THE EFFECT OF VAN HIELE'S INSTRUCTIONAL MODEL ON STUDENTS' ACHIEVEMENTIN GEOMETRY

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Abstract

The main purpose of this study was to study the effect of van Hiele's instructional model on students' achievement in geometry. This study was conducted with both quantitative and qualitative research methods. For quantitative research, an experimental study was used to study the effect of van Hiele's instructional model. In this experimental study, the subjects were Grade seven students selected from No. (7), BEMS, Hlaing and No. (9), BEMS, Insein. The experimental designed adopted in this study was a true experimental design, namely, posttest only control group design. For this study, (60) Grade Seven students from No. (7), BEMS, Hlaing and (62) Grade Seven students from No. (9), BEMS, Insein were selected by random sampling method. These students were divided into two groups: control and experimental. The experimental group was treated with van Hiele's instructional model and the control group was taught with formal instruction. After that, a posttest was administered to two groups. Independent samples *t*-test was used to compare the differences between the two groups. The results showed that the students who received a treatment by van Hiele's instructional model demonstrated significantly better than those who received by formal instruction in No. (7), BEMS, Hlaing ($t = 12.776$, $p < .001$) and in No. (9), BEMS, Insein ($t = 11.778$, $p < .001$). The qualitative data also supported the findings from the experimentation. For this research study, students of the experimental groups were given a questionnaire. It consists of (15) items five-point Likert-scale and (3) open ended questions. The results showed that the students expressed their willingness to learn in van Hiele's instructional model and they had positive attitudes towards van Hiele's instructional model. Research findings proved that van Hiele's instructional model has positive contribution to the geometry teaching at the middle school level.

Keywords: van Hiele levels, van Hiele's instructional model, geometric thinking

Introduction

Geometry is an important branch of mathematics and it has been identified as a basic mathematical skill. It is also applied in other branches of mathematics. According to National Council of Teachers of Mathematics (2000; cited in Ozcakir, 2013), geometry provides describing, analyzing and understanding the world around. Regarding the learning of geometry, students should be able to analyze characteristics and properties of geometric shapes, develop mathematical arguments about geometric relationships, use visualization spatial reasoning and geometric modeling to solve problems.

Many students in various part of the world have been facing difficulties in learning geometry. Pierrer van Hiele and Dian van Hiele-Geldof (1985, cited in Noparit, 2005) formulated a model to explain why students had those difficulties. Because of the importance are of geometry in the daily life of students and the emphasis on the topic of geometry in the mathematics curriculum, the process of teaching and learning geometry should be made more meaningful and should be emphasizing hands-on exploration, creative thinking and the ability to argue and generate conjectures about geometry. The geometry instruction is suggested to be organized according to van Hiele model. So, van Hiele's instructional model can be used to guide

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instruction as well as assess students' abilities. The importance of learning action between students and teacher is emphasized within van Hiele's instructional model. According to this model, students' thinking in geometry progresses sequentially through levels.

Statement of the Problem

Many studies have attempted to develop students' geometric thinking, the statistical data shows that students still lack behind in geometry in comparison to national and international averages. Before, many studies have found that students have difficulties in learning geometry. Usiskin (1982, cited in Abulyasas, 2016) said that if students have their geometric thinking lower than level 2, then they will not be successful in learning geometry in high school or at other higher levels. This failure to the students' weakness in geometric thinking and the teachers' failure to use effective and appropriate teaching methods that can help them overcome the difficulty of teaching geometry. In the traditional class room, the teacher's role is to introduce geometric concepts and theorems on the board and in the front of the class without any active contributions from students in formulating new knowledge. This does not show appreciation for their minds and abilities. Therefore, how to progress the process of teaching and learning geometry is a real problem for current mathematics teachers in order to get high level of achievement in geometry among their students. The van Hiele model related to teaching and learning of geometry and this instruction shows it has been successful in developing students' geometric thinking. Thus, the teachers can give the opportunities and environment which encourages students to think independently as much as possible by emphasizing van Hiele's instructional model in order to enhance students' geometric thinking.

Purpose of the Study

The main purpose of the study is to study the effect of van Hiele's instructional model on students' achievement in geometry. The specific objectives are as follows:

- To study the theoretical foundation of van Hiele's instructional model in teaching geometry.
- To investigate the effect of van Hiele's instructional model on students' achievement in geometry.
- To investigate the attitudes of students from experimental groups on teaching of geometry with the van Hiele's instructional model.
- To give suggestions for the improving of geometry teaching and learning at the middle school level.

