Students’ Perceptions Towards the Van Hiele’s Phases of Learning Geometry Using Geometer’s Sketchpad Software

Abdul Halim Abdullah and Effandi Zakaria

Department of Sciences and Mathematics Education, Faculty of Education Universiti Teknologi Malaysia, Skudai, Johor.
Department of Educational Methodology and Practice, Faculty of Education Universiti Kebangsaan Malaysia, Bangi, Selangor.

Abstract: Students should be given the opportunity to experience effective and interesting learning process. In this age of modern technology, many learning aid tools can be used to facilitate the learning process. For the topics of geometry, the provided activities are arranged properly according to Van Hiele’s phases of learning geometry namely information, guided orientation, explicitation, free orientation and integration. Hence, the objective of this paperwork is to identify the students’ opinion towards the activities developed according to Van Hiele’s phases of learning geometry using Geometer’s Sketchpad (GSP) software. The activities were developed and certified by a few experts. The topic included was Form Two’s Transformations. A 2-day workshop was conducted in a secondary school in Negeri Sembilan to put the developed activities in action. Two teachers conducted the workshop that was attended by 30 Form 2 students. Questionnaires were given to the students to obtain their opinion regarding the activities based on Van Hiele’s phases of learning geometry using GSP. The results of the study showed that most of the students agreed that the prepared activities gave them positive effects such as facilitating their geometry lessons and boosting their confidence to learn geometry. Besides that, the GSP software was easy to use and helped them in their learning process. Hence, the use of Van Hiele’s phases of learning geometry integrated with GSP software is very encouraged as an alternative strategy in learning geometry to increase the students’ understanding and their level of geometric thinking.

Key word: Van Hiele’s phases of learning geometry, Geometer’s Sketchpad (GSP) software.

INTRODUCTION

Effective learning strategy is different for each component of mathematics (Noraini, 2005). For example, the effective learning strategy for the topic Probability is different from the effective learning strategy for Statistics. For the topics of geometry, the hardest thing to handle by teachers is how to plan activities that can help students to understand the nature and concept of geometry (Choi-Koh, 2000). Hence, learning activities for the topics of geometry are indeed encouraged to be built and arranged based on Van Hiele’s phases of learning geometry (Halat, 2008; Choi-Koh, 2000). There were even a few past studies conducted that revealed that the activities arranged based on Van Hiele’s phases of learning geometry had given positive impacts to students in various aspects including the students’ understanding and their level of geometric thinking (Choi-Koh, 2000; Penelope, 2008; Chew, 2009). This matter is seen very essential because in the Mathematics syllabus of Malaysia’s Integrated Curriculum for Secondary School, geometry is one of the main components and it covers about 40% from the overall of Mathematics topics being taught from Form 1 to Form 5 (Education Ministry Malaysia (MOE), 1998).

Van Hiele’s Model:

There are a total of 5 phases in learning geometry as suggested in Van Hiele’s model. Van Hiele’s model has been a subject in continuous academic studies in the field of geometry. It has also been applied in many studies in the field of geometry (Clement & Battista, 1992; Battista, 2002; Noraini, 2005; Halat, 2008). Van Hiele’s model was the brain child of Pierre Van Hiele from the University of Utrecht in the Netherlands. This model comprises of five levels of geometric thinking labelled 1 to 5. These five levels of geometric thinking are arranged in hierarchy and sequence. Advancing from one level of thinking to another depends on the
student’s experience and not on the chronology of the student’s age. The levels of thinking are visualisation, analysis, informal deduction, deduction and rigor. Battista (2002) stated that the pattern of a student’s thinking towards 2-dimensional geometry is clear and best explained by Van Hiele’s model.

