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Analysis of Weaknesses Among Second-Grade Primary School Pupils on Learning Geometry Topic

Mohamad Basri Nadzeri[1], Muzirah Musa[1*], Chew Cheng Meng[1], Irwan Mahazir Ismail[2]

[1]School of Educational Studies,
Universiti Sains Malaysia, 11800, Penang, MALAYSIA

[2]Centre for Instructional Technology and Multimedia,
Universiti Sains Malaysia 11800, Penang, MALAYSIA

*Corresponding Author

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Abstract: The aim of this study is to analyze the weaknesses among second-grade primary school pupils in learning Geometry. According to the Mathematics Standard-Based Curriculum for Primary School, the Geometry topic comprises three content standards which are three-dimensional shapes, two-dimensional shapes and problem-solving. Previous studies have found that pupils have difficulties in learning geometry and lack basic skills in mathematics. Therefore, a questionnaire was developed and administered to 220 primary schools in Kerian District. The data were supported by interviews with three primary mathematics teachers. The questionnaire data were analyzed using the Statistical Package for Social Sciences and the results of the interviews were analyzed using ATLAS.ti. The findings showed that second-grade pupils in primary schools have weaknesses, particularly when it comes to grasping the concept of three-dimensional shapes. This study is expected to assist teachers in developing and providing pupils with relevant teaching and learning resources to enhance their understanding of geometry.

Keywords: Weaknesses, second-grade primary school pupils, learning geometry, primary school

1. Introduction

Mathematics education is a field of knowledge based on concepts, facts, properties, rules, patterns, and processes. In this light, Mathematics generally emphasizes conceptual and practical understanding (Hiebert et al., 2017). Pupils must have a clear understanding of concepts and practices in their learning. Therefore, to ensure that pupils comprehend the content and to encourage them to use critical thinking skills, teachers must carefully plan the learning activities and use various learning strategies (Abramovich, S. et al., 2018). However, some pupils have trouble learning mathematics, as evidenced by pupils' low test scores. These scores reflect their inability to comprehend some mathematics subjects, notably Geometry (Ismail et al., 2020).

Geometry is one of the topics in mathematics. According to a report by the National Council of Teachers of Mathematics in the United States (NCTM, 2000), geometry learning is a crucial and integrated component of the mathematics curriculum. It is related to the study of two-dimensional (2D) and three-dimensional (3D) shapes as well as their descriptions (Aktaş & Aktaş, 2012; Prabowo et al., 2017; Hamdi, 2018). In addition, an understanding of geometry concepts should be developed in geometry learning because it is one of the basic skills pupils need to master in mathematics (Özerem, 2012). Therefore, the Ministry of Education Malaysia (MOE) has developed the Mathematics Standard Document for Curriculum and Assessment (DSKP) for teachers to ensure that mathematics is taught properly in schools. The DSKP's curriculum structure places special emphasis on the four different learning areas (i) Numbers

*Corresponding author: muzirah@usm.my

and Operations, (ii) Measurement and Geometry, (iii) Relation and Algebra, and (iv) Statistics and Probability. In Malaysia, Geometry is the final topic that primary school pupils will learn in the primary school syllabus.

Geometry is one of the concepts that should be mastered by primary school pupils, as 40% of the secondary school syllabus is based on Geometry (Mohd Salleh Abu et al., 2012). In addition, he stated that students in primary school need a deep conceptual understanding of geometry and should be able to visualize geometric features. Therefore, it is an important topic that teachers must focus on to ensure pupils can master and acquire higher-level skills, especially in secondary school. Geometry is introduced in teaching and learning mathematics in primary school as early as the first grade. The first and second-grade pupils are introduced to the three main content standards: (i) 3D shapes, (ii) 2D shapes, and (iii) problem-solving. They also need to learn six basic 3D shapes: cubes, cuboids, pyramids, cones, cylinders, and spheres and four types of basic 2D shapes: squares, rectangles, triangles, and circles. The Malaysian primary school learning standard emphasizes the importance of basic knowledge, including recognizing 3D and 2D shapes, namely naming shapes, identifying shapes, identifying shape characteristics, comparing 2D and 3D shapes and arranging the shapes based on patterns, identifying nets of 3D shapes, drawing basic 2D shapes and problem-solving involving daily situations (Ministry of Education Malaysia, 2017a). According to Khaliza A. Wahid and Norazrena Abu Samah (2020), the initial phase of learning Geometry for first and second-grade pupils involves a basic introduction to 2D and 3D shapes. For second-grade pupils, the syllabus consists of three content standards and six learning standards they must master in geometry. Table 1 shows second-grade Geometry's content and learning standards (MOE, 2016).

