www.ijses.net

Relationship between Mathematics Teachers' van Hiele Levels and Students' Achievement in Geometry

Angelina P. Lumbre
University of the Philippines, Philippines

Ma. Nympha Beltran-Joaquin
University of the Philippines, Philippines

Sheryl Lyn C. Monterola
University of the Philippines, Philippines

To cite this article:

Lumbre, A. P., Beltran-Joaquin, M. N., & Monterola, S. L. C. (2023). Relationship between mathematics teachers' van Hiele levels and students' achievement in geometry. *International Journal of Studies in Education and Science (IJSES), 4*(2), 113-123. https://doi.org/10.46328/ijres.61

International Journal of Studies in Education and Science
2023, Vol. 4, No. 2, 113-123 https://doi.org/10.46328/ijres.61

Relationship between Mathematics Teachers' van Hiele Levels and Students' Achievement in Geometry

Angelina P. Lumbre, Ma. Nympha Beltran-Joaquin, Sheryl Lyn C. Monterola

Article Info

Article History

Received:
08 October 2022
Accepted:
24 April 2023

Keywords

van Hiele
Geometry
Student achievement
Mathematics

Abstract

Using non-experimental quantitative correlational design, the van Hiele levels of thirty grade 9 mathematics teachers, as well as the achievement of 1489 students in geometry were investigated in this study. Results showed a significant difference with a substantial effect size of .64 between the achievement of students whose teachers are operating at level 5 in the van Hiele Levels of Geometric Thinking and those of students whose teachers are operating at level 2. This study underscored the importance to leverage on teachers' van Hiele level of geometric thinking as it is highly correlated to student achievement. Developing teachers' geometric thinking ability at the expected levels in order to improve students' achievement may require trainings, further studies, or curriculum improvement for pre-service teachers. Moreover, a deeper study focusing on other content areas and skills in mathematics may be done to further assess their interrelationships with teachers' van Hiele levels and student achievement. In addition, it would be of interest to investigate the grade level where student mathematics achievement starts to decline.

Introduction

The researchers' passion to teach mathematics and make a positive difference in the field gave rise to the crafting of this research. Concepts and skills learned in mathematics allow one to think analytically and critically leading to informed decisions. Everyday activities such as driving, cooking, playing games, project planning, and many others all require a certain level of mathematical understanding and application. Mathematics plays an important role in one's daily life.

However, studies on Filipino students' academic performance reveal that many students have poor level of achievement in mathematics. In particular, the study of Capate and Lapinid (2015) on the performance and difficulties of students during the first year of implementation of the K to 12 Mathematics showed that students' level of achievement in geometry were still at the beginning to developing stages. Students were also found to have lacked critical problem-solving skills as they have not been re-checking their answers and have been incorrectly applying formulas, properties, theorems, or laws. Moreover, in the Philippines' first participation in the Program for International Student Assessment (PISA) of the Organization for Economic Co-operation and Development (OECD) in 2018, 15-year Filipino students are found to be performing below level 1 (DepEd, 2016).

As defined by PISA, level 1 in the six proficiency levels is when students can answer questions involving basic concepts, carry out routine problems, and perform basic operations. This level is far from what is expected of them which is at level 3 based on OECD average scores. Level 3 is when students can apply basic problem-solving strategies, interpret representations, and reason directly (skills learned if only there is a mastery of the geometry subject according to Herbst et al. (2017). These are also the skills included in geometry content area in DepEd's K to 12 Curriculum for Mathematics. Hence, geometry is a way to develop the students' thinking and reasoning skills since geometry allows learners to have mastery of basic thinking skills such as analysis, comparison, and generalization (Eerdogan et al., 2009; Liwag, 2008).

With the undeniable importance of studying geometry, it is significant to investigate how students learn geometry based on a popular theory by Pierre van Heile (1985), also known as the van Hiele Model of Geometric Thinking. This model accentuates the five levels corresponding to the complexity of learner's understanding of geometry, namely, visualization, analysis, abstraction, deduction, and rigor. A number of studies have actually been conducted using this model (Guloya, 2007; Liwag, 2008; Solaiman et al., 2017; Velasco, 2013) and most of them focused only on student factors that affect achievement. It is important to note that the van Hieles contended that students' achievement is based on the meeting of three elements: teacher, student, and subject matter. Thus, a study on teacher factors relating to student achievement in geometry subject may open another discussion that will help in improving the quality of mathematics education in the country.