Research Hypotheses

1. There is a significant difference in the achievement of van Hiele geometric thinking levels between students who are taught by using van Hiele's instructional model and those who are not.
2. There is a significant difference in the achievement of visualization level of van Hiele geometric thinking between students who are taught by using van Hiele's instructional model and who are not.
3. There is a significant difference in the achievement of analysis level of van Hiele geometric thinking between students who are taught by using van Hiele's instructional model and who are not.

4. There is a significant difference in the achievement of informal deduction level of van Hiele geometric thinking between students who are taught by using van Hiele's instructional model and who are not.
5. The students who learnt with van Hiele's instructional model have positive attitudes, experiences and opinions learning geometry topics.

Scope of the Study

The following points indicate the scope of the study.

1. In terms of geographical area, this study is geographically restricted to Yangon Region.
2. Participants in this study are (120) Grade-7 students from the selected school within the school-year 2018-2019.
3. This study is limited to the content areas of Chapter (6) and Chapter (7) from Mathematics Textbook Volume II prescribed by the Department of Educational Planning and Training, Myanmar.
4. According to the nature of content, this study is limited to visualization level, analysis level and informal deduction level from the van Hiele geometric thinking levels.

Definition of Key Terms

van Hiele levels: The levels of geometric thinking range from level 0 to 4 which are Visualization (level 0), Analysis (level 1), Informal Deduction (level 2), Deduction (level 3) and Rigor (level 4) (Burger & Shaughnessy, 1986, van Hiele, 1986).

van Hiele's Instructional Model: The instruction proposed by van Hiele in order to make the students' geometric thinking levels way up. It has five steps which are Information (step 1), Guided Orientation (step 2), Explicitation (step 3), Free Orientation (step 4) and Integration (step 5) (van Hiele, 1986).

Geometric thinking: The ability to think reasonably in geometric context which have five levels of thinking as seen through the van Hiele levels of geometric development defined by van Hiele's model (Walle, 2004).

Significance of the Study

Geometry is an important branch of mathematics, requires abstract thinking and it has been identified as basic mathematical skill. Geometrical skills have a wide application in other fields of life. According to Serkoak (1996, cited in Abulyasas, 2016), when students have an understanding of geometric concepts, they will be able to learn geometry at the higher level without difficulties and have good attitude towards learning geometry. Nowadays, traditional instruction does not seem effective in developing students' geometric thinking. Teachers need to consider and improve their teaching well because in today's world, the needs and interests of children are very different from the children in the past decades. For effective, all children should be encouraged to express their views, ideas, and feelings. The present teaching method emphasizes only on lecture method which leads to rote learning. Higher level thinking such as reasoning, problem solving, critical thinking, and creative thinking are still weak as Learner Centered Approach is not used in teaching.

In geometry, teachers need to plan classroom activities in a way that can help the learners understand the nature and the concepts of geometry. Teachers can give the opportunities and environment which encourages students to think independently as much as possible by emphasizing van Hiele's instructional model in order to enhance students' geometric thinking. This model indicates that effective learning takes place when student's activity experiences the objects of study in appropriate contexts. This model provides an opportunity for students to solve problems by their own geometric thinking as well as to see a variety of solution from other students. The steps in the model, particularly the fourth step which is "free orientation" will encourage students in solving problems. Teachers can assess their students' levels of thought and provide instruction at those levels. Therefore, teacher should provide experience organized according to the steps of van Hiele's instructional model to develop each successive level of understanding.

Moreover, a research for studying the effect of van Hiele's instructional model on students' achievement in geometry is necessary.

Theoretical Framework

Importance of Teaching Geometry

In the past, most elementary and middle grades teachers spent very little time on geometry. Possibly they felt uncomfortable with the topic themselves or did not regard the topics as important. Traditional norm-referenced tests did not give a lot of weight to geometric thinking. Thanks to the increased NCTM emphasis on geometry and its inclusion in state testing programs, more geometry is being taught. Here are a few reasons that come to mind.

1. Geometry can provide a more complete appreciation of the world. Geometry can be found in the structure of the solar system and in geological formations.
2. Geometric explorations can develop problem solving skills. Spatial reasoning is an important form of problem solving, and problem solving is one of the major reasons for studying mathematics.
3. Geometry plays a key role in the study of other areas of mathematics. E.g. fraction concept of similarity. Measurement and geometry are clearly related.
4. Geometry is used daily by many people. Scientists of all sorts, architects and artists, engineers, and land developers are just a few of the professions that use geometry regularly.
5. Geometry is enjoyable. If geometry increases students' fondness for mathematics more in general, that makes the effort worthwhile.

