# ACHIEVEMENT OF DUAL LANGUAGE LEARNERS IN THE STUDY OF NETS

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**Abstract**

*The authors explore van Hiele phase-based instruction with GeoGebra and its impact on student understanding of nets of three-dimensional (3D) shapes. Subjects, 14 boys and 16 girls, were enrolled in Year 2 of a Dual Language Program (DLP) in Penang, Malaysia. A paired samples t-test shows a significant difference in achievement and retention favoring the experimental instructional method. In addition, authors share qualitative feedback from students about the method.*

**Keywords**: van Hiele, phase-based instruction, Dual Language Program (DLP), geometry

## 1 INTRODUCTION

### 1.1 Malaysia and TIMSS Geometry Achievement

Malaysia has participated in six cycles of *Trends in International Mathematics and Science Study* (TIMSS) Yee et al. (2018). The geometry domain scores of Malaysian 8th graders on TIMSS from 2011, 2015, and 2019 are significantly lower than those from 2007. Even though the geometry domain scores have increased from 2011 to 2019, these numbers they are far lower than those from 1999, 2003, and 2007.

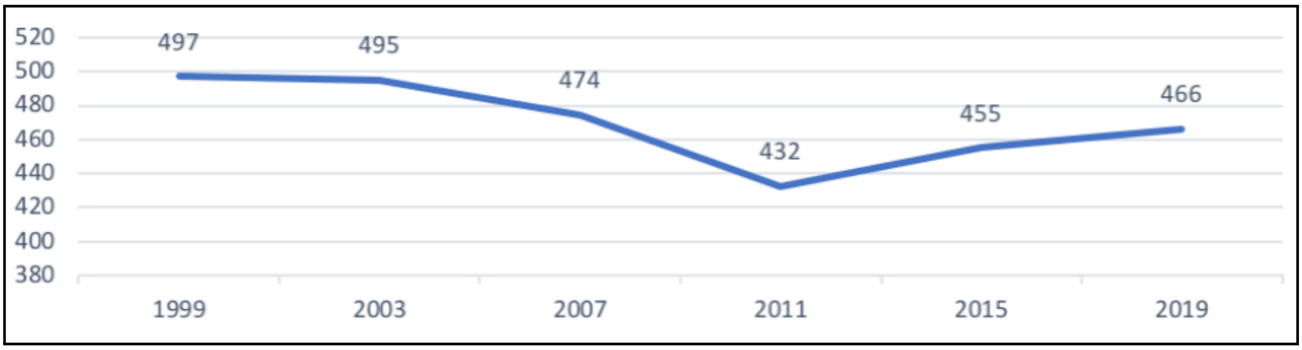


**Figure 1.** The trend of geometry domains in TIMSS among Malaysian 8th graders (Mullis et al., 2020, p. 204).

A direct result of the low test scores in Figure 1 was the creation of Pengajaran dan Pembelajaran Sains dan Matematik dalam Bahasa Inggeris (PPSMI), The Teaching of Mathematics and Science in the English Language, in July 2002 under the administration of Dr. Mahathir bin Mohamad (Ministry of Education Malaysia, 2008). The pioneering cohort for PPSMI began the program in 2003 and included Year 1 students at the primary education level and Form 1 secondary level students. By 2007–2008, PPSMI was fully implemented—with all Malaysian primary and secondary students participating in the program (Ministry of Education Malaysia, 2008). In PPSMI, all resources such as textbooks, activity books, teacher's guide, glossary book, practical science book, and electronic materials for Mathematics and Science are translated into English.

The utilization of English in math and science teaching has sparked controversy in Malaysia. Note that schools in the Malaysian education system can be divided into two types: (1) National Primary School or Sekolah Kebangsaan (SK) and (2) Vernacular Primary Schools or Sekolah Jenis Kebangsaan (SJK), which comprise SJK(C) for Chinese Vernacular Primary School and SJK(T) for Tamil Vernacular Primary School (Mazlan, 2019). Until now, the use of students' native language has been the default for Malaysian schools. The Malaysian union of Chinese schools, Dong Jiao Zong, and many others protested the implementation of PPSMI since the policy runs contrary to practices that have been in place in Malaysia for countless years. Ultimately, a compromise was reached with English and Mandarin (native language). As academics, policymakers, teachers, and parents debated the implementation of PPSMI, they also argued about the future after PPSMI (Hamzah et al., 2019; Soh et al., 2021).

### *1.2 A Policy Change*

In 2012, Deputy Prime Minister Tan Sri Muhyiddin Yassin announced a PPSMI policy reversal: mathematics and science would once again be taught in a student's native language. Figure 1 shows that TIMSS geometry scores of Malaysian 8th graders bounced back after this call, hitting a low point in 2011. Dual Language Program (henceforth DLP) was begun in 2016. Since then, a few pilot schools have been chosen by the Ministry of Education Malaysia to teach mathematics and science subjects using English (Mazlan, 2019).

Further analysis of the 2019 TIMSS data, such as the tables provided in Tables 1 and 2, suggests other possible impacts of the policy change. Table 1 shows the percentage of 8th graders whose first language was the same as the TIMSS test's language along with overall average TIMSS scores relative to these percentages.

| | Student (%) | Avg. TIMSS Score |
|---|---|---|
| More than 90% of Students with Language of Test as Their Native Language | 47 | 462 |
| 51–90% of Students with Language of Test as Their Native Language | 29 | 447 |
| 50% or less of Students with Language of Test as Their Native Language | 24 | 473 |

**Table 1.** Schools with Students Having the Language of the Test as Their Native Language. *Source*: TIMSS language and test performance (Mullis et al., 2020, p. 322).

As Table 1 indicates, schools with 50% or fewer students with the test's language as their native language outperformed the other categories of schools. Even though schools use different native languages to implement DLP, programs with relatively high numbers of non-native speakers exceeded schools with "more than 90% of students with the test's language as their native language" (Mullis et al., 2020, p. 322). Table 2 shows percentages of 8th graders that "always," "almost always," "sometimes," or "never" speak the language of the TIMSS test at home, together with average achievement in mathematics.

| | Student (%) | Avg. TIMSS Score |
|---|---|---|
| Always | 44 | 477 |
| Almost Always | 16 | 465 |
| Sometimes | 32 | 442 |
| Never | 8 | 437 |

**Table 2.** Language of TIMSS and home language (Mullis et al., 2020, p. 297).

The data in Table 2 suggest that students that "always" speak the language of the test at home achieve at higher levels, on average, than students that "sometimes" or "never" speak the language of the test at home. Note that this data appears to be at odds with the data provided in Table 1. *Why is this?* A study is warranted to investigate this apparent contradiction. *Specifically, does the language of instruction impact student learning mathematics and science as measured by the TIMSS?* Or is this a matter of perception fueled by political goals rather than scientific fact? As Figure 1 illustrates, the implementation of PPSMI has seemingly impacted TIMSS results for 8th graders—particularly in geometry. The Ministry of Education Malaysia (MOE) denied that the implementation of PPSMI was a failure.