The first level is visualisation. In this level, the student can recognise geometric shapes. The student gets to know and identify certain geometric shapes based on the entity of the whole object and not on its components or traits. The second level in Van Hiele’s model is analysis. In this level, the student can identify with certain geometric traits and concepts. For example, a square has matching equal-length and parallel sides and each four corners are 90°. The third level is informal deduction. In this level, the student can see the relation between shapes and then the student creates that relation. They can relate existing knowledge and form arguments to come with correct generalisation. The fourth level is deduction. In this level, the student understands the meaning and importance of deduction and the role of postulates, theorem and proof. They are able to create proof based on their own understanding. The fifth level is rigor. In this level, the student understands how to work in axiomatic system. They are able to form a more abstract deduction. Usually, lower secondary students are able to reach up to the third level of Van Hiele’s model, which is informal deduction (van Hiele, 1986; Halat & Peker, 2008)

Van Hiele’s Phases of Learning Geometry:

According to van Hiele (1986), the movement from one level of geometric thinking to the next include five phases of learning: information, guided orientation, explicitation, free orientation and integration. In the first phase, which is information, teacher and student use the question-and-answer approach with regards to the objects learnt. The teacher will pose a question to the student while performing an observation. In the guided orientation phase, the student learns geometry through exploration. In this phase also, the student learns the topic of study deeper using teaching aids provided by the teacher. The student explores through the meticulously planned activity so that the characteristics and properties of a level of thinking can be gradually exposed. In the explicitation phase, the student’s new knowledge is formed through experience and past knowledge. The student explains and states his or her opinion about geometrical structures that he or she has observed. The student will explain the observation on the activities done previously. In the fourth phase which is free orientation, the student can complete a complex task, which is a task that requires a number of steps and can be solved many ways. In the last phase which is integration, the student re-examines and simplifies what he or she has learnt to draw a new overall picture for a network of objects and the correlation between them.

Recently, the activities based on these phases have become more interesting, simple and effective with the presence of many dynamic geometry software. One of them is the GSP software that is becoming more popular to be used in the teaching and learning Mathematics process in schools. In Malaysia, the KBSM Mathematics curriculum specifications shows 29.51% or equivalent with 18 topics that are mostly topics in components of geometry have been suggested to be taught using the GSP software (Norhana Aini 2008). Among the topics of geometry that have been stated clearly are Transformations, Circles, Coordinate, Polygons and Linear Equations.

The Effectiveness of the Activity Based on Van Hiele’s Phases of Learning Geometry in Technological Environment:

There are a few past studies that tested the effectiveness of the activities based on Van Hiele’s phases of learning geometry in a technological environment. Choi-Koh (2000) have developed activities based on Van Hiele’s phases of learning geometry using GSP software. Those activities were done by the student with the aid of Geometer’s Sketchpad software (GSP) and they covered the topic of types of triangles. Penelope (2008) on the other hand has executed a project that used these phases of learning approach by inserting the elements of technology to assist the teaching and learning geometry process in Mathematics class. The topic involved in the study was Space and Geometry where the subtopic being stressed were “classifying, building and identifying traits of triangles and quadrilaterals” and “proving the traits of quadrilaterals”. The results of her studies showed that Van Hiele’s phases of learning were an effective work frame in organising activities that used dynamic geometry software. The students also showed continuous active participation in doing their tasks and they also interacted among themselves from which this situation caused the change of language they used from informal to formal. Besides that, other software such as spreadsheet that was used for recording purposes also played a crucial part to make more effective role of the dynamic geometry software.

Chew (2009) also conducted a research to study the learning of solids geometry among Form 1 students in teaching environment based on Van Hiele’s phases by using the GSP software. His study aimed to know
the early level of thinking of Van Hiele’s phases of learning geometry on cubes and cuboids, and how the students’ Van Hiele's level change after teaching based on phases by using GSP. His findings stated that the students’ early level of Van Hiele’s thinking varied between level 1 and level 2. After teaching based on phases by using GSP, the students’ Van Hiele’s level increased or remained at the same level. This finding showed that there are numerous ways for teacher to increase the students’ level of Van Hiele’s phases of learning geometry on cubes and cuboids. One of them is to design a teaching material based on Van Hiele’s phases of learning. This approach does not only help to increase the students’ level of thinking, but also can strengthen their understanding of geometry concepts.

