences in step1.

Step 3. Image: integrate personal experiences for concepts being taught.

Step 4. Inform: teach the concepts, principle and rules.

Step 5. Practice: practice defined concepts, principle and rules.

Step 6. Extend: add practice for full understanding and verify knowledge.

Step 7. Refine: analyze usefulness of what has been learned.

Step 8. Perform: discover how to apply knowledge and share it with others.

2. After finishing all lessons, each participant was asked to take the summative test and to take the retention test 14 days after taking the summative test.

3. At the end of lesson plan 2, 4, and 6, the researcher made the reflections on students' problems in classroom, on teaching, on students' homework, and on improvement plan.

Data Analysis

Quantitative data: The data from summative test and retention test in each domain were analyzed by using arithmetic means, percentage, standard deviations and t- dependent test.

Qualitative data: The researcher analyzed by content analysis from researcher's reflections. Qualitative data (researcher's reflections) composed of 4 points: 1) students' problems in classroom, 2) teaching, 3) students' homework, and 4) improvement plan.

Results from Data Analysis

   1. Results of Students' Achievement in Mathematics

Table 1 Results of summative test

Number of students (n)	Total score	Mean	Percentage of mean	Number of passed students	Percentage of passed students (%)
30	20	14.67	73.35	22	73.33

   Table 1 showed the arithmetic mean of mathematics achievement, number of passed students and percentage of passed students were 14.67, 22, and 73.33, respectively. In addition, the results showed that more than 70 percent of students passed mathematics achievement test. So, the students who were taught by 4MAT teaching model enhanced their achievement to the level required by the researcher.

   2. Results of students' scores in each domain of summative test

Figure 1 Percentage of students' scores in each domain of summative test
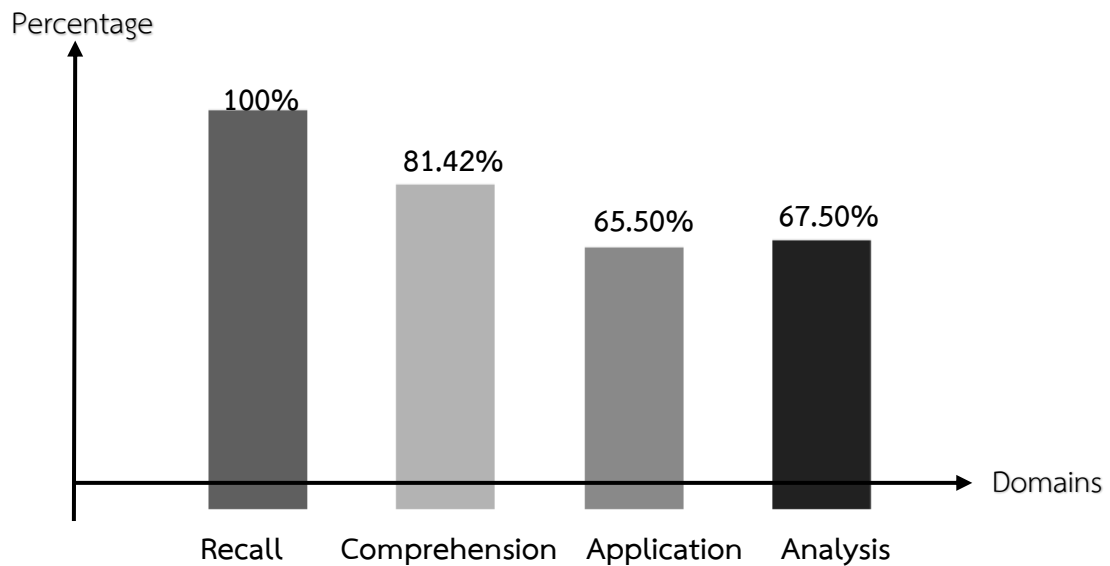
Figure 1 presented the summative test scores on 4 cognitive domains: recall, comprehension, applicat

Moreover, the percentage of application and analysis domains were lower than that of recall and comprehension domains. This maybe because of the difficulty and the higher- order thinking of the test items in the two domains.

3. Results of summative test, retention test, and t-dependent test

Table 2 Results of summative test, retention test, and t test

From Table 2, the t value showed non-significant difference between means scores of summative test and retention test. So, it could be concluded that there was no difference between summative test and retention test. That was the students could maintain the retention 14 days after taking summative test.