The van Hiele Model

Constructivists claim that both mathematical truths and the existence of mathematical objects must be established by constructive methods. This means that mathematical constructions are needed to establish truth or existence, as opposed to methods relying on proof by contradiction. Constructivists will no longer expect a mathematical problem to have only one solution strategy, and they will expect solution explanation from the learners. There are many elements in the van Hiele model that are consistent with constructivist ideas about teaching and learning (Arebe, 2008).

In mathematics education, the van Hiele model is a theory that describes how students learn geometry. The theory originated in 1957 in the doctoral dissertations of Dina van Hiele-Geldof and Pierre van Hiele (wife and husband) at Utrecht University, in the Netherlands. The Soviets did research on the theory in the 1960s and integrated their findings into their curricula. The van Hiele model was created to provide geometric understanding and to develop geometric understanding in learners (Erdogan et al, 2009). This model provides useful empirically-based descriptions of what are likely to be relatively stable and qualitatively different states of understanding in learners. The van Hiele model has three aspects: the existence of levels, the properties of the levels, and the progress from one level to the next level.

The best known part of the van Hiele model is the five levels which the van Hieles postulated to describe how children learn to reason in geometry. Students cannot be expected to prove geometric theorems until they have built up an extensive understanding of the systems of relationships between geometric ideas. These systems cannot be learned by rote, but must be developed through familiarity by experiencing numerous examples and counterexamples. Each of the five levels describes the thinking processes used in geometric contexts. These levels describe how learners think about geometric ideas. The five van Hiele levels are sometimes misunderstood to be descriptions of how students understand shape classification, but the levels actually describe the way that students reason about shapes and other geometric ideas.

In general, these levels are a product of experience and instruction rather than age. A child must have enough experiences with those geometric ideas to move to a higher level of sophistication. The levels are as follows:

Level 0: Visualization

Level 1: Analysis

Level 2: Informal Deduction

Level 3: Deduction

Level 4: Rigor

Visualization: At this level, the objects of thought are shapes and what they "look like". The products of thought are classes or groupings of shapes that seem "alike". Students recognize and name figures based in the global visual characteristics of the figure. Because appearance is dominant at this level, appearances can overpower properties of a shape. The focus of a child's thinking is on individual shapes, which the child is learning to classify by judging their holistic appearance. Children at this level often believe something is true based on a single example.

Analysis: At this level, the objects of thought are classes of shapes rather than individual shapes which the child has learned to analyze as having properties. The shapes become bearers of their properties. Students operating may be able to list all the properties of squares, rectangles, and parallelograms but may not see that these are subclasses of one another. The properties are more important than the appearance of the shape. Properties are not yet ordered at this level. Children can discuss the properties of the basic figures and recognize them by these properties, but generally do not allow categories to overlap because they understand each property in isolation from the others.

Informal Deduction: Children at the informal deduction level not only think about properties but also are able to notice relationships within and between figures. Children are able to formulate meaningful definitions. As students begin to be able to think about properties of geometric objects without the constraints of a particular object, they are able to develop relationships between and among these properties. At this level, properties are ordered. The objects of thought are geometric properties, which the student has learned to connect deductively. The student understands that properties are related and one set of properties may simply another property. Students can reason with simply arguments about geometric figures.

Deduction: Students at this level understand the meaning of deduction. The object of thought is deductive reasoning (simply proofs), which the student learns to combine to form a system of formal proofs (Euclidean geometry). The student at this level is able to work abstract statements about geometric properties and make conclusions based more on logic than intuition. There students build on a list of axioms and definitions to create theorems. They also prove theorems using clearly articulated logical reasoning. They understand how to do a formal proof and understand why it is needed. They understand the role of undefined terms, definitions, axioms and theorems in Euclidean geometry.

Rigor: At this level, geometry is understood at the level of a mathematician. Children at this level can think in terms of abstract mathematical systems. Students understand that definitions are arbitrary and need not actually refer to any concrete realization. The object of thought is deductive geometric systems, for which the learner compares axiomatic systems. There is an appreciation of the distinctions and relationships between different axiomatic systems. Learners can study non-Euclidean geometries with understanding.

van Hiele believes that the level of an individual is influences by learning rather than by age, attended grade or biological maturity (van Hiele, 1957; cited in Fuya, Geddes & Tischer, 1988). van Hiele emphasized the importance of experience; he stated that students cannot operate properly on some level, if they have no experience, allowing them to think at this level. Each level uses its own language and symbols. Students pass through the levels "step by step". This hierarchical order helps them to achieve better understanding and results. A significant difference between one level to the next level is the objects of thought- what they are able to think about geometrically. The products of thought at each level are the same as the objects of thought at the next.