**Methodology:**

Based on the literature review studied, the researcher has developed activities based on Van Hiele’s phases of learning geometry using GSP software as a medium. Those activities included Form 2 topic named Transformation, and a pilot study was conducted on 30 Form 2 students from a school in Negeri Sembilan.

**Example of the Established Activity:**

![Van Hiele's Phases of Learning in GSP Software Environment](image)

The first session is aimed to increase the students’ level of thinking from the first level of Van Hiele’s level of geometric thinking i.e. visualisation to the second level of Van Hiele’s level of geometric thinking, which is analysis. In the first phase i.e information, the student is exposed with the application of the concepts of translation, reflection and rotation in their everyday life. For example, the application of translation in their real life includes the movement of escalators and the movement of baggage retrieval machines at the airport. They are then asked to give other examples of applications of translation, reflection and rotation in their daily life. In the second phase i.e guided orientation, the students learn the concepts of translation reflection and rotation by using the GSP software. They are asked to explore the characters of translation, reflection and rotation using GSP. For example, the characteristics of reflection such as size and shape of the object and image, distance of the object and image, and the orientation of the object and image can be explored easily and accurately by the student by using the GSP. Besides the three characteristics of the three kinds of transformation, other concepts related to the three types of transformation will also be learnt with the help of the GSP software. In the third phase i.e explicitation, based on the data obtained from the activities in the second phase, explanation will be given by the students. For example, the students explain the characteristics of rotation based on the data they obtained while doing the activity using GSP in the second phase. In the fourth phase, which is free orientation, the students are free to build any diagram by using GSP on their own. They are free to find the diagram image under certain transformations, explore the characters of the transformations, and elaborate them. In the final phase i.e integration, the students conclude by making a summary of what they have learnt. They present the results of their works and the teacher corrects the students’ findings. Meanwhile, the second learning session aims to increase the students’ level of thinking from level 2 of Van Hiele’s level of geometric thinking, analysis, to the third level of Van Hiele’s geometric thinking, informal deduction.
The developed activities were given to six experts comprising two content experts, two technical experts and two language experts. Before the pilot study was done in the school, permission was applied beforehand from the Education Planning and Research Department (EPRD), MOE, and State Education Department (JPN). A letter issued by JPN was given to the principal of the school involved. Two teachers were appointed to conduct this pilot study. They were mathematics teacher and computer teacher, respectively. Before the pilot study was done, the researchers briefed the teachers in two sessions. They were taught on how to use the GSP software and also how to conduct activities that have been developed. A 2-day workshop was done in the school’s computer laboratory. The GSP software was installed in advance in each of the computers used. A total of 30 Form 2 students took part in this pilot study that was conducted in the form of 2-day workshop. After the workshop ended, the students were asked to complete a questionnaire asking their opinion regarding the activities conducted. Items of the questionnaire were modified from the studies by Abd Rahman (2005) and Noraini (2007). Items of the questionnaire used 5 Likert scale options i.e 1=strongly disagree (STS), 2=disagree (TS), 3=unsure (TP), 4=agree (S) and 5=strongly agree (SS). The index of reliability of the questionnaire was 0.92. A descriptive statistics was used for the purpose of data analysis.