> "The accusation of PPSMI is a failed policy is not true. PPSMI policy is not failed policy, but the implementation was not wholly implemented across Malaysia. Thus, MOE launching DLP (was) incoherent with Malaysia Education Blueprint or (the stated objective of the) Pelan Pembangunan Pendidikan Malaysia (PPPM) 2013–2025 to choose schools so that students are given significant access to explore knowledge" (Ministry of Education Malaysia, 2017, p. 1).

After PPSMI was lifted in 2012, 8th graders' TIMSS geometry achievement increased significantly from 2011 to 2019. DLP commenced in 2016, with some schools opting to use English to teach math and science. Those who opted out used native languages such as Malay, Mandarin, and Tamil depending on their school type. Thus, TIMSS 2019 data reflect a mix of different language teaching methods (Table 1).

As Figure 1 suggests, 8th graders' geometry performance increased over the interval 2011–2019 but has yet to match previous highs. Taking a more careful look at the data, it's interesting to note differences in how technology was used in teaching and learning geometry in Malaysia across the two periods of time. Since numerous studies have found that the use of technology in mathematics lessons leads to significantly higher student achievement (Meng, 2009; Meng and Sam, 2013; Pacemska, 2012; Reisa, 2010). Technology fosters student construction of mathematical knowledge and understanding, appeal to students' preferences for the visual, and helps remedy students' mathematical misconceptions (Zulnaidi and Oktavika, 2018).

Data from the 2015 and 2019 TIMSS indicate that technology use during mathematics lessons remains low. Tables 3 and 4 provide insight regarding the level of technology (in this case, computer activities) used during mathematics instruction in Malaysia.

| Activity | Malaysia (%) | International average (%) |
|---|---|---|
| Explore Mathematics principles and concepts | 6 | 21 |
| Practice skills and procedures | 5 | 23 |
| Look up ideas and information | 5 | 22 |
| Process and analyse data | 4 | 19 |

**Table 3.** Computer activities during Mathematics Lessons (As reported by teacher). *Source*: TIMSS 2015 International Results in Mathematics (p. 297), Mullis et al., (2015).

Table 4 illustrates that Malaysian students, on average, have less access to computers for use in mathematics than their international counterparts. Because our students will need to be technologically literate to compete in an increasingly global economy, we need to provide more of our teachers with access to technology and make certain that they are aware of changing trends in the use of technology to teach and learn mathematics and the sciences. Moreover, teachers need to understand that technology provides students with the means to solve problems using a wide variety of different methods—one size fits all lessons are disrupted when teachers provide their students with access to digital tools. Teachers are responsible for understanding how students engage (or not) with technology for learning and sharing knowledge (Ferri et al., 2020). Unfortunately, continued low-levels of technology use in mathematics instruction will likely hamper student achievement since the computers provide students with access to a broad array of resources that are out of reach for those without a computer or internet connection.

| Computer Access | Malaysia (%) | International average (%) |
|---|---|---|
| Yes | 13 | 37 |
| No | 87 | 63 |
| Look up ideas and information | 5 | 22 |
| Process and analyse data | 4 | 19 |

**Table 4.** Computers available for students to use during Mathematics lessons. *Source*: TIMSS 2015 International Results in Mathematics (p.297), Mullis et al., (2015).

Further investigation is needed to discover how technology can enhance Malaysian students' achievement in geometry and understand how DLP students cope with this trend. The data from TIMSS from 2011–2019 and 1999–2007 indicate that students from the earlier period were more successful on TIMSS geometry items. *Is this the result of an overall lack of technology in mathematics instruction or language issues?* In this study, teachers and their students use GeoGebra, a freely available, dynamic geometry software (DGS). Several studies have shown that GeoGebra can help enhance student achievement (Arbain and Shukor, 2015; Dayi, 2015; Lee, 2011; Masri et al., 2017; Shadaan and

Leong, 2013; Seloraji and Eu, 2017; Wah, 2015). Specifically, GeoGebra can help students learn basic geometry properties (Lee, 2011) and transition from two-dimensional shapes to three-dimensional shapes (Mihailova et al., 2014).

In addition, further research is needed to evaluate DLP students' achievement in learning geometry to gain insights into the impact that language has on student learning of geometry. It is essential to bear in mind that the DLP end occurred within the phase of improvement in TIMSS (2011 – 2019). Those results were lower than those in the previous period (TIMSS 1999 – 2007). It is crucial to evaluate the influence of DLP on students' achievement in learning geometry to determine if the downward trend was related to language.

## 2 Literature Review

### *2.1 The van Hiele Theory of Geometric Thinking*

Dutch educators, Pierre and Dina van Hiele, explain the development of human geometric thinking in response to difficulties learners encountered in their classrooms (Watson, 2012). The model's main idea is that students progress through a sequence of discrete, qualitatively different levels of geometric thinking for a particular topic that they confront. Each level contains varying markers for language and symbols Wang and Kinzel (2014). These levels are illustrated in Figure 2.

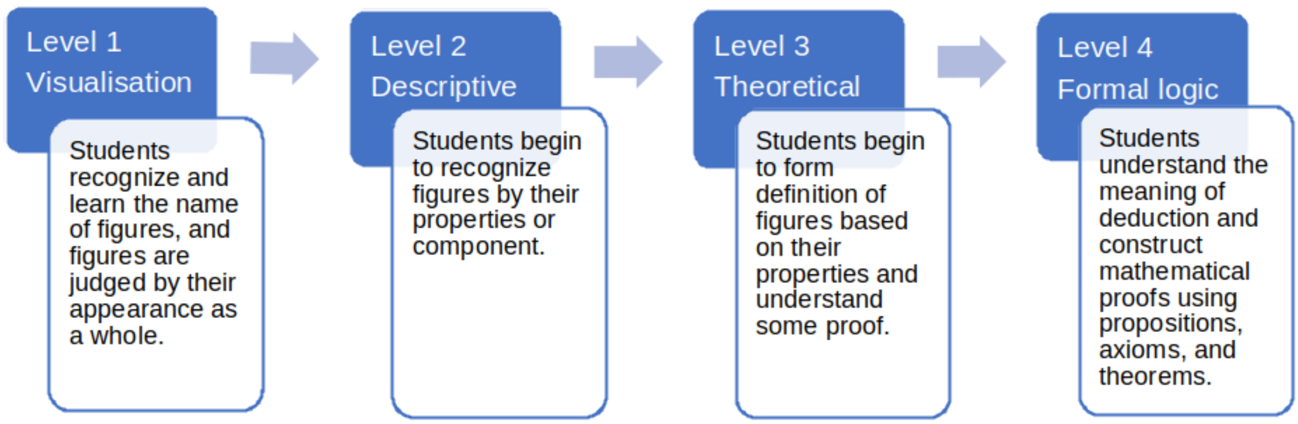


**Figure 2.** Van Hiele levels of geometric thinking (Wang and Kinzel, 2014).

Hourigan and Leavy (2017) proposed a revised version of the van Hiele levels of geometric thinking with the addition of Level 0 where students recognize geometrical shapes based on their visual characteristics as depicted in Figure 3.