Tests	Mean	Percentage	S.D.	$\bar{d}$	S_d	t	p-value
Summative test	14.67	73.35%	2.21	-	-	-	
Retention test	14.80	74.0%	2.05	-	-	-	0.776
t-dependent test	-	-	-	-0.133	0.462	-0.287	

4. Results of student scores in each domain of summative test and retention test

Figure 2 Comparing percentage of student scores in each domain of summative test and retention test
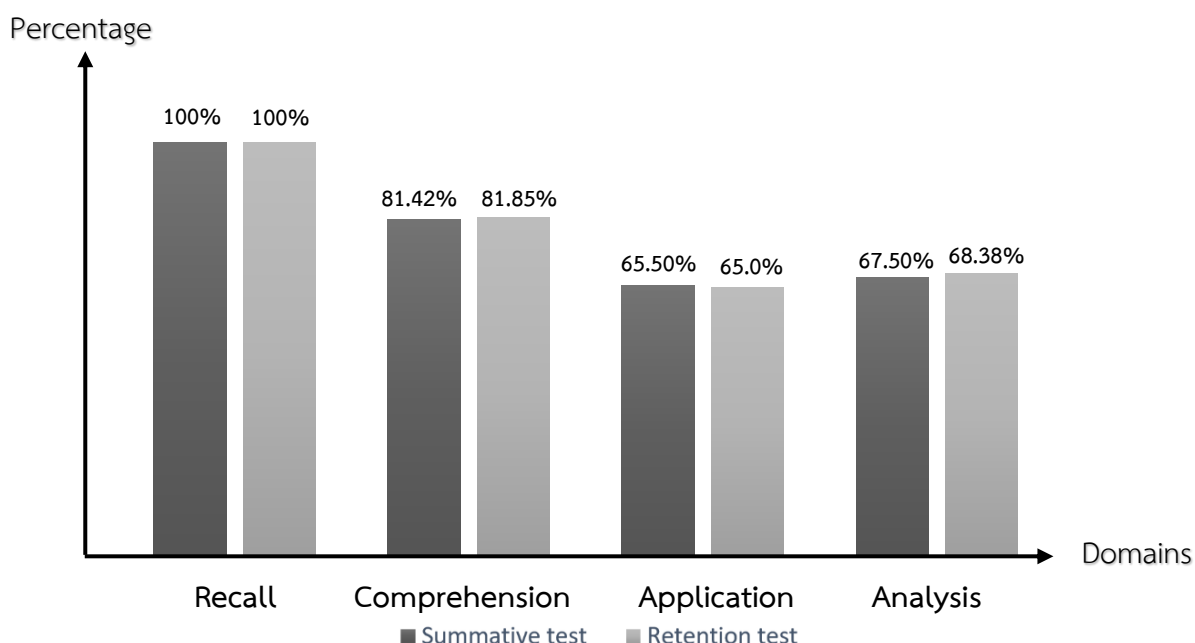
Figure 2 showed the percentage of summative test and retention test in 4 cognitive domains: recall, comprehension, application and analysis. For 4 domains, they could be concluded that there was no difference between percentage score of summative test and percentage score of retention test because the percentage were very close, but the percentage of the application domain and percentage of analysis domain were lower than recall and comprehension domains. Moreover, application and analysis domains mean scores were less than 70 percent of scores.

5. Results from Teacher's Reflections

For teacher's reflections in each cycle, the researcher reflected the following key points: students' problems in classroom, teaching, students' homework, and improvement plan.

1. Students' problems in classroom

Most of the students did not pay attention on mathematics lesson during class and they learned by remembering instead of understanding. However, the researcher found that most of the students had confidence in participating in class and had different styles of learning.

2. Teaching

By using 4MAT teaching model, teacher could engage students to pay more attention and make mathematics more interesting. Most of the students were able to make their own conclusion not only by remembering but also by understanding, to exchange their knowledge and their understanding with peers, to connect experiences to learn new knowledge, and to explain their teacher and classmates about the contents.

3. Students' homework

Some students did homework incorrectly because of the difficultly of the homework. So, the teacher explained the difficult points and gave hints. For some complex problems, students and teacher discussed them together in class.

4. Improvement plan

4.1 Teacher planned to engage students to learn mathematics and created more exercises for supporting different styles of students.

4.2 Teacher added more question, discussion, and presentation in front of the classroom for students to increase their thinking.