Properties of the van Hiele Levels

The van Hiele added the properties: sequential, intrinsic and extrinsic, linguistics, separation, and advancement to clarify certain presumptions that they had about the levels of thought. These properties and a short discussion using comments of the seminal authors are given below.

Sequential (Fixed sequence): According to van Hiele, the levels are sequential and learners must pass through and acquire the lower levels before proceeding to next level (Walle, 2004). Due to the sequential nature, learners cannot skip a level. A student cannot be at level N without having gone through level (N-1). Therefore, the student must go through the levels in order as their understanding increases (except for gifted children). Although, if the learners receive instruction that it may allow them to progress more quickly.

Intrinsic and extrinsic (Adjacent): Properties which are intrinsic at one level becomes extrinsic at the next level. To move from one level to the next, children need to have many experiences in which they are actively involved in exploring and communicating about their observations of shapes, properties, and relationships. Concepts that are implicitly understood at one level become explicitly understood when learners reach the next level.

Linguistics (Distinction): For learning to take place, language must match the child's level of understanding. Each level has its own language or linguistic symbols and way of thinking (van Hiele, 1986; cited in Steyn, 2016). The meaning of a linguistic symbol is more than its explicit definition; it includes the experiences which the speaker associates with the given symbol. If the language that the teacher uses is at a higher level than the level of the learner, the learner will not be able to follow the thought processes and there will be a lack of communication.

Separation: Two persons at different levels cannot understand each other. A teacher who is reasoning at one level speaks a different "language" from a student at a lower level, preventing understanding. When a teacher speaks of a "square" she or he means a special type of rectangle. A student at level 0 or 1 will not have the same understanding of this term. The student does not understand the teacher, and the teacher does not understand how the student is reasoning, frequently concluding that the student's answers are simply "wrong".

Advancement (Attainment): In order to advance from one level to the next requires "direct instruction, exploration and reflection" by the learner (Pegg, 1992; cited in Steyn, 2016). This is one of the differences between the theories of van Hiele and Piaget. In Piaget's theory, development is age dependent whereas in van Hiele progress to the next level depends more on the content and method of instruction than on the age of the learner.

The van Hiele's Instructional Model

van Hiele believed that cognitive progress in geometry can be accelerated by instruction. The progress from one level to the next one is more dependent upon instruction than on age or maturity. He gave clear explanations of how the teacher should proceed to guide students from one level to the next level. The instructional steps were made up of five steps which were to ensure that students move from one van Hiele learning level to a higher one in their geometric thinking. These steps are given below.

i. **Information:** The first step is the step in which the geometric thinking levels of students are determined. In this step, the students' geometric thinking levels are determined through communication between the teacher and the student. Students get the material and start discovering its structure. The teacher holds a conversation with the pupils, in well-known language symbols, in which the context he wants to use becomes clear.

ii. **Guided Orientation:** In this step, students deal with tasks which help them to explore implicit relationships. The teacher suggests activities that enable students to recognize the properties of the new concepts. The relations belonging to the context are discovered and discussed. The teacher gives instructions and assignments related to the studies which will be done in the light of the answers he gets from the students. The purpose of the teacher giving assignments is to make students explore the structures about the topic by means of research.

iii. **Explicitation:** Teacher introduces the topic to students in this step and students combine their experiences with the words they used related to the topic. In this step, it is important for the teacher to arouse students' interests. Students formulate what they have discovered, new terminology is introduced. They share their opinions on the relationships they have discovered in they activity. The van Hieles thought it is more useful to learn terminology after students have had an opportunity to become familiar with the concept.

iv. **Free Orientation:** Students work on different solutions of multiphase problems in this step. The effect of the van Hiele Model based among the various objects of the structure in the topic they work on. The teacher should guide students in their thinking about different solutions. Students solve more complex tasks independently. It brings them to master the network of relationships in the materials. They know the properties being studied, but they need to develop understanding of relationships in various situations. This type of activity is much more open-ended.

v. **Integration:** This step is the step in which students summarize and gather what they learned. Students internalize what they learned as a new thinking structure. The teacher should give to the students an overview of everything they have learned. It is important that the teacher does not present any new material during this phase, but only a summary of what has already been learned.

The teacher has different roles in various stages: task planning, directing a student's attention to geometric properties of shapes, introducing the terminology, fostering students to use appropriate terminology, and promoting student's explanations and problem solving. The major relevance of the van Hiele learning steps is their link with the level descriptions. The description of the van Hiele steps given above appears to be consistent with constructivism as a theory of instruction in education.

