ME – 35

SHIFTING STUDENTS' AWARENESS OF GEOMETRICAL CONCEPTS THROUGH LESSON STUDY

Lilla Adulyasas*
Yala Rajabhat University

Shafia Abdul Rahman
Universiti Sains Malaysia
*lilla.a@yru.ac.th

Abstract

Students' performance in geometry and hence, their geometric thinking remain a concern for researchers globally. This quasi-experimental research design aims to investigate the effects of Phase-Based Instruction (LS-PBI) using Geometer's Sketch Pad to reveal Thai students awareness of geometric concepts. Three groups of mixed ability Grade 7 students (aged 12 – 13) were chosen as participants in one of the schools in Yala Province, Thailand. These groups were taught the topic of Properties of 2D and 3D geometric shapes in a cycle of three instructions by three different teachers engaging in Lesson Study method. A twelve-item multiple choices test was administered to students in each group before and after each lesson study session to assess their understanding of geometrical concepts. Findings of the pre-tests and post-tests revealed that LS-PBI using GSP was effective in revealing students' shifts in awareness of geometrical concepts.
Keywords: Geometer's Sketchpad, Geometric Thinking, Geometry, Lesson Study

Introduction

The National Council of Teacher of Mathematics (NCTM) states that "geometry is a natural place for the development of students' reasoning and justification skills, culminating in work with proof in the secondary grades." (NCTM, 2000, p. 41). This is the reason for the placement of geometry in the mathematics curriculum from pre-kindergarten to high school in many countries. Therefore, Geometric thinking, which is the ability to think reasonably in geometric context (van de Walle, 2004), is very important because it will lead student to have spatial visualization – an important aspect of geometric thinking, geometric modelling and spatial reasoning that will provide ways for students to understand and explain physical environments and can be an important tool in problem solving (NCTM, 2000).

The Basic Education Core Curriculum in Thailand (Thailand Ministry of Education, 2008), states that geometry is an important content standard in the curriculum for Thai students from primary school to secondary school. At secondary school level, students are expected to be able to construct and explain the compass and straight edge of 2D geometric figures and explain characteristics and properties of 3D geometric figures such as prisms, pyramids, cylinders, cones and spheres. The Thai curriculum on geometry comprises two standards:

- Standard M 3.1: Ability to explain and analyse two-dimensional and three-dimensional geometric figures.
- Standard M 3.2: Ability for visualization, spatial reasoning and application of geometric models for problem solving.

Though geometry is very important and many studies in Thailand have attempted to develop students' geometric thinking, the statistical data shows that Thai students still lag behind in mathematics and geometry in comparison to national and international averages.

Many studies have found that Thai students have difficulties in learning geometry. Chatbunyong (2005) investigated the problem in learning geometry of Thai students and found that the most problem about learning geometry is students do not know how to start proving, subordinated problem are students cannot understand the properties of geometric shape, cannot give the reasoning in proving, cannot find the way in proving, cannot connect the information given in question with what question ask and cannot use the properties of geometric shape to help in their proving. This is consistent with the study of Maneewong (1999). Moreover, there are a number of students cannot applied the concepts of solving a problem to another similar problems in the same topic (Fongjangvang, 2008). Sawangsri (2002) investigated Thai Students' geometric thinking in Suphanburi province of Thailand by using geometric test developed from Usiskin (1982) and found that 75.28% of 90 students have geometric thinking in level 0, 24.72% are in level 1 and no one in level 2 or up. This shows that Thai students' geometric thinking is rather poor. According to Usiskin (1982), if students have their geometric thinking lower that level 2, then they will not be successful in learning geometry in high school or at higher level (Usiskin, 1982).