Table 1 - Content standard and learning standard of learning geometry for second-grade pupils

Content Standard	Learning Standard
Three-dimensional shapes (3D)	• Identify three-dimensional shapes based on descriptions • Identify basic shapes of three-dimensional shapes • Identify various nets of three-dimensional shapes
Two-dimensional shapes (2D)	• Identify two-dimensional shapes based on descriptions • Draw basic shapes of two-dimensional shapes
Problem Solving	• Solve problems involving daily life situations.

Source: MOE, 2016.

2. Problem Statement

Pupils' difficulties in mastering the basic skills in Mathematics have created misunderstandings regarding Geometry topics. It was found that most mistakes are from pupils' mistakes (Luneta & Makonye, 2010; Özerem, 2012). Therefore, serious attention should be given to rectifying pupils' misunderstandings and addressing the cause or type of errors committed by pupils while learning this topic.

Previous studies on pupils' misunderstanding of learning Geometry found four common difficulties faced by pupils, namely remembering the names of geometric shapes, understanding the descriptions of geometric shapes, identifying the actual shape of the geometry based on the net, and traditional learning in the classroom (Özerem, 2012; Mackle, 2016). Marchis (2012) also argued that pupils often face conflicts between the process of imagination and visualization of geometric shapes. Another factor influencing primary school students' understanding of geometric concepts is low visual skills (Berna, 2014; Gunčaga & Žilková, 2019). Besides that, the lack of visualization skills in identifying the net of 3D shapes and features of geometric shapes hinders pupils' mastery of this topic (Ibli et al., 2019).

A case study in Malaysia involving 40 second-grade primary school pupils found. Furthermore, pupils face multiple difficulties learning Geometry (Ismail et al., 2020). Six types of misconceptions led to difficulty factors faced by primary school pupils in Geometry are (1) Recognizing the types of 2D and 3D shapes, (2) Drawing 2D and 3D shapes, and (3) Calculating the number of sides of 2D and 3D shapes, (4) Identifying straight sides, curved sides and the number of surfaces of 2D and 3D shapes, (5) Drawing 3D shape nets, and (6) Combining 2D shapes into nets.

Past studies have shown that misconception is a major issue in students' Geometry mastery. Misconceptions in mathematics can be a serious problem because the error in the basic concepts can lead the pupil to make persistent errors and impact the pupil's learning outcomes (Sujarwo & Kurniawan, 2020). This calls for analyzing second-grade pupils' misconceptions in mathematics learning. As teachers are responsible for identifying and rectifying pupils' misconceptions, the present study aims to investigate the difficulties faced by pupils in learning Geometry. The results of this study will be useful to give feedback to the teacher in revitalizing the learning sources and activities to enhance the pupils' conceptual understanding of mathematics.

3. Methodology

The study used the mixed-method convergent parallel research design. In convergent parallel designs, quantitative and qualitative data are collected simultaneously but analyzed independently. The results are then combined for meaningful interpretation (Creswell & Clark, 2011). The qualitative data were collected through a semi-structured interview, while the quantitative data were collected through a questionnaire. Figure 1 illustrates the mixed-methods design model used in this study.