Research Methodology

Research Design

The design used in this study was one of the true experimental designs, known as the posttest only control group design.

Procedures

In exploring the effects of van Hiele's instructional model on student's achievement in teaching geometry, one of the experimental designs, the posttest only control group design was adopted. Participants were first selected by random assignment and then they were divided into groups an experimental group and a control group by using their mid-term grades. The experimental group was taught by using van Hiele's instructional model and the control group was taught by using formal instruction. The treatment period was from November 12, 2018 to December 7, 2018. At the end of the treatment period, all the selected students will to sit for posttest. The allocated time for posttest was (45) minutes and given marks were 30 marks. A questionnaire was used to explore students' attitude towards learning through van Hiele's instructional model.

Instruments

In this study, a posttest for students' achievement of van Hiele geometric thinking levels and questionnaire for students' attitude towards van Hiele's instructional model.

(a) Posttest

A posttest was constructed to measure students' achievement of van Hiele geometric thinking levels. They were (30) multiple choice items. Test items were constructed based on the content areas of Chapters (6) and (7) from Grade Seven Mathematics Textbook Volume II with the advice and guidance of the supervisor. The students had to answer all the questions there were no choice of items. This test was constructed based on van Hiele geometric thinking levels: visualization, analysis and informal deduction. In order to get validation, the posttest questions were distributed to six experienced mathematics teachers. According to their suggestions, test items were modified again and its marking scheme was also presented.

(b) Questionnaire

A questionnaire was used to observe the students' attitudes, experiences and opinions towards learning through the van Hiele's instructional model. It consists (15) items five-point Likert-scale and (3) open ended questions (see Appendix D). The questionnaire was constructed according to the advice and guidance of the supervisor. In order to get the validation, the copies of questionnaire were modified again.

Population and Sample Size

This study was geographically restricted to Yangon Region. There are four districts in Yangon Region. Two districts (North and West) were randomly selected. One township from each district was selected by using a randomly sampling method. The required sample schools were selected by using a randomly sampling method. The sample schools were No. (7) BEMS, Hlaing and No. (9) BEMS, Insein. The population in this study was (106) students who were learning mathematics in Grade Seven at No. (7) BEMS, Hlaing and (62) students who were learning mathematics in Grade Seven at No. (9) BEMS, Insein. To obtain the required data, (60) students from No. (7) BEMS, Hlaing and (62) students from No. (9) BEMS, Insein were selected by using a random sampling method.

Data Analysis

The data were analyzed by using descriptive statistics (mean and standard deviation) and independent sample '*t*' test. The independent sample '*t*' test was used to compare the achievement of students who learned by van Hiele's instructional model and that of students who learned by formal instruction at virtualization, analysis and informal deduction levels.

Research Findings

Quantitative Research Findings

The researcher provided the treatment to the experimental groups in the selected schools. At the end of the treatment period, the posttest was administered to measure the geometric achievement of students. The data were analyzed by using the Statistical Package of Social Sciences (SPSS). In order to compare geometric achievement, the *t*-test of independent samples was used. The results are presented in Table (4.1).

Table 4.1 *t*-Values for Students' Geometric Achievement on Posttest

School	Group	N	M	SD	MD	*t*	*df*	Sig. (2-tailed)
BEMS (7) Hlaing	Experimental	30	24.73	2.765	7.63	12.776	58	.000***
	Control	30	17.10	1.748				
BEMS (9) Insein	Experimental	31	25.13	2.692	7.68	11.778	60	.000***
	Control	31	17.45	2.433				

Note: ***$p < .001$

The results showed that there were significant differences between the experimental and control groups for the scores on the geometry achievement on the posttest in each school. It means that the scores of the experimental group were significantly higher than that of the control group on posttest in each school.

It can be shown that there were significant differences between the experimental and control groups for the scores on the geometry achievement on the posttest in each school. It means that the use of van Hiele's instructional model had positively contributed to the geometric teaching and learning at the middle school level.

In order to compare the students' achievement at visualizing level between the experimental and control groups. The results are presented in Table (4.2).

Table 4.2 *t*-Values for Scores on Visualization Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig. (2-tailed)
BEMS (7) Hlaing	Experimental	30	8.33	.758	1.26	4.513	58	.000***
	Control	30	7.07	1.337				
BEMS (9) Insein	Experimental	31	8.42	.764	1.07	4.971	60	.000***
	Control	31	7.35	.914				

Note: ***$p < .001$

The results showed that there were significant differences between the achievement of experimental and control groups on visualization level questions in each school. It means that the scores of experimental group were significantly higher than that of control group on visualization level questions in each school.