One theory that many researchers have been used to develop students' geometric thinking is the van Hiele theory which describes the level of development in learning geometry. The five levels of geometric thinking are visualisation (Level 1), Analysis (Level 2), Abstraction (Level 3), Informal deduction (level 4) and Rigour (level 5) (van Hiele,1986). Additionally, van Hiele (1986) also proposed the *phased-base instruction* (PBI) as a teaching strategy to move up the levels of geometric thinking. The five phases of instruction are phase 1: Information, phase 2: Guided Orientation, phase 3: Explicitation, phase 4: Free Orientation, phase 5: Integration. And regarding to this theory, studies in Thailand have found that there was an increase in the level of geometric thinking of students who were taught geometry through phase-based instruction and also in the attitude towards geometry (Chutkaew, 2006). Besides, students also had geometric achievements more than the criterion (Namchittrong, 2003).

The van Hiele theory which describes five levels of geometric thinking and the five phase of instruction has been applied in many studies related to teaching and learning of geometry and this instruction shows it has been successful in developing students' geometric thinking (Liu & Cummings, 2001; Hanlon, 2011). In the "free orientation" stage of the phase-based instruction, student will have the opportunity to learn by general tasks to find their own way in the network of relation of solving problem (van Hiele, 1986). Thus, teachers can give the opportunities and environment which encourages students to think independently as much as possible by emphasizing phase-based instruction in order to enhance students' geometric thinking. However, teachers in Thailand tend not to use the van Hiele theory of geometric thinking in their classroom settings (Chamnankit, 2001).

Additionally, there still have another concern in finding the ways to make students understand the concepts in geometry. Researchers have been studied ways to teach geometry by considering students difficulties. These studies showed that using technology such as GSP was useful in developing students' understandings of geometric concepts (Liu & Cummings, 2001). These studies indicate that GSP is a useful tool for enhancing children's thinking through van Hiele's hierarchy because it allows students to discover relationships among geometric concepts through investigation (Key Curriculum, 1999). Hence, the integration of technology, pedagogy with the teaching content is important in developing students' understanding of a particular mathematical content especially in geometric concept.

However, despite the availability of hardware and software in the technology-rich secondary school, a study by Norton et al. (2000) found that teachers rarely use computers in their teaching because they believe in their existing pedagogy; they are concerned about time constraint and their preference for particular text resources. Moreover, some teachers had restricted images of the potential of computer in mathematics teaching and learning because they have absorbed images of teacher-cantered and content-focus pedagogy (Norton et al. 2000). Therefore, it seems that only technology is not enough to improve student learning.

Teachers need to consider and improve their teaching as well because in today's world, the needs and interests of children are very different from the children in the past decades and the traditional approach may not response to the potential of children (Battista & Clement 1999).

This suggests that professional teacher development is also one element which is important and brings out the professionals in the teacher, which will lead to student success. Lesson study (LS) is one of the professional teacher development programs which many scholars have studied for developing teaching process and it obviously shows success in teaching and learning because it provides opportunities for teacher to work collaboratively, have a deep understanding of the pedagogy and cultivate the skill of observation, analysis and reflection of the teacher (Fernandez, 2005; Lewis, Perry, & Hurd, 2009; Isoda, 2010). In addition, Stigler and Hiebert (1999) also stated in their book that "if our educational system can find a way to use lesson study for building professional knowledge of teaching, teaching and learning will improve" (p. 131).

For these reasons, this study purposes to shift students' awareness of geometrical concepts after using lesson study incorporating phase-based instruction (LS-PBI) using GSP by looking at students' geometric thinking and the changes of students' awareness of geometric concepts during lesson study session in order to support the effective teaching and learning geometry in Thailand.

Research Method

Research Design

A mixed method research design using quasi-experimental and a case study was employed in this study. A quantitative method was used to see the effectiveness of LS-PBI using GSP on students' geometric thinking while a qualitative method was used to see the students' awareness of geometric concepts in learning the topic of *Relationship between 2D and 3D geometric shapes.*

Purposive sampling technique was used to select three classes of mixed-ability students in grade seven (group 1: N=30, group 2: N=28 and group 3: N=29) from a secondary school in Yala province Thailand. From these three groups, six students will be chosen to be observed their awareness of geometric concepts.

Procedure

1) Before using LS-PBI using GSP, a pre-test was given to the students in group 1, group 2 and group 3 to determine their initial level of geometric thinking.