4.3 Teacher explained more the difficult points and gave answers to every item of their homework in detail. These activities prevented students copying homework from their peers.

Conclusions

1. By using 4MAT teaching model, the students' mathematics achievement was enhanced to the level required by the researcher. That was more than 70% (73.33%) of students gained at least 70% of the total score.

2. Result from t-dependent test (t=-0.287) showed that students could retain their learning after 14 days of instruction. In addition, students' scores from summative test and retention test were close in all 4 cognitive domains: recall, comprehension, application, and analysis.

3. From teacher's reflections, the researcher engaged students to pay more attention, created more exercises for supporting different styles of students, added more questions, discussion, and presentation. These activities prevented students copying homework from their peers.

Discussions

The students' mathematics achievement was enhanced because of the effectiveness of the 4MAT teaching model. When the students studied by using 4MAT teaching model, their learning was developed effectively because this teaching model supported 4 learner styles of students: concrete experiencer (feeling), reflective observer (watching), abstract conceptualizer (thinking), and active experimenter (doing). This model helped the researcher developed and created interesting lessons for students. These lessons were suitable for students. Thus, the students could express their opinions independently to seek answers. Janse (2016) also mentioned that this model helped teacher to make their lessons more interesting because it stimulated students' higher levels of thinking.

Furthermore, 4MAT teaching model developed the right and left hemispheres alternately and continually so that the students could relieve stress during their study session because the students could do the activities together. It conformed to the study of Prescott (Prescott, 1961) who found that the relationship among the same age friends could influence on the achievement. From his study, Bower (1987) also supported the mentioned points that the students could apply the knowledge in classroom and developed their knowledge

completely. It was a natural and usual processes resulting from helping students to have balanced thought.

The researcher taught students and got some ideas which detailed the 8 steps to be as follows: 1) provide activities for students' concrete learning connect between students' knowledge and students' existing experience (connect), 2) consider students past experience (attend), 3) connect existing past experience to new concept to be taught (image), 4) teach concepts until students understand clearly by various activities (inform), 5) students do exercises , a presentation or test (practices), 6) students create their own work to reflect themselves (extend), 7) students apply their knowledge (refine) ,and 8) students share their work, knowledge or teach their peers (perform).

For the second objective, the result showed that students maintained their learning achievement when the retention test was used again after 14 days. This result was from using 4MAT teaching model. From the learning pyramid developed by the National Training Laboratory (National Training Laboratories Bethel, 1947), it suggested that most students only remember about 10% of what they read from textbooks, but retain nearly 90% of what they learn through teaching their peers. Besides, 4MAT teaching model in step 5 (practice) and step 6 (extend) conformed to learning pyramid in the level of discussion and practice which could retain understanding and remembering the learning content about 50-75%. Moreover, the students could understand and remember the learning content about 90% when the researcher taught by using step 8, exchanging opinions with peers and discussing on problem solving in the classroom. All students took part in class discussion to make them understand problems clearly. The researcher also used the exercises based on 4MAT teaching model, and arranged from easy to difficult steps.

In addition, the learning pyramid model suggests that some methods of learning are more effective than the others and that varying study methods would lead to deeper learning and longer-term retention. The study from Riedesel (1990) also supported that communication helped a learner to obtain clear thinking.

Recommendations

For Teaching

1. From classroom practice of the researcher, consecutive steps in 4MAT teaching model were close. They might be combined to be one step. So, the 8 steps could be reduced to 4 steps as follows: 1) connect and attend, 2) image and inform, 3) practice and extend, and 4) refine and perform.

2. Teacher should try 4MAT teaching model in some periods or in some areas of mathematics as a different teaching experience beside usual practices.

3. Using variety of activities in classroom such as discussion or think-pair-share supported left-brained or right-brained using skills of students in mathematics learning according to 4MAT teaching model.

For Further Research

1. Further research might try using reduced 4MAT teaching model in 4 steps as follows: 1) connect and attend, 2) image and inform, 3) practice and extend, and 4) refine and perform, and checking students' retention one semester after the summative test.

2. For further research, the researchers might try using a 4MAT teaching model about 4 cognitive domains in order to improve the mean scores of applications and analysis domains.

3. Further research should investigate student learning styles by using learning style questionnaire based on David Kolb Theory (Honey and Mumford, 2006). The results would be helpful to design suitable activities which improve and support students' achievement.

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