It can be interpreted that students of experimental groups could recognize and name figures based in the global visual characteristics than students of control groups.

In order to compare the students' achievement at analysis level between the experimental and control groups, the independent samples *t*- test was used. The results are presented in Table (4.3).

Table 4.3 *t*-Values for Scores on Analysis Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig. (2-tailed)
BEMS (7) Hlaing	Experimental	30	9.07	1.363	3.54	10.457	58	.000***
	Control	30	5.53	1.252				
BEMS (9) Insein	Experimental	31	8.55	1.410	3.33	9.445	60	.000***
	Control	31	5.22	1.359				

Note: ***$p < .001$

The results showed that there were significant differences between the experimental and control groups for the scores on analysis level questions in both schools. It means that the scores of the experimental group were significantly higher than that of control group on analysis level questions in each school.

The results of the two selected schools can be interpreted that students' ability to list all the properties of figures and discuss the properties of the figures and recognize them by these properties than the use of formal instruction.

In order to compare the students' achievement at informal deduction level between the experimental and control groups, the independent samples *t*- test was used. The results are presented in Table (4.4).

Table 4.4 *t*-Values for Scores on Informal Deduction Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig. (2-tailed)
BEMS (7) Hlaing	Experimental	30	7.33	1.56	2.83	8.268	58	.000***
	Control	30	4.50	1.042				
BEMS (9) Insein	Experimental	31	8.22	1.116	3.35	9.229	60	.000***
	Control	31	4.87	1.688				

Note: ***$p < .001$

The results showed that there were significant differences between the experimental and control groups for the scores on informal deduction level questions in both schools. It means that the scores of the experimental group were significantly higher than that of control group on informal deduction level questions in each school.

The results of the two selected schools can be interpreted that the use of van Hiele's instructional model in geometry teaching could bring about more improvement of students' ability to formulate meaningful definitions and develop relationships of between these properties than the use of formal instruction. Students of experimental groups could understand that properties are related and one set of properties may simply another property. They could understand necessary and sufficient conditions and could write concise definitions.

Qualitative Research Findings

The following table is constructed to describe only the percentage of students' positive and negative attitude towards each dimension.

Table 4.5 Percentage of Students' Positive and Do Not Have Positive Attitude towards Each Dimension.

No.	Dimension	Percentage of Positive Attitude	Percentage of Do Not Have Positive Attitude
1	Attitude towards Learning	98%	2%
2	Experience towards Learning	95%	5%
3	Opinion towards Learning	95%	5%

According to the results of (15) items five Likert-scale, (96%) of the students have positive attitudes and (4%) do not have positive attitudes towards experimental learning towards van Hiele's instructional model.

In this research, the qualitative study for students from the experimental group of two selected schools was carried out with a questionnaire. It consists of (15) items five-point Likert-scale and (3) open ended questions. In this study, it was found that learning by doing increase students' conceptual understanding. Moreover, this learning also developed students' self-reliance and self-confidence. Most of students expressed that they were very excite and happy by using hands-on activities. They gained the habit of cooperation with others. By relating previous experiences with the new experiences, it can promote their logical thinking skills. Moreover, students learned geometric concepts with extra activities that are related to the lesson. Therefore, they have mastered their learning. Moreover, students expressed that their knowledge was increased and they have willingness to learn more from experience than as usual. Some students do not have positive attitudes because they have had no experience in that kind of asking questions and discussion in the classroom. Therefore, experiential learning has positive contribution to the geometry teaching and learning at the middle school level.

Discussion, Suggestions, Conclusion

Discussion

In this study, the geometrical thinking levels of experimental groups which were given instruction according to the van Hiele's instructional model and of control groups which were given instruction according to the formal instruction. In this context, when the post test results of geometry achievement test of the participants were examined, a significant difference was found in favor of experimental group. In other words, it was found that the instruction given according to the van Hiele's instructional model was more effective than the formal instruction in developing geometrical thinking levels of students. Therefore, this result supports the first hypothesis. It can be claimed that the instruction given according to van Hiele's instructional model was effective in developing geometrical thinking levels of students. This finding of the study is consistent with the other research (Siew, Chong & Abdukkah, 2013).