2) Next, the first teacher carried out the phase-based instruction using GSP. During this time, the other teachers observed the teaching and learning in term of student's difficulties in learning the topic an also the students awareness of geometric concept. Then a post-test was given to the students in group 1.

3) After the first lesson study session of students in group 1, the group of teachers reflected on the teaching and learning process and revised the lesson plan by focusing on students' difficulties and students' awareness of geometric concepts based on the situation happened in the classroom.

4) Following this, the revised lesson plan was taught for a second time by the second teacher to the students in group 2. Students' geometric thinking and students' awareness of geometric concepts were observed. Then Post-test was administered to the students in group 2

5) The same process was repeated to the students in group 3.

Instrument

1) Lesson plan in the topic of "Properties of 2D and 3D geometric shapes" which was design for teaching through phase based instruction using GSP.

2) Pre-test and Post-test for assessing van Hiele level of geometric thinking of students.

3) Classroom observation protocol for observing students' awareness in geometric concept.

Data analysis

The researcher employed quantitative data analysis in identifying the level of geometric thinking, comparing the pre-test and post-test scores, and comparing the post-test scores among 3 groups of students.

First the researcher will prepare the gathered data by scoring the pre-test and post-test of students in group 1, 2 and 3 based on adapted Usiskin's (1982) scoring criteria. According to each question in the geometric thinking test is assigned to a van Hiele level of geometric thinking as follow:

Item 1- 4 are for assessing students' geometric thinking in level 1
Item 4- 8 are for assessing students' geometric thinking in level 2
Item 9-12 are for assessing students' geometric thinking in level 3

The criterion using in this study to identify the students' van Hiele level of geometric thinking will be adapted from Usiskin's dissertation (Usiskin, 1982). From the items in each level, if a student can choose correctly answer around 60% or more from the questions in each level, he/she will be considered that they can pass the criterion of that level. Therefore, from item 1-4, if students choose the correct answer at least 3 items, they are considered to be satisfactory for level 1. From item 4-8, if students choose the correct answer at least 3 items, they are considered to be satisfactory for level 2. Last, from item 9-12, if student choose the correct answer at least 3 items, they are considered to be satisfactory for level 3.

After students were satisfied in a level of geometric thinking. Student will be assigned a weight sum score as following:

A student will get 1 point if he/she meets the criterion on items 1-4 (level 1).
A student will get 2 points if he/she meets the criterion on items 5-8 (level 2).
A student will get 4 points if he/she meets the criterion on items 9-12 (level 3).

Once students got the points from each level, the points in each level will be combined to become a weight sum score. Finally the classification of the van Hiele level of geometric thinking will be identified according to the Usiskin's operational definitions (Usiskin, 1982).

Weight sum scores	assigned to	**van Hiele level**
0		0
1		1
3		2
7		3

Results

Students' level of geometric thinking

Table 1: Frequency and percentage of students in each group at each van Hiele level

	Group 1		Group 2		Group 3	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**Pretest**	**Posttest**
Level 1	8 (26.67%)	1 (3.33%)	6 (21.43%)	0 (0%)	7 (24.14%)	0 (0%)
Level 2	14 (46.67%)	5 (16.67%)	15 (53.57%)	4 (14.29%)	13 (44.83%)	4 (13.79%)
Level 3	4 (13.33%)	22 (73.33%)	5 (17.86%)	23 (82.14%)	6 (20.69%)	25 (86.21%)
No Level	4 (13.33%)	2 (6.67%)	2 (7.14%)	1 (3.57%)	3 (10.34%)	0 (0%)
Total	30 (100%)	30 (100%)	28 (100%)	28 (100%)	29 (100%)	29 (100%)

From Table 1, the results show that the initial van Hiele level of students in group 1, group 2 and group 3 were predominantly at level 2 (46.67%, 53.57% and 44.83% respectively). After

the intervention, the van Hiele level of students in group 1, group 2 and group 3 were predominantly at level 3 (73.33%, 82.14% and 86.21% respectively). This indicates that students progressed from level 1 to level 3. However, there is just only one student in group 1 who did not make any progress. The results also reveal that group 3 has the most percentage of the students who attained level 3. This indicates that lesson plan 3 is the most effective.