Generally, there are limited studies on teachers' van Hiele levels relating to students' geometric achievement. The teachers' van Hiele levels may tell another story and open another hope in helping students achieve better in mathematics. Since it has been established that the van Hiele theory is applicable to adult learners (Crowley, 1987), this study aims to investigate how teachers' van Hiele levels of thinking is related to students' achievement in geometry.

Statement of the Problem

This study seeks to answer the following questions:

1. What are the teachers' van Hiele level of geometric thinking?
2. What is the status of students' achievement in geometry?
3. Is there a relationship between teachers' van Hiele level of geometric thinking and their students' achievement in geometry?

Significance of the Study

This study may expand our understanding on teachers' level of geometric thinking. It aims to provide mathematics teachers some insights on how students think and how to help them make progress in geometry. In addition, this study also hopes to influence teacher education institutions in reviewing the current set of pedagogies being taught to pre-service teachers. A review may include looking at the extent to which the inclusion of van Hiele levels and their applications in classroom teaching may also be considered.

Furthermore, this study envisions to help teachers become more effective in teaching mathematics. The results of this study may be used by school heads and administrators in planning for the professional development of their in-service teachers. It may benefit both the teachers and students if teachers' professional training will focus on specific mastery of skills that may impact student achievement.

The results of this study may also help curriculum planners see not only students' level of mastery in geometry but also teachers' van Hiele level of thinking which will help them look into the teachers' strengths and weaknesses and relate these to a more effective planning of the mathematics curriculum. This study may inform instructional material developers of how mathematical models such as the van Hiele levels may influence the design of discussion and activities, mathematical applications, and technology integration in geometry lessons. Finally, this study hopes to encourage researchers to explore further on teacher factors such as van Hiele level of thinking strategies that positively influence student achievement in mathematics.

Method

The objectives of this study were achieved through a non-experimental quantitative method that utilized the correlational research design. The study focused on the analysis of data gathered through researcher-made and an adapted test.

The Participants

Multistage cluster sampling was performed in selecting the participants. Thirty teachers and one of their heterogeneous intact class from Cluster RoS (Rodriguez and San Mateo) of the Division of Rizal participated in the study.

Of these 30 mathematics teachers, 21 or 70% were from Rodriguez district while 9 or 30% were from San Mateo and a total of 1489 students participated in the study. They belonged to the respective grade 9 classes of the 30 teacher-participants.

The Instruments

The van Hiele Geometry Test (Usiskin, 1982) and a researcher-made achievement test in geometry was used in the study. All the instruments underwent validity process and reliability analysis to ensure internal consistency of the items.

The Van Hiele Geometry Test

Permission was granted by Usiskin (1982) to use the van Hiele test provided that the test would not be changed nor modified. The test was used to assess teachers' van Hiele levels of geometric thinking.

Achievement Test in Geometry

To determine the students' achievement in geometry, the researcher developed an achievement test in geometry based on the grade 9 third quarter topics from DepEd's K to 12 Mathematics Curriculum Guide (2016). The achievement test was composed of 35 multiple-choice items validated by a panel of content experts in mathematics. The test was pilot tested with a reliability coefficient of .77. The mastery level of achievement test results was classified per student and per class based on the report on quartile distribution of mean percentage scores (MPS) among schools by DepEd (2018).

Data Collection Procedure

Approval from concerned institutions and offices were sought prior data collection. Data gathering started on January 6, 2020 and ended on February 28, 2020. There were 30 grade 9 mathematics teachers and 1489 students participated in this study.

Findings and Discussion

The following subsections present the findings and discussions:

The Teachers' Van Hiele Levels

The actual van Hiele levels of teachers show that out of 30, 9 or 30% of the teacher-participants are operating at level 2. For level 3, there were also 9 or 30%, while 7 or 23.3% are operating at level 4, and 5 teachers or 16.7% are operating at level 5. As expected, no teacher was operating at level 1 since this van Hiele level is expected for elementary students.

It can be observed that the result of the actual van Hiele levels of teachers in this study were mostly lower than expected as it was mentioned by Mistretta (2000) that teachers in high school should be operating at level 5 (rigor). Level 5 is when a learner investigates other geometry courses like analytic geometry and modern geometry, which are usually done by mathematics majors in college. In actual van Hiele levels of teachers, only 5 or 16.7% of the teacher-participants are operating at level 5. This suggests that some grade 9 teachers may have questionable competence in terms of teaching geometry. These results are similar to what other researchers have found in their studies that van Hiele levels of the teacher-respondents are just one level ahead of their students or weaker than expected (Browning et al., 2014; Erfe, 1996; Halat & Sahin, 2008; Ndlovu, 2014).