According to the comparison of means on visualization level in two selected schools, the results pointed out that there were significant differences between the control and experimental groups. The result supports the second hypothesis. By using concrete or virtual models, using models to focus on defining properties, making properties lists, and discussing sufficient conditions to define a shape and classifying using properties of shapes were used in this study for analysis level. The result generalized that van Hiele's instructional model provided students with an opportunities to recognize and identify certain geometric shapes based on the overall entity of the objects. They had the opportunity to participate actively in the instructional process.

Besides, there were a significant between the experimental group and the control group in two selected schools for the mean scores on Analysis Level. The result supports the third hypothesis. The result generalized that students of experimental groups had adequate understanding regarding the identification of the geometric shapes using their properties and their orientation in space. In this study, the students shared their idea and opinion when they were at the information, explicitation, and integration steps. They had the opportunity to participate actively in the instructional process.

Moreover, the results of mean scores of the informal deduction level were also significantly higher of experimental group than of control group in two selected schools. The result supports the fourth hypothesis. The result indicates that the implementation of van Hiele's instructional model assisted students in achieving better levels of geometric thinking as compared to those students who learned the topics conventionally. The students change to the higher level is based on the open approach. This finding of the study is consistent with the other research (Chew Chew Meng, 2009). So, the van Hiele's instructional model takes the Learner Centered Approach such as cooperative learning, learning by doing, and experience as the basis.

In this study, (15) items five-point Likert-scale and (3) open ended questions for analyzing of Grade Seven students' attitudes towards van Hiele's instructional model was used. According to the results of (15) items five Likert-scale, (96%) of the students have positive attitudes and (4%) of the students do not have positive attitudes towards experimental learning towards van Hiele's instructional model. According to the findings of students' attitude survey, most of the selected students from each experimental group expressed that they enjoyed their learning by using van Hiele's instructional model. In this study, students must cooperate together, questioning, researching, analyzing and finding solution to problems. Some students do not have positive attitudes because they have had no experience in that kind of asking questions and discussion in the classroom. On the other hand, they have no experiences in solving problems in this new way and they've never seen this type. They always solve the problems by following the teacher's instruction. So, they have no confidence to solve problems themselves.

The study has also found that improvement from one level of geometric thinking to a higher level of geometric thinking depends on the lesson taken by the students and not on their maturity. Therefore, the method and learning organization and also the contents and teaching aids used are the important elements of the pedagogy. In this study, the students went through all the five steps in their first learning session to assist them to advance from first level of geometric thinking, visualization to the second level of geometric thinking, analysis. The van Hiele's instructional model is dynamic and not static. It focuses on students' actively participation. Students can apply their learning experiences, concepts and ideas in real world. Therefore, successful learning can be achieved by using the van Hiele's instructional model.

Suggestions

Findings and discussion in the research will contribute to the development of geometry teaching at the middle school level in Myanmar. Geometry teachers should strive to use van Hiele's instructional model in order to reinforce student's logical reasoning and deductive thinking for modeling abstract problems. Besides, teachers should consider the importance of the strategies which can be used to encourage effective participation by all members in the group. Students should be developed reasoning and thinking powers more and demanded less from memory. Students should come to realize that thinking makes successful students of all the subjects. According to Locke, cited in Sidhu, 1995; "Mathematics is a way to settle in the mind a habit of reasoning". Therefore, mathematics teachers should build new mathematical knowledge through problems and introduce most mathematical concepts through problem solving. Teachers should create students to explore ideas and think problems.

The van Hiele model of geometric thought can be used to guide instruction as well as assess student abilities. The van Hiele's instructional model indicates that effective learning take place when students actively experience the objects of the study in appropriate contexts. Therefore, it is suggested that by using van Hiele's instructional model, the geometry teachers should provide experiences organized according to the steps of learning to develop each successive level of understanding. Teachers should be to refine the steps of learning develop van Hiele based materials and philosophies in the classroom setting. Students should be accessible geometric thinking.

Learning through memorization without understanding is considered not achieving the levels of van Hiele model. Therefore, the teaching of geometry should be done systematically to help students move from one level to another. Furthermore, the presence of various educational technologies can facilitate the process of teaching and learning geometry in the classroom. The geometric thinking level of the students should be identified before the teaching program. To improve geometry teaching, teachers should be to develop tasks or activities that help them better understand the nature of their students' geometric reasoning and they also should have an understanding about research concerning such reasoning.

Changes in the instructional practices should be coupled with the changes in the curriculum to observe the efforts on students' achievement. Constructive activities should be encouraged. Learners should be made familiar with the techniques of drawing and folding for enhancing their geometric thinking. Higher levels of geometric thinking can be attained by the implementation educator guided, learner centered, hands on instructional programme. The process of gradually moving from the concrete to abstract and from passive to active learning under the guidance of the teachers would make objectives should be to help students to gain insight and understanding of the subject matter and consolidate their conceptual understanding.

