PRE-SERVICE MATHEMATICS TEACHERS' PERSPECTIVE ABOUT LEARNING GEOMETRY USING VAN HIELE'S PHASE-BASED TEACHING STRATEGY: A CASE STUDY OF NIGER STATE COLLEGE OF EDUCATION, MINNA NIGERIA

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Abstract

The purpose of this study is to determine pre-service mathematics teachers' perspective about learning geometry using van Hiele's phase-based teaching strategy. A case study research design, an aspect of qualitative method was employed. Twelve pre-service mathematics teachers of Niger State college of Education, Minna form the sample of the study. Purposive sampling technique was employed base on achievement level that is, low, moderate and high achievers. Data were gathered by means of semi-structured interview protocol during 2017/2018 academic session. The information gathered from the interview conducted was recorded and manually transcribed, and then the data was organized and coded to come up with the emerging themes. Four strengths, three weaknesses and three corresponding suggestions to improve the weaknesses were identified after the interview. The findings therefore suggest despite the weaknesses observed, van Hiele's phase-based teaching strategy is found to be effective and therefore enhanced geometry achievement. This consequently resulted in changing pre-service mathematics teachers' negative impression about mathematics in general.

Keywords: Pre-Service mathematics teachers', perspective, van Hiele's phase-based teaching strategy

Introduction

The description of mathematics in general has been the focal point of researches over the last few years (Swars, Smith, Smith, Carothers, & Myers, 2018). Wasserman, Villanueva, and Mejia-Ramos (2018) put forward that there are several views about the ways in which learner and teachers perceived mathematics, which therefore determine the process of teaching and learning. In the same direction, Presmeg (2002) has responded that beliefs about the features of effective learning of mathematics on the other hand permit or restrict "the bridging process between everyday practices and school mathematics" (p. 295). Noraini (2005) however posit that effective teaching techniques for each segment of mathematics is different from each other. For instance, learning strategy that might be effective for statistics might not be effective strategy for probability. In view of this, Van Merriënboer and Kirschner (2018) affirmed that the strength and weakness of particular teaching method could be seen in area of teaching method employed. Consequently, Halat (2008) and Choi-Koh (2000) stressed that learning actions for geometry topics in particular is expected to stimulate learners through the use of van Hiele's phases of teaching strategy.

Van Hiele's model in particular, explains process of reasoning particularly in geometry, it comprises of five levels and five phases of instruction already applied in several research

(Abdullahi & Zakaria, 2013; Abu et al., 2012; Alex and Mammen 2016; Atebe, 2008; Cannizaro & Menghhni, 2006; Chang et al., 2007; Chew, 2007; Chew, & Lim, 2013; Erdogan & Durmus, 2009; Fuys et al., 1988; Hoffer, 1983; & Usiskin, 1982) associated to teaching and learning of geometry. In all of these researches, it was found out to be efficient in improving learners' performance. The model/theory was initiated and developed by two Dutch mathematicians in the 1950s, Pierre van Hiele and his wife Dina van Hiele-Geldof. According to Van Hiele (1986) the five levels according are: Recognition, Analysis, Order, Deduction and Rigor. The levels are arrived at as a result of experience and instruction rather than age. Hence, a learner is expected to have adequate knowledge of (classroom or otherwise) geometric thoughts to move to a sophisticated stage of difficulty. In order word, the characteristics of the model is hierarchical in nature. Respectively, the levels (levels 1 – 5) go together with by five phased-based teaching strategies. Chew (2009) and Choi-Koh (2000) established this by indicating that students has to pass over all the five phases to attain every of van Hiele's level. Accordingly, each and every level of geometric thought is arrived at as a result of sequence of the phases. The five phases of instruction are: Information, Guided orientation, Explicitation, Free-orientation and Integration.

Consequently, Choi-Koh (2000) and Chew (2009) affirmed that the field of activities organised in line with van Hiele's phases impacted positively on learner achievement in geometry. This therefore is seen as a welcome development in Nigeria context because topics on geometry constitutes 38% of the mathematics curriculum (Tsoho, 2011), and about 45% of total topics to be covered in the SSCE syllabus (WAEC, 2014).