Students' awareness of geometric thinking

There are six students that researcher selected for observing their awareness of geometric concepts. Six students are Nop, Anna, Mat, Jim, Plearn and Dan.

Before LS-PBI using GSP

At the beginning Nop and Anna were identified their geometric thinking at level 0 (No level) in their geometric thinking. They can recognize some of 2D geometric shapes which are simple such as circle triangle and rectangular but they couldn't recognize the trapezoid and kite . They did not show any awareness on 3D geometric shapes and its properties.

Additionally they both did not know the differences between 2D and 3D geometric shapes as the teacher asked "What is the difference of Cube and square?" (In Thai language the word "cube" and "square" are very similar). Nop said "it's the same thing" while Anna did not response anything back. These show that their awareness of geometric concepts on 2D and 3D geometric shapes are very low.

The other four students, Mat, Jim, Plern and Dan were identified their geometric thinking at level 1. They can recognize the name of 2D and 3D geometric shapes. Some of them know the components of the 3D shapes. Mat said that they have experiences in seeing the real shapes of 2D and 3D geometric shapes which their teacher brought and showed in the classroom when he was in the Primary school as same as Plern . Therefore, these 2 students know about the components of some simple 3D shapes. For example Mat knows that a pyramid comprises of a square and 4 isosceles triangle. Jim and Dan Never experience the real shapes in the classroom when they were in the primary school level. So Jim and Dan can only recall the name of some shapes but still cannot explain the components of the shapes even the simple 3D shapes. However, there is no evidence to show that these four students have awareness of the properties of 3D geometric shapes and also the relationship between 2D and 3D geometric shapes.

After LS-PBI using GSP

Nop, Anna and Dan progress their level of geometric thinking to level 2 while Mat, Jim and Plern progress to level 3.

In the first lesson study session the teacher found the difficulties in learning the properties of 3D shapes using GSP as some students not familiar in using computer. During the reflecting meeting of the first lesson study session, one teacher suggested to use the real 3D geometric shapes in the classroom for helping students who are not familiar in using computer. Everybody agree with this idea and this helps students who are not familiar with using computer in learning the 3D shapes. One student investigated the properties of the 2D and 3D geometric shapes in GSP and also with the real shapes at the same time and this make them have a very good awareness of the properties of 3D geometric shapes.

In the third lesson study session, the spinning GSP pre-constructed of 3D shapes which was requested from the students from the second lesson study session were created and this improve students awareness of the properties of 3D geometric shapes which lead them to understand the relationship between 2D and 3D geometric shapes.

Nop, Anna and Dan can identified the components and the properties of 2D and 3D geometric shapes but could not identified the relationship between 2D and 3D geometric shapes as they confuse and take long time to answer "which 3D geometric shapes is form by a hexagon and six triangle while Mat, Jim and Plern understood and have a good awareness of properties and relationship between 2D and 3D geometric shapes as they can immediately answer the questions about the relationship between 2D and 3D geometric shape

Discussion

The results show that after each lesson plan which was taught using phase-based instruction using GSP has an effective on students' geometric thinking since student progress from level 0 (no level) to level 3. These findings are consistent with Choi (1996), Choi-Koh (1999) and Chew (2009) which reported that phase-based instruction using GSP had enhanced students' understanding in learning geometry.

In this study, the use GSP helped students in improving the awareness of geometric concept. However there are a lot of student who are not familiar with using computer. Therefore it quite difficult at first for them to improve their awareness of geometric concept using GSP. But after the second lesson study session a group of teacher design lesson for student to investigate the shapes using GSP and the real shapes in the same times and this help student a lot in visualising the shape and improve their awareness in this particular topic and GSP helps students to familiar with using computer. Once students familiar with using GSP they will be able to visualize the shape because GSP provide pictures in several perspectives for students to investigate, and dragging objects makes students conjecture about the properties of the shapes. GSP also provide a nice and effective visualization and makes students enjoy and appreciate the beauty of geometry.