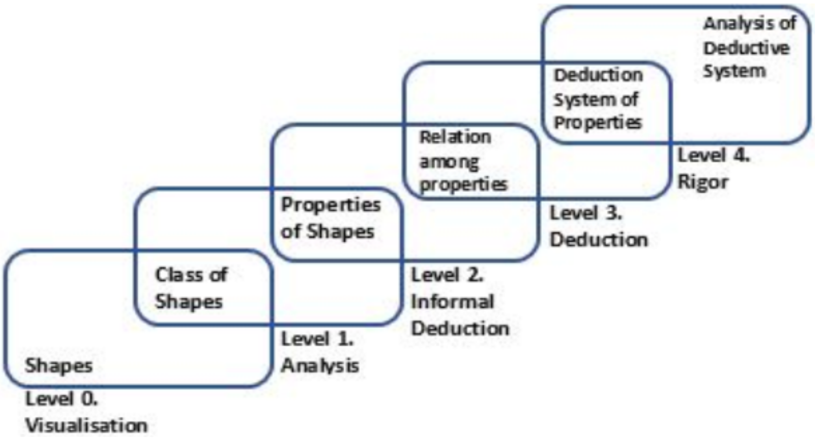


**Figure 3.** A revised version of the van Hiele levels of geometric thinking (Hourigan and Leavy, 2017).

### 2.2 *Phase-based Instructions*

To help pupils elevate from one level to another level in van Hiele's geometric thinking levels, the five phases of learning or phase-based instruction were also proposed by van Hiele (Abu and Abidin, 2013; Meng and Sam, 2013; Meng, 2009).

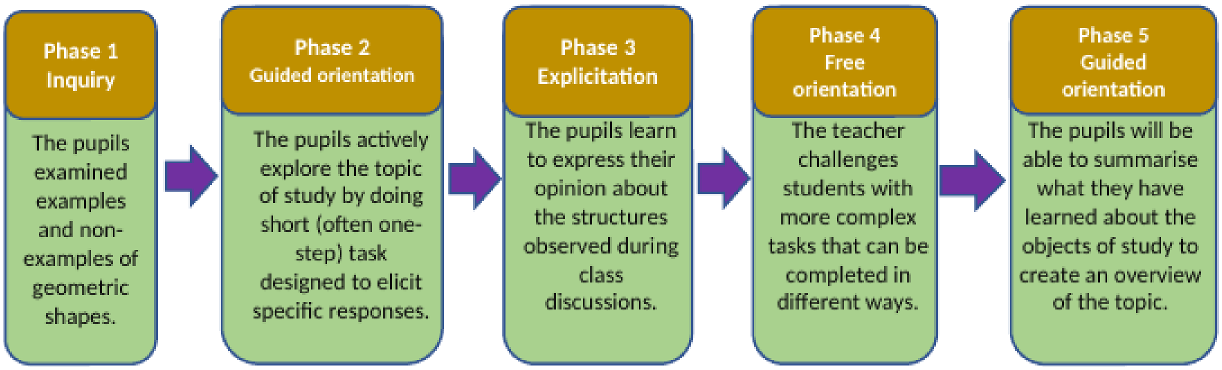


**Figure 4.** The phase-based instruction (van Hiele, 1999).

### 2.3 *Dual Language Learners (DLLs) in Learning Mathematics*

DLP has long been implemented in many developed countries. This program is widely called with various names such as dual immersion program, two-way bilingual program, bilingual education program, and heritage language program (Hamaludin and Rosli, 2019). Dual language learners (DLLs) in the current interpretation include all students exposed to two languages during early childhood (Bialystok et al., 2001). According to Barac et al. (2014), all DLLs are potentially "bilingual," and all young learners in these situations to be bilingual to some extent. Hamaludin and Rosli (2019) have surveyed to investigate Form 1 (13 years old) and Form 2 (14 years old) students' perception and achievement in learning Mathematics in English and Malay language in a secondary school in Malaysia. They found out that DLP students' achievement scored higher than non-DLP students, showing that learning Mathematics other than their native language negatively impacts their mathematics achievement.

Aunio et al. (2019) has investigated the influence of cognitive skills (executive function), language factors (listening comprehension, English as a second language, ESL), and kindergarten attendance on early numeracy in a cross-sectional sample of 442 South African children. In South Africa, having eleven official languages makes the schools provide the curriculum's content in these languages. The structural equation path model showed that kindergarten attendance predicted children's early numeracy performance even when controlling executive function and language skills. In contrast, listening comprehension skills predicted the early numeracy skills more strongly than execution function skills.

Méndez et al. (2019) hypothesized the association of oral language, including expressive vocabulary and grammar comprehension, with early numeracy skills within and across languages in Spanish-English speaking Latino children who are DLL at the beginning of preschool in urban communities from the states of New York. They discovered that Spanish oral language measures contributed to early numeracy outcomes only in Spanish, while English language measures contributed to early numeracy outcomes in English. These findings contradict Aunio et al. (2019), indicating that word knowledge is important to facilitating children's understanding of early numeracy concepts presented in the same language.

According to a Phase 1 study by MOE, DLP has helped 36.28% of primary school students, and 46.44% of secondary students showed an increase in their English language exam results in 2016. While in Phase 2, 55.82% of primary students and 57.23% of secondary students showed an increase in their English language exams in 2017 (Rashid, 2018). Deputy Education Minister Teo Nie Ching (at that time) raised some issues in DLP where she stated that not all students were suitable for the program. However, parents and guardians still wished to enroll their kids in DLP.

To cater to this issue, the Ministry of Education has set up new guideline in implementing DLP at school where students who wished to enroll must gain a minimum result in Malay language subjects (compulsory subject) in the previous year of schooling or three years of improvement in Malay language subject (if they did not meet the minimum criteria) (Ministry of Education Malaysia, 2020). This improvement shows that DLP enhances the students' performance in the English language so as in the Malay language incoherent with the ministry's initiative in Upholding the Malay Language and Strengthening the English Language Policy or Memartabatkan Bahasa Melayu Memperkukuhkan Bahasa Inggeris (MBMMBI) (Abdullah et al., 2019; Hamaludin and Rosli, 2019; Yamat et al., 2014). Nevertheless, a further investigation is needed to probe DLL in learning Mathematics, especially geometry, as the positive progress shown by the last three cycles of TIMSS (2011 - 2019) among 8th graders.

## 3 Methodology

### *3.1 Research Questions*

The authors of this study aim to answer the following research questions.

1. Is there a significant effect of teaching using van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' achievement in learning nets of 3-D shapes?
2. Is there a significant effect of teaching using van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' retention of achievement in learning nets of 3-D shapes?