Little studies have however investigated the issue of teacher's and learner's perspective on the strategy. Brooks, Dobbins, Scott, Rawlinson, and Norman (2014) in their research titled; "Learning about learning outcomes: the student perspective", employed students from three departments at the university of Leicester to form the focus group. A survey questionnaire was use as the instrument for the study to determine learners' perspectives and utilisation of learning outcome. The result however, revealed that generality of learners discovers learning outcome effective. At the same time, result further indicate that certain number of students, battled to comprehend the level of learning expected in their syllabus. Similarly, specific number of interviewees reported that learning outcome can limit their knowledge. While numerous learners, wanted learning outcome retained a focal point of their learning experience. It was therefore suggested that additional research is needed to come up with more efficient use of learning outcome as a learning resource. To this end, to come up with more efficient learning outcome, this study is expected to fill the gap as there is no research that specifically investigate the strength and weaknesses of a particular teaching stategy.

Chua, Tengah, Shahrill, and Leong (2017) in their research work on analysing students' perspectives on geometry learning from the combination of van Hiele phase-based instructions and GeoGebra, emphasized that opportunity should be given to learners to undergo efficient and fascinating learning technique taking advantage of modern technology, especially van Hiele theory, since learning activities in geometry are arranged accordingly. Thus, the main aim of the study was to identify learners' views on the activities formulated in accordance with the van Hiele's phases of learning geometry employing GSP software. Two teachers and 30 form two students form the sample of the study while questionnaire to gather information on students views on activities based on van Hiele's phases of learning geometry using GSP was the instrument used for the data collection. The result revealed that majority of the student agrees their geometry lessons was facilitated by the prepared activities and was however boosted their confidence in learning geometry. In addition, the GSP software was very easy in term of usage, which therefore assisted them in the process of learning.

Consequently, eliciting pre-service mathematics teachers' perspective about the strength and weaknesses of teaching strategy is crucial for assessing ways in which pre-service teacher programs might be organised with a view to best adjust future teachers with a particular teaching strategy required for their future teaching profession.

Aim and Objectives of the Study

The aim of this study is to elicit the pre-service mathematics teachers' perspective on the strengths, weaknesses of van Hiele's phase-based teaching strategy in Niger state, Nigeria. Specifically, the research objectives were as follows:

1. Ilicit the strengths, weaknesses of van Hiele's phase-based teaching strategy and suggestions to improve it from the pre-service mathematics teachers' perspective.

Research Questions

In an effort to elicit the pre-service mathematics teachers' perspective about geometry learning, the following research questions was raised:

1. What are the strengths, weaknesses of van Hiele's phase-based instructional strategy and suggestions to improve it from the pre-service mathematics teachers' perspective?

Methodology

In an attempt to address the research questions for this study case study research design, an aspect of qualitative method was employed. It was employed because it affords the enabling environment for the researcher to create an in-depth evaluation of social circumstances, happenings and interactions. (Mullen, 2005; Creswell 2007; Maxwell, 2004). According to Silverman, (2004), qualitative research is essentially concerned with explaining the manner of occurrence of certain experiences, how such experiences are understood by people concerned and the values which the people assign to them. In qualitative study, the researcher is mostly concerned in studying individual's or group's opinion of reality thus approximating the reality behind the story. By investigating multiple opinions, the qualitative researcher may describe the concerns and try to discover a unanimity amongst the voices heard (Thomas, 2010).

The population for this study was made up of all the 86 pre-service mathematics teachers in Niger state college of education Minna, Nigeria (College Department of Mathematics, 2017). The target population is year one (100 level) pre-service mathematics teachers who had registered MAT 122 (coordinate geometry) during 2017/2018 session.

The sample of this study consisted of 12 year one (100 level) pre-service mathematics teachers purposively selected from colleges of education Minna, Niger State, Nigeria. The reason for choosing 100 level pre-service mathematics teachers is because MAT 122 is a geometry course designed to prepare the pre-service mathematics teachers to teach geometry content based on basic education level constitutes part of the course to be studied at this level. The 12 pre-service mathematics teachers were purposively sampled base on achievement level that is, low, moderate and high achievers. The purposively sampled pre-service mathematics teachers (four pre-service mathematics teachers in each level) were consequently interviewed to elicit their views in respect of the strength, weaknesses and suggestions to improve the teaching strategy.

Interview protocol for eliciting pre-service mathematics teachers' perspective about van Hiele's phase-based teaching strategy was adapted from Sahar (2017) and was validated in terms of content validity by experts in the field of mathematics education from sampled college. The instrument gave room for interaction between the researcher and focus group at the end of the experiment.

The entire study lasted for 8 weeks. Shortly after administering the treatment and an achievement test, interview on pre-service mathematics teachers' perspectives on the strengths and weaknesses of van Hiele's phase-based teaching strategy was conducted. Analysis of the information gathered was done with a total of twelve pre-service teachers based on the emerging themes identified. Guest, Bounce, and Johnson (2006) and Creswell (2012) affirmed that 10, 20, 30, subjects might be engaged in an interview to permit theoretical saturation, and this will assist to minimizing the chance of creating theory based on insufficient data.