If we focus on lesson study process, we found that group 3 has the highest percentage of students who obtained the highest level of geometric thinking. This suggests that lesson study process of teachers working collaboratively in observing, analyzing, reflecting and revising the lesson plan has a positive effect on students' learning. Although lesson study aim to improve mathematics teaching, results on the student achievement are also positive as it shows that the number of students who attained level 3 are increased and this consistent with the study of Meyer & Wilkerson (2007) which reported that students' achievement in mathematics appeared to have improved and lesson study had a positive impact on students' engagement in mathematics.

Conclusion and Suggestion

From the pre-test results, analysis suggests that students' initial van Hiele level of geometric thinking about the properties of 2D and 3D geometric shapes ranged from Level 0 (no level) to Level 3. After the intervention, the post-test indicated that the students' level of geometric thinking ranged from Level 1 to Level 3. We can see the progress of students' geometric thinking in group 1, group 2 and group 3 by the frequency and percentage of students which show that the initial van Hiele level of students in every group before the intervention was predominantly at level 2 but after the intervention, the van Hiele level of students in every group was predominantly at level 3. This suggests that LS-PBI using GSP has a positive effect on students' geometric thinking in learning the properties of 2D and 3D geometric shapes. Moreover, the results reveal that students in group 3 who were taught by the last revised lesson plan has the most percentage of the students who were at Level 3 (highest level).

Besides, the lesson in this particular content will be enhanced because the lesson study process changed teacher's roles in their teaching, which is different from the traditional method. A group of teachers discuss collaboratively on how to improve the instruction and the designed lesson by focusing their attention on students' difficulties because the difficulties in learning indicate the weakness of teaching and makes the teacher become more aware and help each other by looking into the situation that happens during the classroom activities more attentively. Working collaboratively also leads teachers to exchange different points of view, reflect weaknesses of each other and also the weakness of the lesson in order to improve the teaching and the lesson until they come up with the best way to teach that builds on student understanding.

In the first lesson study session the teacher found the difficulties in learning the properties of 3D shapes using GSP as some students not familiar in using computer. One teacher suggested to use the real 3D geometric shapes in the classroom for helping students who are not familiar in

using computer. This helps students who are not familiar with using computer in learning the 3D shapes. One student investigated the properties of the 2D and 3D geometric shapes in GSP and also with the real shapes at the same time and this make them have a very good awareness of the properties of 3D geometric shapes.

Additionally, in the third lesson study session, the spinning GSP pre-constructed of 3D shapes which was requested from the students from the second lesson study session were created and this improve students awareness of the properties of 3D geometric shapes which lead them to understand the relationship between 2D and 3D geometric shapes.

At the beginning, some students have experience in seeing the example of real 3D shapes in the classroom when they were in the primary school level. Therefore they know the components of the 3D geometric shape. However, there are some students never see the real 3D shapes; these students could not explain the components of the shapes even the simple shapes.

During lesson study session there are some student have difficulties in learning the properties of 3D shapes on GSP since they are not familiar with using computer. The teachers solve this problem by constructing the real shape for demonstrating in the class room. Therefore student can investigate GSP together with the real shapes at the same time. This makes them shift there awareness in learning the topic.

The findings suggests that a well-designed teaching and learning process using phase-based instruction, appropriate instructional tool (such as GSP) and improvement of teaching methodology and teacher competencies by lesson study are the elements that can shift students' awareness of geometric concepts.

Bibliography

Battissa, M. T. & Clement, D. H. (1999). Research into practice: Using Spatial Imaginary in geometric reasoning. *Arithmetic Teacher*, 39 (3), 18-21.

Chamnankit, N. (2001). *The Development of a Model to Create Teaching Competancy on Geometric Concept Image for Pre-service Teachers*. Dissertation, Ed.D. Srinakharinwirot University.

Chatbunyong, A. (2005). *The instructional package on congruence emphazing the van Hiele level for Mathayomsuksa II students.* M.Ed. Thesis. Srinakharinwirot University.

Chew, C. M. (2009). Enhancing students' geometric thinking through phase-based instruction using Geometer's Sketchpad: A case study. *Jurnal Pendidik dan Pendidikan,* 24, 89-107.