3. What are Year 2 pupils' thoughts and feelings regarding their learning of nets of 3-D shapes using van Hiele's phase-based instruction incorporating GeoGebra?

### *3.2 Null Hypotheses*

To answer the research questions, the following null hypotheses will be evaluated.

1. $H_0$: There is no significant effect of teaching using the van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' achievement in learning nets of 3-D shapes.

2. $H_0$: There is no significant effect of teaching using the van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' retention of achievement in learning nets of 3-D shapes.

### *3.3 Research Design and Conceptual Framework*

This study was a one-group pretest-posttest design where one group of pupils has undergone a series of learning activities designed with Phased-based learning within two weeks. The sample group has learned using van Hiele's phase-based instruction incorporating GeoGebra. To comprehend how GeoGebra's learning shape and space, the one group pretest-posttest research design has been chosen. The research design for this study is depicted in Figure 5.

| | | | | |
|---|---|---|---|---|
| Sample Group | $O_1$ | $X_1$ | $O_2$ | $O_3$ |

Legends:
$O_1$ = Shape and Space Achievement Test (SSAT) Pre-test
$O_2$ = Shape and Space Achievement Test (SSAT) Post-test
$O_3$ = Shape and Space Achievement Test (SSAT) Delayed-post-test
$x_1$ = Teaching using the van Hiele's phase-based instruction incorporating GeoGebra

**Figure 5.** Design of the study.

The teacher has determined which van Hiele levels of geometric thinking their pupils are before conducting intervention involving designated theories and selected DGS. Then, phase-based learning is used to design suitable lesson activities to suit pupils' geometric thinking level. With these observations in mind, Figure 6 illustrates the conceptual framework of this study.

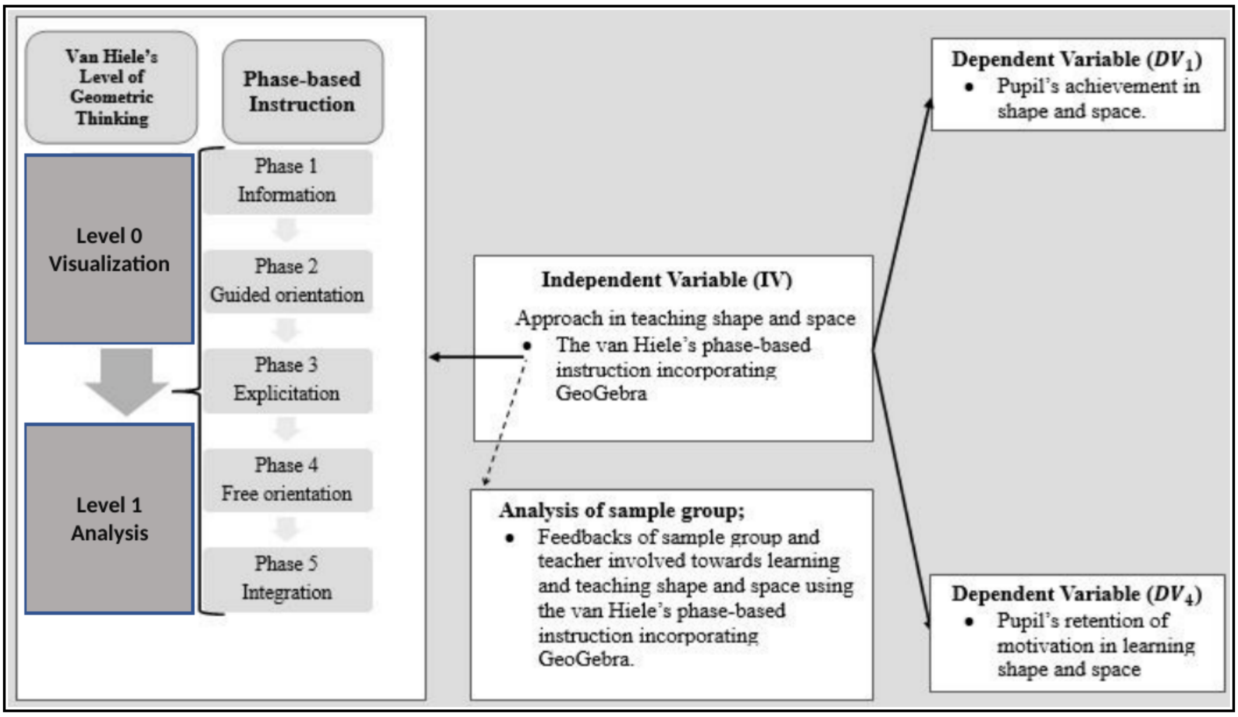


**Figure 6.** Conceptual framework of the study.

### *3.4 Population and Sample*

The population consisting of Dual Language Program (DLP) schools in Northern Peninsular of Malaysia. The accessible population is Year Two primary school pupils in Penang, Malaysia. A class of Year Two pupils consists of 14 boys and 16 girls in selected school has undergone treatment. The sample chosen has learned mathematics by using English as a second language in Dual Language Program.

**Figure 7.** Study participants using GeoGebra in Malaysian classrooms.

### *3.5 Instrument: Shape and Space Achievement Test (SSAT)*

SSAT was developed by the researcher based on the Year Two Mathematics Curriculum Standard (Curriculum Development Centre, 2016). SSAT consists of 20 items that have been given to the sample group. The items have been used for all pretest, post-test, and delayed-post-tests. Still, the test items' sequence is rearranged so that the post-test is different from the pretest. The pretest has been given before the implementation of the intervention. In contrast, the post-test has been shown to the pupils after the implementation of the intervention. The delayed-post-test has been administrated four weeks after the post-test.

### *3.6 Validity and Reliability of SSAT*

SSAT has been validated by two experienced teachers from Seberang Jaya Primary School. Those experience teachers have been teaching for more than 10 years, marked Ujian Penilaian Sekolah Rendah (UPSR) for Mathematics paper and university graduated with a degree in the related field. During this process, those two teachers have read and discussed certain things that need to be adjusted and improved with the researcher. Later then, those instruments have been enhanced based on the suggestions provided by the teachers.

The pilot test has been carried out to test the reliability of SSAT. From the data gathered through the pilot test, Cronbach's alpha for SSAT has been determined. Cronbach's alpha is a measurement of internal consistency that shows how closely related a set of items are as a group (Santos, 1999).

| Cronbach's Alpha | N of items |
|---|---|
| 0.656 | 20 |

**Table 5.** Reliability test result for SSAT from SPSS 25.0

The alpha coefficient value ranges from $0$ to $1$, where the higher the score, the more reliable the generated scale is. If the reliability coefficient (Cronbach's alpha) of one instrument is more than $0.75$, it is more reliable. The test-takers performances are consistent and stable. This number indicates that the instrument is suitable for measuring pupils' achievement in learning shape and space. However, the Cronbach's Alpha coefficient value for this reliability test is just $0.66$, which is below $0.75$, though, this value is acceptable.