In analyzing the data, the information gathered from the interview conducted was recorded and manually transcribed, and then the data was organized and coded to come up with the emerging themes. The following method was employed thus:

Step 1. The documented data was transcribed and coded by means of highlighting and extracting pattern themes to create a pre-set (first) group of similarities. This is done to generate occurrences of the responses, persistent presence of items in each group question (pattern themes/similarities). The goal was to break the data and organize them in the next groups to ease comparison between responses (pattern themes/similarities) (Drake, Pytlarz & Patel, 2018).

Step 2. In this stage, all the initial extracted pattern themes in the first category are narrowed down in order to describe the participants'concepts and beliefs as a sub-categorization; it is a verified or theoretical classification. This is more accurate in describing data, but closer to data category of the last stage of thematic classification. This stage trimmed the first group to be smaller and exact, as a theoretical or thematic strategy for concept reduction.

Step 3. This phase signifies the researcher's ideas as summary of extracted sub-themes/pattern themes, therefore it is more theoretical and the formation of themes that represent stage 1 and 2 of the qualitative data analyses (Bernard, Wutich, & Ryan, 2016).

Findings

The entire responses of pre-service mathematics teachers on the strength of van Hiele phase-based teaching strategy were centered on the fact that the teaching strategy is effective. Four strengths, three weaknesses and three corresponding suggestions to improve the weaknesses were identified. The strengths identified are: the teaching strategy motivated pre-service mathematics teachers to learn geometry, it is sequential in nature (step-by step), it is strategically planned in phases and the need of the learners are considered with the strategy. Contrary to this, overcrowded classroom, no adherence to time and lack of incorporation of technology into geometry class were identified as the weaknesses of the strategy.

It was in view of this that it was suggested that to improve the weaknesses identified, stand-by generator with equipped mathematics laboratory where all students will be going to learn geometry should be provided and used instead of relying on national grid. This will facilitate the understanding of geometry because, every student can see, touch and feel. Furthermore, technology should be in-cooperated into learning process to provide efficient and productive education in all regards, and also improve performance and encourage student's participation. Furthermore, moderate class size of about 20-25 students per class were recommended. Moderate class size of 20-25 in a class will assist the lecturer to have absolute control of the class and this will therefore enhance better understanding of the lesson taught. In addition to step by step implementation of the content taught, concrete object should be integrated to make it practically oriented.

In view of the abovementioned, despite the weaknesses observed, still the researcher concludes that van Hiele's phase-based teaching strategy is found to be effective and therefore enhanced geometry achievement. This consequently resulted in changing their negative impression about mathematics in general.

Conclusion/Recommendation

Based on the finding, it was 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. 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 can give a positive impact to students such as increasing students' achievement in geometry, their understanding in geometry and level of confidence in mathematics in general.

References

Abdullah, A. H., & Zakaria, E. (2013b). The effects of van Hiele's phase-based instruction using the geometer's sketchpad (GSP) on students' levels of geometric thinking. *Research Journal of Applied Sciences, Engineering and Technology*, *5*(5), 1652-1660.

Abu, M. S., Ali, M. B., & Hock, T. T. (2012). Assisting primary school children to progress through their van Hiele's levels of geometry thinking using Google SketchUp. *Procedia-Social and Behavioral Sciences*, *64*, 75-84.

Alex, J. K., & Mammen, K. J. (2016). Lessons learnt from employing van Hiele theory-based instruction in senior secondary school geometry classrooms. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(8), 2223-2236.

Brooks, S., Dobbins, K., Scott, J. J., Rawlinson, M., & Norman, R. I. (2014). Learning about learning outcomes: the student perspective. *Teaching in Higher Education*, *19*(6), 721-733.

Cannizzaro, L., & Menghini, M. (2006). From geometrical figures to definitional Rigour: Teachers' analysis of teaching units mediated through van Hiele's theory. *Canadian Journal of Math, Science & Technology Education*, *6*(4), 369-386.

Chang, K. E., Sung, Y. T., & Lin, S. Y. (2007). Developing geometry thinking through multimedia learning activities. *Computers in Human Behavior*, *23*(5), 2212-2229. doi.org/10.1016/j.chb.2006.03.007

Chew C M (2009). Assessing pre-service secondary mathematics teachers' geometric thinking. *Proceedings of the 5th Asian Mathematical Conference Penang, Malaysia.*

Chew, C. M., & Lim, C. S. (2013). Enhancing primary pupils' geometric thinking through phase-based instruction using the geometer's sketchpad. *The Asia Pacific Journal of Educators and Education (formerly known as Journal of Educators and Education)*, *28*(1), 1-19.