In this study, the researcher used van Hiele's instructional model. According to the research, time was an issue. It is difficult for the teacher to apply van Hiele's instructional model in a short period of time. Therefore, teachers should carefully arrange sets of guiding activities designed to be performed actively by the students to reduce time constraints. Class size was also a factor. If the class size is large, the students can miss the main points about the topic, lack of chance to answer the teacher's question, lack of opportunity the teaching aids independently, and low chance to discuss with the teacher. Therefore, the class size should be (30) students to grasp the merits of van Hiele's instructional model. Furthermore, the emphasis of instruction and assessment should be based on the exploration of students' ideas and reasoning rather than on factual information.

This research was conducted to develop the teaching of geometry at the middle school level. However, no study is perfect in a single effort. As this study had to be carried out in four weeks duration for each group, the time was too short to be able to yield reliable and valid results. So, further research studies require necessary with long time duration. This study was dealt with the efforts of van Hiele's instructional model on students' achievement in geometry at the middle school level. Further research should be carried out at primary and high school levels. Moreover, further study should be used the van Hiele's instructional model to carry out in other levels and areas. Therefore, mathematics teachers should use the van Hiele's instructional model in teaching geometry at all level.

Conclusion

This study found that van Hiele's instructional model can be used to help students to move from shape properties to geometrical properties, namely relationship among shapes and their properties. These activities may help students progressing from shape properties to geometrical properties. Therefore, students can easily explore and analyze how the shapes change or what measures change when manipulating, and they can understand the relationships among shapes which is the basic requirement for van Hiele geometric thinking levels.

The van Hiele's instructional model develops students' geometric thinking and learners to be more independent, resourceful, interactive and cooperative as well as enabling them to build interpersonal relationships. This model produces learners that think creatively to solve problems, mange themselves and others, and possess independence skills. The van Hiele's instructional model fosters cooperation then competition. Thus, students develop a sense of responsibility and can transfer the learned skills into real life situations. Therefore, van Hiele's instructional model can encourage the improvement of the students' higher order thinking skills, social skills, communication skills, and reasoning skills in learning geometry.

According to the posttest scores for geometric achievement, there were significant differences between van Hiele's instructional model and formal instruction on the geometric achievement in each school. Conclusions can be drawn on the basic of the results of research findings. In terms of the statistical results, students' achievement between van Hiele's instructional model and formal instruction had significant difference on overall geometric achievement. It can be concluded that van Hiele's instructional model had positively contributed to the improvement of geometry achievement and can promote the students' geometric thinking levels.

A qualitative study was done to study the students' feelings, attitudes, experiences and opinions about geometry teaching with van Hiele's instructional model. Most of the students described that they were very happy and satisfied by using the van Hiele's instructional model. It also promoted their conceptual understanding. They also felt that they wanted to learn geometry by doing experiments and activities. Thus, students' interest and attitudes are very important for geometry learning. According to this research, the qualitative research findings indicated that the attitudes, experiences and opinions of students towards learning of geometry were positive. Therefore, van Hiele's instructional model is a useful strategy in the school system.

Finally, using statistical analysis and findings of the study the conclusions drawn were as follows:

1. The van Hiele's instructional model has positive impact on teaching geometry.
2. The van Hiele's instructional model plays an important role in teaching of geometry.
3. The geometric thinking levels of students who were taught by van Hiele's instructional model were better than that of students who were not taught by formal instruction.
4. The van Hiele's instructional model helps students to develop their levels of geometric thinking. Moreover, their problem solving skills and their academic achievement also developed.

In teaching and learning of mathematics at the basic education level in Myanmar, teaching-learning process needs to be transformed: from the current teacher-centered approach to learner-centered approach. The students should become active and independent learners in the active learning classroom with the help and guidance of their mathematics teachers. So, if possible, van Hiele's instructional model should be used in teaching geometry. There is no one best way of teaching for all kinds situations. Each teacher must decide for himself what strategies work best for him with his students. Although this model cannot manipulate all the issues that found in the teaching and learning environment of geometry, it is hoped that this study can be beneficial to some extent for geometry teaching in Myanmar.

It can be concluded that van Hiele's instructional model brings positive contributions to the geometry teaching at the middle school level. It is essential in teaching geometry. It can also develop geometric thinking, the core of teaching geometry. So, further researches are recommended to explore the effect of van Hiele's instructional model in all levels for the improvement of geometry teaching.

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