The Students' Achievement in Geometry

Results of the achievement test indicate that out of 1489 students, only 9 students or .6% are able to reach the superior level of mastery, 242 or 16.26% are at average level, 678 or 45.53% are at low level, and 560 or 37.61% are at poor level. Most of the student-participants, 1238 or 83.14% fall below the 75%-acceptable level.

Accordingly, based on class mean percentage scores (MPS), none of the 30 intact classes are at superior level, only 2 or 6.67% fall under average level, 26 or 86.66% under low level, and 2 or 6.67% under poor level of mastery. It is remarkable that not even 1% of the intact classes are able to reach the superior level of mastery. Meanwhile as with the classes, 28 or 93.33% of the classes are below acceptable level, while only 2 or 6.67% are at the average mastery level. The results confirm the reports of several studies (Buendicho, 2009; Caluya, 2000; Escaran, 2005; Guloya, 2007; Liwag, 2008; Solaiman, 2013; Velasco, 2013) which emphasized that only a few number of students achieved the mastery level in geometry. This being the scenario for over decades needs so much attention.

Several local studies mentioned similar thoughts on the importance of developing students' geometric skills because it contributes to the development of their critical thinking and problem solving skills (Buendicho, 2009; Liwag, 2008; Solaiman et al., 2017). Upon confirming results on students' achievement in the last decades to be below mastery level, it is suggested by this study to look into some teacher factors related to students' achievement in geometry since it was established that mathematics teachers' geometric competencies are critical to the effective teaching of the subject (Ndlovu, 2014). To further look into the meeting of three elements, teacher, student, and subject matter as argued by the van Hieles and to contribute to the studies involving student achievement in geometry, this study sought to look into teachers' van Hiele levels and teaching styles and their association with student achievement in geometry.

The Teachers' van Hiele Levels and Students' Achievement in Geometry

Kruskal-Wallis test was conducted to examine whether there are differences between the achievement test results of students based on the van Hiele level of thinking of their teachers. Results show that there is a significant difference ($H(3) = 8.932$, $P = .030$) between student achievement and teachers' van Hiele levels. Post hoc comparisons using Mann-Whitney U test procedures were likewise used to determine which pairs of the four group means differ. Among the pairwise comparisons, the result of the Mann-Whitney U test, showed a significant difference ($U=.000$, $p=.003$) only between achievement of the students whose teachers are operating at level 5 and those whose teachers are operating at level 2. It is also good to note that the mean scores of students whose teacher is operating at level 5 ($M = 44.66$) is significantly higher than those of the students whose teacher is operating at level 2 ($M = 30.48$).

For this significant result, effect size was computed using r^2 and a substantial effect size for this significant pairwise difference was computed at 0.6429 or 64.29%. This means that 64.29% of the variance in student achievement is explained by the teachers' van Hiele level. This indicates a strong relationship between the two variables in that particular level.

It is possible that students whose teacher is operating at a higher level of van Hiele level performed better than those students whose teacher is operating at a lower level of van Hiele. This result may reinforce the claims that raising the van Hiele levels of mathematics teachers would result in a higher student achievement (Erfe, 1996; Halat, 2008, Solaiman et al., 2017). Moreover, it shows an evidence that teachers' level of thinking affects student achievement and supports Solaiman's claim that mastery of the subject enables a teacher to find effective ways to develop students' reasoning and skills in mathematics.

Subsequently, Goodman and Kruskal's gamma was run to determine the relationship between teachers' van Hiele level of geometric thinking and students' achievement (see Table 1) and it was found that there is a weak positive correlation between the two variables, which is statistically significant ($G = .428$, $p < .0005$). This may be because when the pairwise comparison was made between achievement of students in geometry in the respective teachers' van Hiele level, only one pair generated significant results. Perhaps if more than one pair generated significant differences, this could have resulted in stronger correlation.

Table 1. Correlation of Teachers' van Hiele Levels and Students' Achievement

	Value	Asymp Std. Error	Approx. *t*	*p*
Gamma	.428	.121	3.492	.000
N	30			

* *p < .05*

The result of the analysis suggests a weak positive correlation between teachers' van Hiele level and students' achievement. This means that there is a low probability that a teachers' van Hiele level is associated with student achievement. This is still worthy to look into as a factor that needs to be enhanced among teachers as significant difference is found among achievement of students whose teachers are operating at levels 2 and 5. Note that these are opposite levels and remember that students whose teachers are operating at level 5 performed better as their mean scores are significantly higher than those students whose teachers are operating at level 2.