Choi-Koh, S. S. (2000). The activities based on van Hiele model using computer as a tool. *Journal of the Korea Society of Mathematical Education Series D: Research in Mathematical Education*, *4*(2), 63-77.

Chua, G. L. L., Tengah, K. A., Shahrill, M., Tan, A., & Leong, E. (2017). Analysing students'perspectives on geometry learning from the combination of van hiele phase-based instructions and geogebra. In *Proceeding of the 3rd International Conference on Education* (Vol. 3, pp. 205-213) Kuala Lumpur, Malaysia.

Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five traditions (3rd ed.)*. Newbury Park, CA: Sage Publications, Inc.

Creswell, J. W., & Clark, V. L. P. (2007). *Designing and conducting mixed methods research.* Thousand Oaks California: Sage publication.

Drake, B. M., Pytlarz, I., & Patel, M. (2018). Let me paint you a picture: Utilizing visualizations to make data more accessible. In *Building Capacity in Institutional Research and Decision Support in Higher Education* (pp. 81-93). Springer, Cham.

Erdoğan, T., & Durmuş, S. (2009). The effect of the instruction based on Van Hiele model on the geometrical thinking levels of preservice elementary school teachers. *Procedia-Social and Behavioral Sciences*, *1*(1), 154-159. doi.org/10.1016/j.sbspro.2009.01.029.

Fuys, D., Geddes, D., & Tischler, R. (1988). The van Hiele model of thinking in geometry among adolescents. *Journal for Research in Mathematics Education. Monograph*, *3*, i-196.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field methods*, *18*(1), 59-82.

Halat, E., & Sahin, O. (2008). Van Hiele levels of pre-and in-service Turkish elementary school teachers and gender related differences in geometry. *The Mathematics Educator*, *11*(12), 143-158.

Hoffer, A. (1983). Van Hiele-based research. In R. Lesh & M. Landau (Eds.) *Acquisition of mathematics concepts and processes* (pp. 205-227). New York: Academic Press

Maxwell, J. A. (2004). *Qualitative research design: An interactive approach* (2nd ed.). Beverly Hills, CA: Sage.

Mullen, C. A. (2005). *Fire & ice: Igniting and channeling passion in new qualitative researchers*. Peter Lang Publishing

Presmeg, N. (2002). Beliefs about the nature of mathematics in the bridging of everyday and school mathematical practices. In G. Leder, E. Pehkonen, & G. Torner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 293-312). Dordrecht: Kluwer.

Sahar, A. I. (2017). *Using a concrete-representational-Abstract (CRA) approach in learning fractions among grade five Iraqi*, Unpblished doctoral thesis, Universiti Sains Malaysia, Penang.

Silverman, D. (2004). Doing qualitative research (2nd ed): Thousand Oaks, CA: Sage

Swars, S. L., Smith, S. Z., Smith, M. E., Carothers, J., & Myers, K. (2018). The preparation experiences of elementary mathematics specialists: examining influences on beliefs,

content knowledge, and teaching practices. *Journal of Mathematics Teacher Education*, *21*(2), 123-145.

Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2011).Historical Research in Physical Activity. *Thomas, JR; Nelson, JK y Silverman, SJ (edición): Research methods in Physical Activity (6th ed., pp. 217-233). Champaign: Human Kinetics*.

Tsoho, L. T. W. (2011). *Effects of problem solving and student-centered teaching strategies on students' geometry performance and retention in junior secondary schools in Kano state.* Unpublished M Ed dissertation, ABU Zaria, Nigeria.

Usiskin, Z. (1982*). van Hiele levels and achievement in secondary school geometry*. (Final Report of the Cognitive Development and Achievement in Secondary School Geometry Project) Chicago: University of Chicago (ERIC Document Reproduction service Number ED220288).

van Merriënboer, J., Kirschner, P. (2018). *Ten Steps to Complex Learnin*g. New York: Routledge, https://doi.org/10.4324/9781315113210

Wasserman, N., Weber, K., Villanueva, M., & Mejia-Ramos, J. P. (2018). Mathematics teachers' views about the limited utility of real analysis: A transport model hypothesis. *The Journal of Mathematical Behavior*, *50*, 74-89.

West African Examination Council WAEC (2014). *West African Senior Secondary School Certificate Examination* Chief Examiner's Report. Lagos: WAEC