Choi, S. S. (1996). *Students' learning of geometry using computer software as a tool: Three case studies.* (Ph.D. Dissertation, University of Georgia). UMI Publications.

Choi-Koh, S. S. (1999). A student's learning of geometry using the computer. *Journal of Educational Research, 92*(5), 301-311.

Chutkaew, C. (2006). *A development of geometric unit and levels of geometric thought based on the van Hiele model by using dynamic geometry software for Mathayomsuksa II students.* Ed.D. Thesis. Kasetsart University.

Fernandez, C. (2005). Lesson Study: A Means for Elementary Teachers to Develop the Knowledge of Mathematics Needed for Reform-Minded Teaching? *Mathematical Thinking & Learning: An International Journal, 7*(4), 265-289**.**

Fongjangvang, S. (2008). *Comparison of Spatial Ability and Mathematics Learning Achievement on Two and Three Dimensional Geometric Figures by Mathayomsuksa 1 Students, Using the GSP Program and General Teaching*. M.Ed Thesis. Pibulsongkram Rajabhat University**.**

Hanlon, A. E. C. (2011). *Investigating the influence of Quick Draw on pre-service elementary teachers beliefs, in concordance with spatial and geometric thinking: A mixed methods study.* ProQuest Information & Learning, US.

Isoda, M. (2010). Lesson Study: Problem Solving Approaches in Mathematics Education as a Japanese Experience. In R. A. A. A. F. M. Tarmizi (Ed.), *International Conference on Mathematics Education Research 2010 - Icmer 2010* (Vol. 8, pp. 17-27).

Key Curriculum. (1999). *Teaching geometry with the Geometer's Sketchpad.Emery-ville,* CA: Author.

Lewis, C. C., Perry, R. R., & Hurd, J. (2009). Improving Mathematics Instruction through Lesson Study: A Theoretical Model and North American Case. *Journal of Mathematics Teacher Education, 12*(4), 285-304.

Liu, L., & Cummings, R. (2001). A Learning Model That Stimulates Geometric Thinking Through Use of PCLogo and Geometer's Sketchpad. [Article]. *Computers in the Schools, 17*(1/2), 85.

Maneewong, W. (1999). *The Effects of Cooperative Learning on the Achievement in the geometry classroom and Self-esteem Levels of Mathayomsuksa Two Students.* M.A. Thesis. Kasetsart University.

Meyer, R., & Wilkerson, T. L. (2007). Lesson Study: The Effects On Teachers and Students In Urban Schools In the United States. [Article]. *Conference Papers -- Psychology of Mathematics & Education of North America,* 1-26

Ministry of education of Thailand (2008), *The Basic Education Core Curriculum 2008, Mathematics.* Ministry of education, Bangkok.

Namchittrong, N. (2003). *The comparison of students' geometric achievement between teaching emphatic the van Hiele model and traditional model.* M.A. Thesis. Kasetsart University.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics. Reston,* VA: NCTM.

Norton, S., C. J. McRobbie, et al. (2000). "Exploring secondary mathematics teachers' reasons for not using computers in their teaching: five case studies." *Journal of Research on Computing in Education, 33*(1), 87.

Sawangsri, B. (2002). *The Effect of Geometric Teaching with Teaching of Diana van Hiele's Phases on the Level of Geometric Thinking and Achievement of Mattayomasuksa 1 Students.* M.Ed. Thesis. Rajabhat Institute Nakhonsawan.

Stigler, J., & Hiebert, J. (1999). *The teaching gap : Best ideas from the world's teachers for improving education in the classroom*. New York: Free Press.

Usiskin, Z. (1982). *Van Hiele levels and achievement in secondary school geometry*. CDASSG Project. The University of Chicago.

Van de Walle, J. A. (2004). *Elementary and middle school mathematics: Teaching developmentally* (6th ed.). Boston, MA: Pearson Education.

Van Hiele, P. M. (1986). *Structure and insight: A theory of mathematics education*. Orlando, FL: Academic Press.