The teachers just need to be aware of the van Hiele theory and how the theory has been used to improve students' achievement in geometry because during the interview, most of the teachers were not aware of the van Hiele theory and some of them admitted that it was their first time to hear it. Learning about the van Hiele theory will help teachers to become aware of the students' reasoning and their phases of learning, leading to better student achievement. This agrees with the observation of other researchers who also explored the van Hiele theory. According to them, student achievement may influence by the teachers' awareness of how students learn best, how reasoning ability of students are developed, continuous training, and even the affective factors (Guloya, 2007; Liwag, 2008; Solaiman et al., 2017; Ndlovu, 2014).

To look deeper into the association between the teachers' van Hiele levels and students' achievement in geometry, the researcher ran a regression analysis using dummy coding to test if the teachers' van Hiele level affects students' achievement in geometry. The results are significant at $F(3, 26) = 3.908$, $p<.02$ and that the output shows that 31% of the variance in the students' achievement is caused by the teachers' van Hiele level. This r^2 value from the regression analysis is consistent with the weak positive correlation result from Table 1 since it is apparent from the result of the pairwise comparison (see Table 2) that not all of the pairs generated significant results.

Table 2. Summary of Regression Analysis for Teachers' van Hiele Levels and Students' Achievement

Teachers van Hiele Levels		*B*	Std. Error	Beta	*t*	*p*
Level 2	(Constant)	31.72	2.58		12.28	.000
	Level 3	7.99	3.66	.42	2.19	.038*
	Level 4	7.63	3.91	.37	1.95	.062
	Level 5	14.19	4.33	.61	3.28	.003*

Note: $r = .56$, $r^2 = .31$, adj. $r^2 = .23$

* $p < .05$

Along with this, it can be observed in Table 2 that: (a) students of teachers who are operating at level 3 will realize a 7.99 increase in achievement compared to students of teachers who are operating at level 2, significant at p = .038; (b) *s*tudents of teachers who are operating at level 4 will realize a 7.63 increase in achievement compared to students of teachers who are operating at level 2, but not significant since p = .062; and (c) it is very remarkable that students of teachers who are operating at level 5 will realize a 14.19 increase in achievement compared to students of teachers who are operating at level 2, significant at $p = .003$.

Recall that the result of the Mann-Whitney U test showed a significant difference between achievement of students whose teachers are operating at van Heile level 5 than those whose teachers are operating at level 2. In addition, the mean scores of students whose teacher is operating at level 5 in the van Hiele levels of geometric thinking is significantly higher than those of the students whose teacher is operating at level 2. The regression analysis result implies that a teacher with a higher van Hiele level of thinking may lead students to better understanding of geometry. Although for the regression analysis conducted, only 31% of the variance in the students' achievement is caused by the teachers' van Hiele level. Teachers with low van Hiele level of thinking may also lead to students having low achievement in geometry. Therefore, there really is a need for teachers to do well in the van Hiele levels so they can help their students perform better in geometry. This study fails to reject the research hypothesis that the teachers' van Hiele level of geometric thinking is correlated with students' achievement in geometry. In fact, the teachers' van Hiele level is a function of students' achievement in geometry.

Ndlovu (2014) argued that mathematics teachers' geometric competencies are critical to the effective teaching of the subject, and based on the results, these competencies would include the teacher's geometric level of thinking. Part of the teaching standards set by the National Council of Teachers of Mathematics (NCTM, 2000) is that effective mathematics teaching requires understanding of students' knowledge and concepts and challenging and supporting them to learn it well. Understanding the van Hiele theory including the phases of learning means understanding how students think as well as applying methods of teaching that will suit them well. Both experienced and novice teachers may be given capability building to help integrate these theories in practice.

Meanwhile, the Commission on Higher Education (CHED) may review the curriculum for mathematics teachers because based on CHED Memo No. 75 S.2017 (Policies and Guidelines for Bachelor of Secondary Education), although 63 units of mathematics courses are required, only 3 units are allotted for principles and strategies in teaching mathematics and 3 units for plane and solid geometry (this is where high school geometry topics are taught). Although there are advanced geometry courses (Analytic Geometry and Modern Geometry) which total to 7 units, an immersed course on high school geometry teaching and conceptual understanding may be considered. On contrary, other researchers explained that the weak positive relationship may also indicate that there are other teacher factors that relate to students' achievement (Mahmud & Saliman, 2012 as cited in Kusen & Marinovi, 2013). This is why observation of different teaching strategies and teaching styles in the mathematics classroom may explain the reason for poor geometric reasoning abilities among Filipino students (Liwag, 2008; Paz, 2009).