RESULTS AND DISCUSSION

The results shown in Table 1 are based on the students’ evaluation on the activities conducted and the use of the GSP software. For the purpose of discussion, Strongly Disagree (STS) and Disagree (TS) are stated as “disagree”, Agree (S) and Strongly Agree (SS) as “agree”, while “unsure” is maintained. In overall, the majority of students opined that the prepared activities; were easy to execute (96.67% agreed), facilitated them to learn the geometry topics (86.67% agreed), produced enjoyable learning (100% agreed), needed to be spread to other geometry topics (83.33% agreed), have clear and comprehensible/understandable contents (96.67% agreed), have systematically organised contents (90% agreed), and have complete explanation (100% agreed). The students’ views were in line with the opinions by Halat (2008) and Choi-Koh (2000) who stressed that learning activities done by students will be more structured based on the phases of learning geometry suggested in Van Hiele’s model. Moreover, 86.67% of the students agreed that the prepared activities encouraged the active participation of students in learning geometry. This finding is in line with Anne’s (1991) study who said that students will take part actively in the prepared activities based on Van Hiele’s phases of learning geometry. A majority of the students also agreed that the conducted activities; increased their interest towards topics in geometry (83.33% agreed), were able to increase their skills in solving geometric problems (83.33% agreed), enabled them to master geometric concepts well (80% agreed), and gave confidence to them to succeed in mathematics (83.33% agreed). This finding is in line with studies by Usiskin (1982), Penelope (2008), and Chew (2009) who proved the necessities of systematic geometry instructions to increase the knowledge and understanding of students. Meanwhile, according to Stipek (1998), the study environment and tasks given give a deep impact to the students’ attitude. Middleton and Spanias (1999) also explained that the structured learning design influences the students’ attitude towards the subject learnt. Most of the students also found that the Geometer’s Sketchpad (GSP) software was easy to use; with clear instructions (90% agreed), and with graphics given (83.33% agree). Besides that, 93.33% of the students agreed that GSP software attracted them to learn geometric topics, 86.66% of the students agreed that the GSP software helped them to understand geometry concepts easily, and 90% agreed that the GSP software boosted their confidence in learning geometry.

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Unsure</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>The prepared activities are easy to do.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The prepared activities make me learn geometry topics easily.</td>
<td>3</td>
<td>10</td>
<td>16</td>
<td>53.33</td>
<td>10</td>
<td>33.33</td>
</tr>
<tr>
<td>The prepared activities produce fun learning experience.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The prepared activities need to be spread to other geometric topics as well.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The prepared activities have very clear and understandable contents.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The prepared activities have systematically organised contents.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The prepared activities have a complete explanation.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The prepared activities encourage my active participation in the learning process.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The activities increase my interest towards geometry topics.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The activities increase my skills in solving geometry problems.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The activities enable me to master the geometric concepts well.</td>
<td>2</td>
<td>6.67</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The activities gave me confidence to succeed in Mathematics.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The GSP software is easy to use with clear instructions.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The GSP software with graphics given is easy to use.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The GSP software helps me to understand geometry concepts easily.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>The GSP software boosts my confidence to learn geometry.</td>
<td>1</td>
<td>3.33</td>
<td>14</td>
<td>46.67</td>
<td>19</td>
<td>50</td>
</tr>
</tbody>
</table>
Conclusion:
Based on the results and discussion, it can be concluded that Van Hiele’s phases of learning geometry namely information, guided orientation, explicitation, free orientation and integration are a referable and implementable alternative learning strategy for geometry topics. Van Hiele’s phases of learning make students’ geometry activities more organised and systematic. In the first phase, that is information, new ideas will be introduced to the student to give an early description to the student about the concepts of geometry that they will explore and learn. In phase two, directed orientation, the prepared activities give the student opportunities to explore concepts of geometry themselves. Based on the observation from the finding obtained in the second phase, the students will explain the concepts that they have found. In the fourth phase, free orientation, the students will solve more complex problems and usually the questions can be solved in many ways. In the last phase, integration, the student will make a summary of what they have learnt for the purpose of drawing a new general picture of a network of objects and a correlation between them. The students will present the results of their work and the teacher will then correct their findings. Meanwhile, the Geometer’s Sketchpad (GSP) software can be used as a medium to make the students’ learning activities smoother and more fun. In addition to that, students can explore a concept accurately, quickly and effectively with the use of technology especially the GSP software as compared to the traditional approach, which consumes more of the students’ learning time. For example, a student measures the length of a side of a square. Using the traditional approach, the student uses a pencil and ruler to build and measure each side of the square. The length of the sides may not be exactly equal for each side of the square. However, that problem will not occur if GSP software is used to build and measure each side of the square. Hence, the use of Van Hiele’s phases of learning geometry is very much encouraged to be applied in learning geometry topics because there are many past studies that have proved that the use of those phases with the aid of dynamic geometry software, especially the GSP software, can give a positive impact to students such as increasing students’ achievement in geometry, their understanding in geometry and level of confidence in learning geometry.

REFERENCES