### *3.7 Data Analysis*

## 4 RESULTS

***Pupil's achievement and retention of achievement of learning nets of 3-D shapes through van Hiele's phase-based instruction incorporating GeoGebra***

The one-sample Kolmogorov-Smirnov test for normality was used to determine whether a sample comes from a normally distributed population. Table 7 below shows the one-sample Kolmogorov-Smirnov test for normality of the SSAT pretest scores for the sample. The result of the test indicates that the SSAT pretest scores are normally distributed.

| **Research Questions** | **Data** | **Data Analysis** |
|---|---|---|
| Is there a significant effect of teaching incorporating GeoGebra on Year 2 DLP pupils' achievement in learning nets of 3-D shapes? | Data collected from the SSAT pretest and the post-test. | Paired Samples t-test. (The Wilcoxon Signed Rank Test was carried out for the SSAT pretest and post-test of the sample group to determine any outliers that appear far away from most of the data). |
| Is there a significant effect of teaching using the van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' retention of achievement in learning nets of 3-D shapes? | Data collected from the SSAT posttest and delayed-post-test. | Paired Samples t-test (The Wilcoxon Signed Rank Test was carried out for the SSAT posttest and delayed-post-test of the sample group to determine any outliers that appear far away from most of the data). |
| What is Year 2 pupils' feedbacks of learning nets of 3-D shapes using the van Hiele's phase-based instruction incorporating GeoGebra. | Data collected from interview protocol from pupils in the sample group. | Pupils' responses from interview protocol (Qualitative analysis) |

**Table 6.** Data analysis of each of the research questions involved in this study.

| **SSAT Prestest** | **Statistic** |
|---|---|
| Absolute | 0.135 |
| Positive | 0.135 |
| Negative | -0.103 |
| Test statistic | 0.135 |
| Asymp. Sig. (2-tailed) | 0.169 |

**Table 7.** One-Sample Kolmogorov-Smirnov Test for Normality of SSAT Pretest

The paired samples t-test was used in analyzing the data collected to determine whether there is a significant effect of the van Hiele's phase-based instruction mediated through GeoGebra on Year Two pupils' achievement in learning nets of 3-D shapes. The paired sample t-test has four main assumptions (Wilcoxon et al., 1963).

1. The dependent variable must be continuous (interval/ratio).
2. The observations are independent of one another.
3. The dependent variable should be approximately normally distributed.
4. The dependent variable should not contain any outliers.

For this study, Assumptions 1. and 2. have been fulfilled since the dependent variable is already continuous (since scores are continuous data) and observations are independent of one another. A one-sample Kolmogorov-Smirnov test for normality was carried out for the SSAT posttest of the sample group to fulfill Assumption 3.. Table 8 shows the results.

| SSAT Prestest | Statistic |
|---|---|
| Absolute | 0.125 |
| Positive | 0.125 |
| Negative | -0.073 |
| Test statistic | 0.125 |
| Asymp. Sig. (2-tailed) | 0.200 |

**Table 8.** One-Sample Kolmogorov-Smirnov Test for Normality of SSAT posttest.

One-sample Kolmogorov-Smirnov test indicates that the SSAT posttest scores for the sample follow a normal distribution, $p = 0.20 > .05$, thus the variable is normally distributed. To fulfill assumption 4., the Wilcoxon Signed Rank Test was carried out for the SSAT posttest of the sample group to determine any outliers that appear far away from most of the data. Outliers can bias the results and potentially lead to incorrect conclusions if not appropriately handled. Table 9 shows these results.

| Prestest - Posttest | N |
|---|---|
| Negative Ranks | 3 |
| Positive Ranks | 16 |
| Ties | 1 |
| Total | 20 |

**Table 9.** The Wilcoxon Signed-Rank Test of SSAT pretest - posttest.

Table 9 provides some interesting data comparing pretest and posttest scores where three pupils had a higher pretest score after the treatment. However, 16 pupils had a higher posttest score after the treatment, and one pupil showed no change in the SSAT score. Thus, there are not many outliers that appear far away from most of the data.

### *Results of First Null Hypothesis*

$H_0$: There is no significant teaching effect using van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' achievement in learning nets of 3-D shapes. Since all four assumptions have been fulfilled in the Wilcoxon Signed Rank Test, the paired samples t-test was carried out to determine whether there is a significant effect of teaching integrating GeoGebra on Year 2 pupils' achievement in learning shape and space. The result is shown in Table 10.

| Mean | SD | SE | Lower | Upper | t | df | p-value |
|---|---|---|---|---|---|---|---|
| -2.200 | 3.397 | .760 | -3.790 | -.610 | -2.897 | 20 | .009 |

**Table 10.** Paired Samples two-tailed t-test on the SSAT Pretest - Posttest Scores for the sample group.

Based on Table 10, a paired-samples t-test was conducted to compare pretest and posttest scores of the sample group. There was a significant difference in the scores for pretest (M=12.50, SD=3.09) and posttest ($M = 14.70$, $SD = 2.47$) conditions; $t(20) = -2.90$, $p = 0.01$. Thus, the null hypothesis was rejected. This result suggests that van-Hiele's phase-based instruction incorporating GeoGebra influences Year 2 DLP pupils' achievement in learning nets of 3-D shapes.

***Results for Second Null Hypothesis***

$H_0$: There is no significant teaching effect using van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' retention of achievement in learning nets of 3-D shapes.
Since all four assumptions have been fulfilled in the Wilcoxon Signed Rank Test, the paired samples t-test was carried out to determine whether there is a significant difference in retention of achievement in learning nets of 3-D shapes on Year 2 pupils who learned the topic through van Hiele's phase-based instruction incorporating GeoGebra. The result is shown in Table 12.

| Mean | SD | SE | Lower | Upper | t | df | p-value |
|---|---|---|---|---|---|---|---|
| -1.800 | 3.443 | .770 | -3.411 | -.189 | -2.338 | 20 | .030 |

**Table 11.** Paired Samples t-test on the SSAT Posttest - Delayed-post-test Scores for the sample group.

A paired-samples t-test was conducted to compare posttest and delayed-post-test scores of the sample group. There was a significant difference in the scores for posttest (M=14.70, SD=2.47) and delayed-post-test (M=16.50, SD=2.01) conditions; t (20) = -2.34, p = 0.03. Thus, the null hypothesis was rejected. This result suggests a significant difference in retention of achievement in learning nets of 3-D shapes on Year 2 DLP pupils who learned the topic through van Hiele's phase-based instruction incorporating GeoGebra. Pupil's feedback of learning nets of 3-D shapes through van Hiele's phase-based instruction incorporating GeoGebra.