Conclusions

The results that emerged in this study yielded the following conclusions:

1. Very few of the teachers have the geometric thinking level they are expected to exhibit while the majority of them only have the geometric thinking levels onto which their students are expected to exhibit.
2. Most of the students achieved below acceptable mastery level in geometry and it is remarkable that not even one-percent of them are able to reach the superior mastery level.
3. There is a significant difference between achievement of students whose teachers are operating at level 2 and achievement of students whose teachers are operating at level 5 in the van Hiele theory.
4. There is a weak positive correlation between teachers' van Hiele level and students' achievement in geometry.

Recommendations

From the findings, this study recommends the following:

1. Mathematics teachers have to work on developing their geometric thinking ability to make sure that they operate at levels 4 or 5, the levels expected from high school mathematics teachers. This may be done through attending capacity building seminars, taking geometry courses, or pursuing graduate studies in mathematics. Ensuring highly qualified teachers especially in this aspect will increase student achievement.
2. Aside from teachers' van Hiele levels, other factors may be looked into in future researches such as limited time of lectures, class size, learning environment, study habits, and the usual disruption of classes due to valid reasons such as typhoon, calamities, and epidemic disease and viruses to further improve student achievement in mathematics.
3. Another study may be done focusing on other content areas and grade levels. This will give a different viewpoint of teaching and will help determine in which grade level the student achievement started to decline since this study is limited to grade 9 lessons only.
4. DepEd may continue to capitalize in implementing trainings that will help improve teachers' geometric thinking ability. Moreover, it should ensure maximizing academic learning time by allowing teachers to have more time in preparing lessons, teaching the students, and continuing education rather than doing ancillary office tasks.

5. A review of the curriculum for preservice secondary mathematics teachers can be done by the Commission on Higher Education (CHED) because based on the Policies and Guidelines for Bachelor of Secondary Education, although 63 units of mathematics courses are required, only 3 units are allotted for principles and strategies in teaching mathematics and 3 units for plane and solid geometry (this is where high school geometry topics are taught). Although there are advanced geometry courses (Analytic Geometry and Modern Geometry) which total to 7 units, an immersed course on high school geometry teaching and conceptual understanding may be considered.

Acknowledgement

Acknowledgment goes to the Scholarship Committee of the UP College of Education for the financial assistance to complete the paper. Likewise, to the Department of Science and Technology (DOST) for the thesis grant scholarship under its Capacity Building Program in Science and Mathematics Education (CBPSME).

References

Browning, C., Edson, A. J., Kimani, P. M., & Aslan-Tutak, F. (2014). Mathematical Content Knowledge for Teaching Elementary Mathematics: A Focus on Geometry and Measurement. *Mathematics Enthusiast, 11*(2), 333–383.

Buendicho, B. M. (2009). *Effects of student-initiated questions on reasoning ability and geometry achievement.* University of the Philippines – College of Education, Diliman, Quezon City.

Caluya D. C. (2000). *Students' level of geometric thinking in relation to teachers' transformational practices in geometry classes.* University of the Philippines – College of Education, Diliman, Quezon City.

Capate, R. N., & Lapinid, M. R. (2015). *Assessing the mathematics performance of grade 8 students.* Proceedings of the DLSU Research Congress. pp. 1-7. De La Salle University, Manila.

Commission on Higher Education (2017). CHEd Memorandun No. 75 S. 2017: *Policies, Standards and Guidelines for Bachelor of Secondary Education.* Office of the President. Republic of the Philippines

Crowley, M. L. (1987). The van Hiele model of the development of geometric thought. In M. M. Lindquist (Ed). Learning and teaching geometry, K-12, *Yearbook of the National Council of Teachers of Mathematics* (pp.1-16). Reston, Va.: National Council of Teachers of Mathematics. Retrieved from http://www.csmate.colostate.edu/docs/math/mathactivities/june2007/The%20van%20Hiele%20Model%20of%20the%20Development%20of%20Geometric%20Thought.pdf

Department of Education. (2016). *K to 12 curriculum guide: Mathematics*. Retrieved from http://www.deped.gov.ph/sites/default/files/page/2016/Math%20CG_with%20tagged%20math%20equipment.pdf

Department of Education. (2019*). Statement on the Philippines' ranking in the 2018 PISA results* Retrieved from https://www.deped.gov.ph/2019/12/04/statement-on-the-philippines-ranking-in-the-2018-pisa-results/