Qualitative data were collected to analyze each of the pupils' feedback through interview protocol for the sample group. Pupils are being asked five questions during interview protocol. Pupils had been taught using van Hiele's phase-based instruction incorporating GeoGebra. Five questions have been developed to elicit a detailed description of pupil's feedback of their experiences learning through van Hiele's phase-based instruction integrating GeoGebra. Since there are 30 pupils in the sample group, quite some time is needed to gather pupil's feedback. Thus, only nine pupils have been interviewed by the researcher. Three pupils from the high-performance group, three pupils from the moderate performance group, and three pupils from the low-performance group.

For those who have been interviewed, the researcher has carried out face-to-face, semi-structured audiotaped interviews (average two minutes) with them. The interview has been conducted in the staff room where pupils being called one by one. The researcher then transcribed verbatim, noting important information in answering the third research question. The researcher read and coded transcripts using latent content analysis and constant comparison (Glaser & Strauss, 1967). Data collected regarding pupils' feedback about van Hiele's phase-based instruction incorporating GeoGebra are as follows.

| Group | Respondents | Feedback |
|---|---|---|
| High-performance | Pupil 1 | Yes |
| | Pupil 2 | Yes |
| | Pupil 3 | Yes |
| Moderate-performance | Pupil 4 | Yes |
| | Pupil 5 | Yes |
| | Pupil 6 | Yes |
| Low-performance | Pupil 7 | Yes |
| | Pupil 8 | Yes |
| | Pupil 9 | Yes |

**Table 12.** Item 1: Do you understand the topic of nets of 3-D shapes by incorporating GeoGebra?

Table 12 shows transcribed feedback gathered from nine pupils whom the researcher has interviewed. From Table 13, it is shown that all performance groups agreed that they understand nets of 3-D shapes by incorporating GeoGebra. It can be said that GeoGebra can help all groups to understand the topic of shape and space by incorporating GeoGebra without having language difficulties even though the lesson was being conducted in dual language. As for low-performance pupils, the Malay language is also being used interchangeably to cater to pupils' needs as they enrolled in DLP.

| Group | Respondents | Feedback |
|---|---|---|
| High-performance | Pupil 1 | Yes |
| | Pupil 2 | Yes |
| | Pupil 3 | Yes |
| Moderate-performance | Pupil 4 | Yes |
| | Pupil 5 | Yes |
| | Pupil 6 | Yes |
| Low-performance | Pupil 7 | Yes |
| | Pupil 8 | Yes |
| | Pupil 9 | Yes |

**Table 13.** Item 2: Do you want to learn more on the topic nets of 3-D shapes incorporating GeoGebra?

Table 13 shows transcribed feedback gathered from nine pupils who have been interviewed by the researcher. From Table 13, it is shown that all performance groups agreed that they wanted to learn more on nets of 3-D shapes incorporating GeoGebra. This collected data shows that GeoGebra can motivate pupils regardless of their performance to learn more on the topic of nets of 3-D shapes.

| Group | Respondents | Feedback |
|---|---|---|
| High-performance | Pupil 1 | Yes |
| | Pupil 2 | Yes |
| | Pupil 3 | Yes |
| Moderate-performance | Pupil 4 | No |
| | Pupil 5 | Yes |
| | Pupil 6 | Yes |
| Low-performance | Pupil 7 | No |
| | Pupil 8 | No |
| | Pupil 9 | No |

**Table 15.** Item 4: Is learning using GeoGebra can remove your fear towards this topic?

| Group | Respondents | Feedback |
|---|---|---|
| High-performance | Pupil 1 | Is easier to learn 3D-nets. |
| | Pupil 2 | Easier using GeoGebra |
| | Pupil 3 | I like to learn 3D-shapes |
| Moderate-performance | Pupil 4 | Easy to learn 3D-nets |
| | Pupil 5 | Easy to learn 3D shape |
| | Pupil 6 | I like to learn 3D-shape |
| Low-performance | Pupil 7 | Easy to learn 3D-net |
| | Pupil 8 | Easier to learn 3D nets |
| | Pupil 9 | It's easy to learn the net |

**Table 14.** Item 3: What do you like about learning 3-D shapes using GeoGebra?

Table 14 shows transcribed feedback gathered from nine pupils whom the researcher has interviewed. Table 15 shows that all performance groups agreed that they were affected positively using GeoGebra in learning various topics of shape and space, such as understanding the characteristic of 3D shapes and learning the 3D-shape nets. For the high-performance group, pupils stated that GeoGebra eases their difficulty in learning 3D-shapes and 3D-nets. In contrast, one of the pupils responded that the pupil likes to learn 3D-shapes because of GeoGebra. This shows that GeoGebra can motivate pupils to learn 3-D shapes. For the moderate performance group, their feedback is the same as pupils of the high-performance group. For the low-performance group, all three pupils responded that GeoGebra makes them easier to learn 3D-nets.

Table 15 shows transcribed feedback gathered from nine pupils whom the researcher has interviewed. Table 16 shows that feedback from three performance groups regarding learning shape and space incorporating GeoGebra can remove your fear towards this were divided. For the high-performance group, all pupils agreed that GeoGebra could remove their fear towards this topic. It can be said that GeoGebra can motivate pupils from the high-performance group to discard fear of learning of this topic. As for the moderate performance group, the feedback was divided. One pupil does not agree that GeoGebra can remove their fear towards this topic. In contrast, two pupils agree that GeoGebra can remove their fear. Thus, whether GeoGebra can remove the fear of learning the subject of shape

| Group | Respondents | Feedback |
|---|---|---|
| High-performance | Pupil 1 | Yes |
| | Pupil 2 | Yes |
| | Pupil 3 | Yes |
| Moderate-performance | Pupil 4 | No |
| | Pupil 5 | Yes |
| | Pupil 6 | Yes |
| Low-performance | Pupil 7 | Yes |
| | Pupil 8 | Yes |
| | Pupil 9 | No |

**Table 16.** Item 5: By using GeoGebra, do you think you can learn the topic of nets of 3-D shapes by yourself at anytime and anywhere?

and space for moderate performance pupils is divided. For low-performance groups, all three pupils agreed that GeoGebra does not remove their fear of learning the topic of shape and space. Thus, conclude that GeoGebra cannot motivate pupils from the low-performance group to discard fear of learning nets of 3-D shapes.

Table 16 shows transcribed feedback gathered from nine pupils who have been interviewed by the researcher. Table 16 demonstrates that eight pupils agreed that by incorporating GeoGebra, pupils can learn nets of 3-D shapes by themselves at any time and anywhere. In contrast, one pupil from a low-performance group disagrees that by incorporating GeoGebra, the pupil can learn nets of 3-D shapes by themselves at any time and anywhere.

## 5 Discussion and Conclusion

This study investigated the effects of teaching using van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupil's achievement and feedbacks in learning nets of 3-D shapes. Hypotheses 1 and 2 were supported. There was a significant effect of teaching van Hiele's phase-based instruction incorporating GeoGebra on Year 2 DLP pupils' achievement and retention of learning nets of 3-D shapes. Following (Hamaludin and Rosli, 2019), DLL achieves better than non-DLL, noting that learning Mathematics other than students' native language negatively impacts their mathematics achievement. The results indicate that the use of GeoGebra in teaching mathematics can help students to enhance their achievement in learning Mathematics. (Arbain and Shukor, 2015; Dayi, 2015; Em and Roman, 2020; Lee, 2011; Masri et al., 2017; Shadaan and Leong, 2013; Seloraji and Eu, 2017). In specific highlight, this result suggests similar findings with Mihailova et al. (2014).

Year 2 DLP feedbacks regarding this instruction were divided into some items. All performance groups agreed that they understand nets of 3-D shapes by incorporating GeoGebra without having language difficulties, even though the lesson was being conducted in dual language, in coherence with Aunio et al. (2019). All performance groups also agreed that they wanted to learn more on nets of 3-D shapes incorporating GeoGebra. This underpinning data shows that GeoGebra can motivate pupils, regardless of their performance, to learn more on nets of 3-D shapes to learn mathematics (Kusuma and Utami, 2017; Wah, 2015).

On the contrary, the use of GeoGebra to remove students' fear towards this topic is divided. GeoGebra can motivate pupils from high-performance groups to discard the fear of learning about this topic. As for the moderate performance group, the feedbacks were divided. One pupil does not agree that GeoGebra can remove their fear towards this topic. In contrast, two pupils agree that GeoGebra can remove their fear towards this topic. Thus, whether GeoGebra can remove the fear of learning the topic of shape and space for moderate performance pupils is divided. For the low-performance group, all three pupils agreed that GeoGebra does not remove their fear of learning the topic of shape and space. Thus, highlighting that low-performing students are having problems due to language issues indicating Méndez et al. (2019) study that word knowledge is vital to facilitating children's understanding of early numeracy concepts presented in the same language.

### *5.1 The implication of the study*

The findings provide important information to the stakeholders such as teachers or educators, curriculum specialists, and the Ministry of Education on the effectiveness of van Hiele's phase-based instruction incorporating GeoGebra and how Dual language Program pupils are responding to this type of pedagogy. The findings showed a significant effect of van Hiele's phase-based education integrating GeoGebra on Year Two DLP pupil's achievement and retention of learning geometry achievement.

Moreover, the findings showed that van Hiele's phase-based instruction incorporating GeoGebra is one approach for teaching and learning the topic of geometry in school. It could help pupils to understand better the nets of 3-D shapes and their conceptual knowledge.

Teachers should try various approaches to find the best method to improve pupils' geometry conceptual understanding, especially in learning nets of 3-D shapes. The van Hiele's phase-based instruction incorporating GeoGebra is an alternative option for the teachers to implement such pedagogy to apply on nets of 3-D shapes during the teaching and learning process.

The findings of this study can help curriculum specialists consider the integration of van Hiele's phase-based instruction incorporating GeoGebra in the development of the Mathematics curriculum. They can develop well-planned lesson plans and well-designed activities incorporating van Hiele's phase instruction integrating GeoGebra for teachers' guidebook. The Ministry of Education could organize seminars and workshops to understand better teaching geometry incorporating van Hiele's phase-based instruction incorporating GeoGebra.

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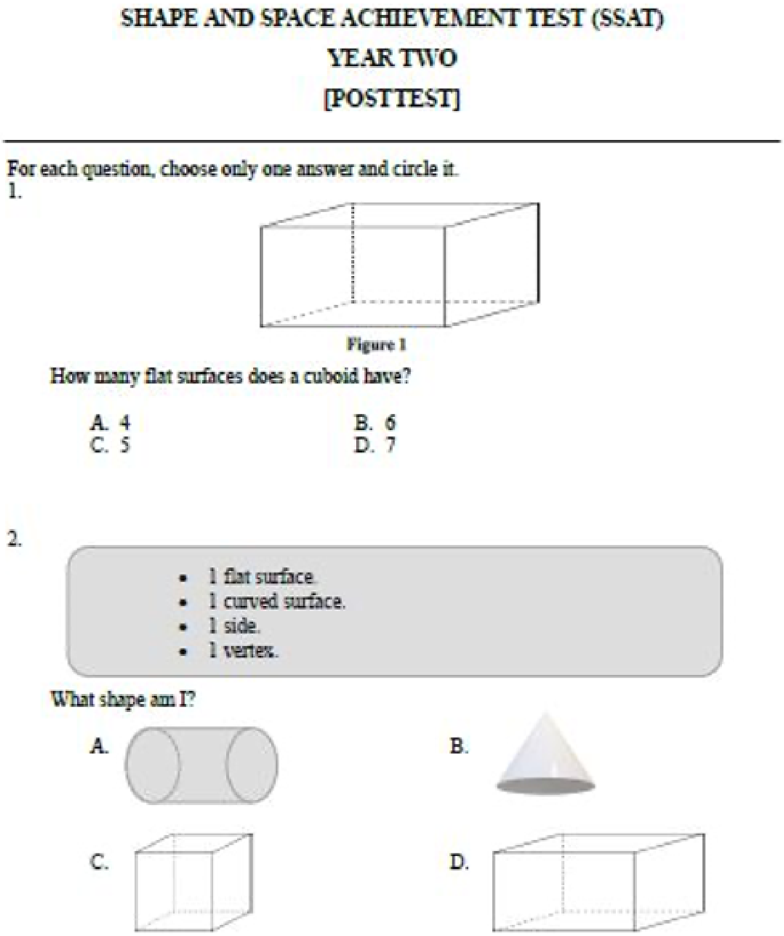
## APPENDIX



SHAPE AND SPACE ACHIEVEMENT TEST (SSAT)
YEAR TWO
[POSTTEST]

For each question, choose only one answer and circle it.

1.

Figure 1

How many flat surfaces does a cuboid have?

A. 4　　B. 6
C. 5　　D. 7

2.