Department of Education. Region 02 Cagayan Valley. (2019, May). URM. s, *2019:2018 National Achievement Test (NAT) 6, 10 &12 Results and Analysis.* Isagani R. Duruin. https://region2.deped.gov.ph/urm-s-20192018-national-achievement-test-nat-610-12-results-and-analysis/

Erdogan, T., Akkaya, R., & Akkaya, S. (2009). The effect of the van Hiele model based instruction on the creative thinking levels of 6th grade primary school students. *Educational Sciences: Theory & Practice, 9*(1), 181-194. Retrieved from http://files.eric.ed.gov/fulltext/EJ837779.pdf

Erfe, A. C. (1996). *A validation of the van Hiele levels of thinking in learning high school geometry.* University of the Philippines – College of Education, Diliman, Quezon City.

Escaran, O. M. (2005). *Investigating hypothetico-deductive reasoning using inductive approach*. De La Salle University, Taft Avenue, Manila.

Guloya, L. (2007). *Software-assisted instruction, students' thinking level, and achievement in geometry*. University of the Philippines – College of Education, Diliman, Quezon City.

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 2008, 11*(1/2), 143-158. Retrieved from https://pdfs.semanticscholar.org/9a6e/3c23e1e0185b6f3e03b159ce9be8a848630e.pdf

Herbst, P., Fujita, T., Halverscheid, S., & Weiss, M. (2017). *The learning and teaching of geometry in secondary schools: A modeling perspective.* New York: Routledge.

Kušen, Ema & Marija, Marinović. (2013). *An approach to Operations Research course in the curriculum for Computer Science students.* Retrieved from https://www.researchgate.net/publication/236649492_An_approach_to_Operations_Research_course_in_the_curriculum_for_Computer_Science_students

Liwag, J. M. (2008). *Geometric thinking and reasoning abilities of fourth year high school students.* University of the Philippines – College of Education, Diliman, Quezon City.

Mahmud, Y. & Salimian M. (2012). *Assessment of student performance in Operations Research class delivered by an innovative approach.* American Society for Engineering Education.

Mistretta, R. M. (2000). Enhancing geometric reasoning. *Adolescence*, 35 (138), pp. 365-379. Retrieved from https://www.questia.com/library/journal/1G1-66171011/enhancing-geometric-reasoning

Ndlovu, M. (2014). Preservice teachers' understanding of geometrical definitions and class inclusion: An analysis using the van Hiele model. *Proceedings of INTED2014 Conference 10th-12th 2014.* South Africa: Stellenbosch University. Retrieved from https://www.researchgate.net/publication/260853961

Paz, E. P. (2009). *Teaching styles and student performance in conceptual and algorithmic problem solving in chemistry.* University of the Philippines – College of Education, Diliman, Quezon City.

Solaiman, N. P. (2013). *Assessment of third year high school students' van Hiele levels of geometric conceptual understanding in selected secondary public schools in Lanao del Sur.* Mindanao State University, Marawi City.

Solaiman, N., Magno, S. & Aman, J., (2017). Assessment of the third year high school students' van Hiele levels of geometric conceptual understanding in selected secondary public schools in Lanao del Sur. *Journal of Social Sciences, 6*(3), *603-609.*

Usiskin Z. (1982). *Van Hiele levels and achievement in secondary school geometry. Cognitive Development and Achievement in Secondary School Geometry (CDASSG) Project.* Retrieved from http://ucsmp.uchicago.edu/resources/van-hiele/

Usiskin Z & Griffin J (2008). *The classification of quadrilaterals: A study of definition.* Charlotte, NC: Information Age Publishing.

Van Hiele, P. M. (1984). *The child's thought and geometry.* Retrieved from ERIC database. (ED436231)

Velasco, Q. M. (2013). *Mind mapping with proofblocks: Effects on student geometric level of thinking and self-efficacy*. University of the Philippines – College of Education, Diliman, Quezon City.

Author Information

Angelina P. Lumbre
https://orcid.org/0000-0001-8645-4625
College of Education
University of the Philippines, Diliman
Philippines
Contact e-mail: *aplumbre@up.edu.ph*

Ma. Nympha Beltran-Joaquin
https://orcid.org/0000-0001-9774-6367
College of Education
University of the Philippines, Diliman
Philippines

Sheryl Lyn C. Monterola
https://orcid.org/0000-0002-7979-4522
College of Education
University of the Philippines, Diliman
Philippines