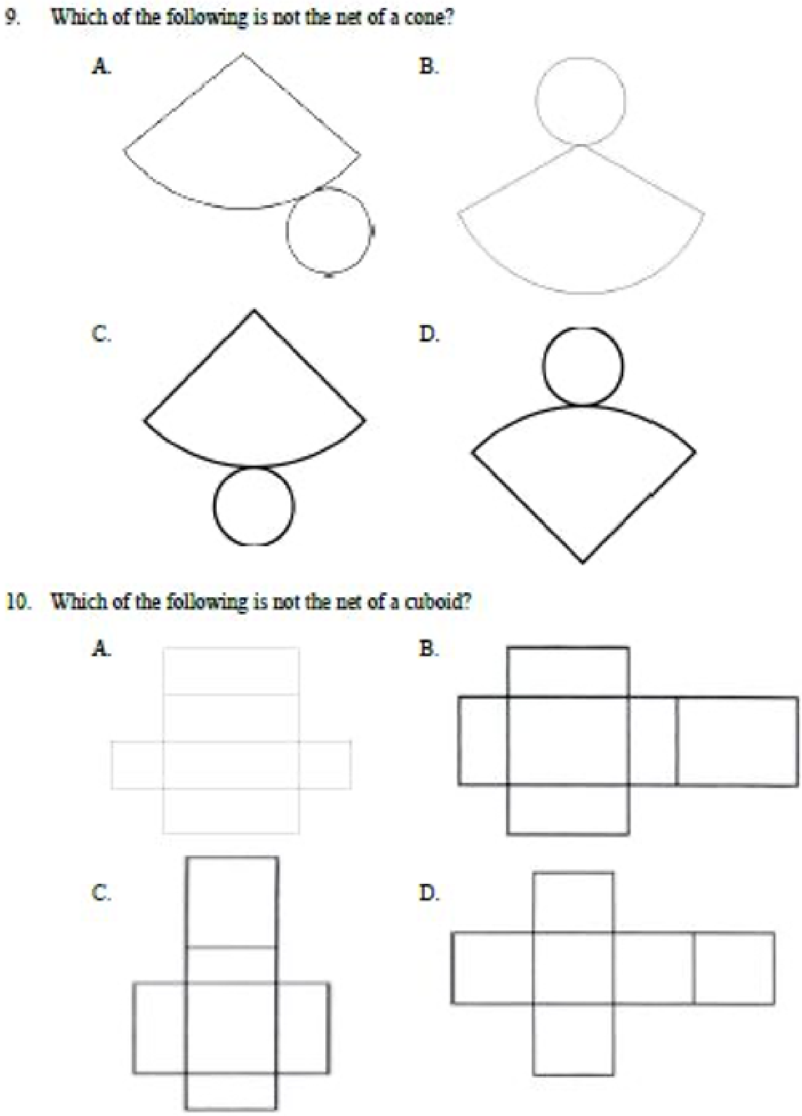
- 1 flat surface.
- 1 curved surface.
- 1 side.
- 1 vertex.

What shape am I?

A.　　B.

C.　　D.

**Figure 8.** Post Test Page 1


9. Which of the following is not the net of a cone?

A. B.

C. D.

10. Which of the following is not the net of a cuboid?

A. B.

C. D.

**Figure 9.** Post Test Page 4

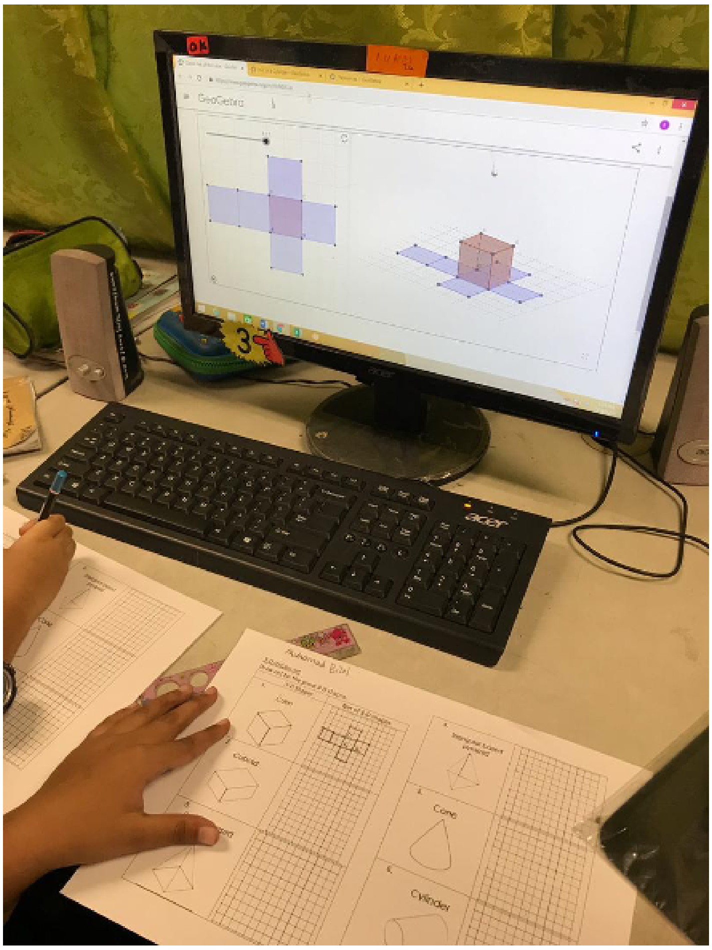


**Figure 10.** Pupils used GeoGebra to draw the nets of the 3-D shapes.

**TEST SPECIFICATION TABLE FOR**
**YEAR TWO SHAPE AND SPACE ACHIEVMENT TEST**

| No. | Learning Objectives | Learning Standard | Thinking Skill | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Remembering | | | Understanding | | | Applying | | | Analyzing | | | Evaluating | | | Creating | | |
| | | | Item's Level of Difficulty | | | | | | | | | | | | | | | | | |
| | | | E | M | D | E | M | D | E | M | D | E | M | D | E | M | D | E | M | D |
| 1. | 13.1 Identify Three Dimensional Shapes | 13.1 (i) Identify three-dimensional shapes based on descriptions. | 1 | | | | | | | | | | | | | | | | | |
| 2. | | | | 1 | | | | | | | | | | | | | | | | |
| 3. | | | | | | 1 | | | | | | | | | | | | | | |
| 4. | | | | | | | | | 1 | | | | | | | | | | | |
| 5. | | 13.1 (ii) Identify basic shapes of three-dimensional shapes. | | | | 1 | | | | | | | | | | | | | | |
| 6. | | | | | | | 1 | | | | | | | | | | | | | |
| 7. | | | | | | | | 1 | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | 1 | | | | | | | |

**Figure 11.** Rubric: Items 1 - 8

**TEST SPECIFICATION TABLE FOR**
**YEAR TWO SHAPE AND SPACE ACHIEVMENT TEST**

| No. | Learning Objectives | Learning Standard | Thinking Skill | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Remembering | | | Understanding | | | Applying | | | Analyzing | | | Evaluating | | | Creating | | |
| | | | Item's Level of Difficulty | | | | | | | | | | | | | | | | | |
| | | | E | M | D | E | M | D | E | M | D | E | M | D | E | M | D | E | M | D |
| 1. | 13.1 Identify Three Dimensional Shapes | 13.1 (i) Identify three-dimensional shapes based on descriptions. | 1 | | | | | | | | | | | | | | | | | |
| 2. | | | | 1 | | | | | | | | | | | | | | | | |
| 3. | | | | | | 1 | | | | | | | | | | | | | | |
| 4. | | | | | | | | | 1 | | | | | | | | | | | |
| 5. | | 13.1 (ii) Identify basic shapes of three-dimensional shapes. | | | | 1 | | | | | | | | | | | | | | |
| 6. | | | | | | | 1 | | | | | | | | | | | | | |
| 7. | | | | | | | | 1 | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | 1 | | | | | | | |

**Figure 12.** Rubric: Items 9 - 20