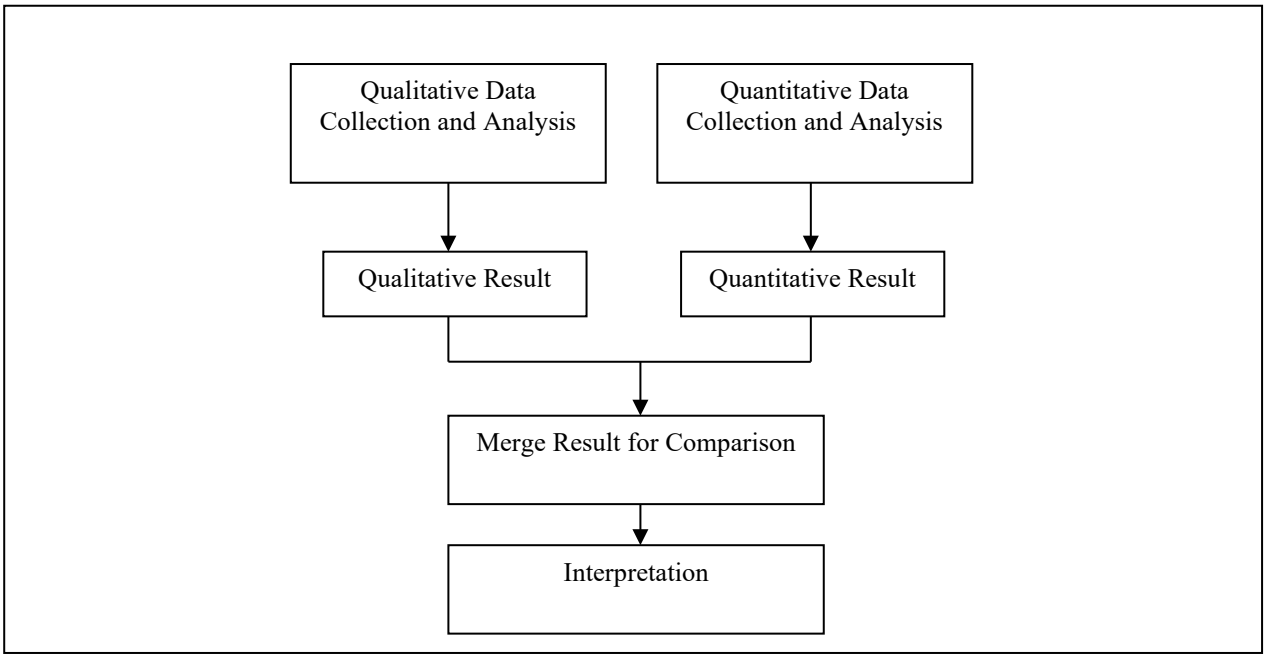

Fig. 1 - Diagram of the applied convergent parallel design (Creswell & Clark, 2011)

A semi-structured interview was subsequently conducted with three primary school teachers. The interviews were conducted to obtain rich data about the cause of misconceptions from the teachers. Informants with more than five years of teaching experience were selected to describe the weaknesses of second-grade pupils in learning Geometry (Berliner, 2014). The interview sessions were audio recorded and transcribed verbatim to facilitate the researcher to make further data analysis. The informants validated the interviews' transcripts before the analysis and were then classified and coded (Cohen et al., 2017).

The data about the pupils' misconceptions were gathered using a questionnaire adapted from Lee Abdullah and Wei (2017) and based on the year 2 mathematics learning standards (DSKP). Dichotomous items with 'yes' or 'no' were used where the respondents would choose one of the two options. The questionnaire consisted of 12 items and was validated by experts in Mathematics Education before it was used. The Cronbach's Alpha value for this questionnaire is 0.72. Based on the recommendation by Gay et al. (2012), the minimum value of Cronbach's Alpha coefficient must be above 0.7 so that the questionnaire will be reliable to be used in the research. The study sample comprised 220 second-grade pupils from a primary school in Kerian District. The data collected were then processed and analyzed descriptively using SPSS.

4. Research Findings and Discussions

4.1 Semi-Structured Interview

Three informants with more than five years of experience in mathematics education were selected for this study. The demographics of the informants are shown in Table 2.

Table 2 - Informants' demography

Informant	Teaching Experience	Expertise Field
A	7 years	Master Teacher
B	15 years	Master Teacher
C	25 years	STEM Coach

Based on Table 2, it was found that a total of three informants involved in this study's interviews are experts with experience in education for five years. All the informants interviewed are experts in specific areas, such as STEM coaches and master teachers. The interview transcripts were analyzed using ATLAS.ti software. The semi-structured interview protocol includes determining the number of interview questions and adding supplementary questions during the interview to obtain additional information from the researcher and informant (Gay & Airasian, 2000). The researcher ensured that teachers focus on important aspects such as language, special terms, and words that the respondents do not understand. These elements could affect the respondents' understanding of the items and their answers.

The results of the interviews indicated the pupils have weaknesses in learning Geometry. Informant A claimed that pupils face difficulties understanding the concept in 3D due to a lack of visual skills and limited teaching materials, especially in identifying various nets of 3D shapes.

> *"Pupils lack understanding in 3D basic concepts… when I ask to draw cube and cuboid without my guidance, they take a lot of time to think and draw".* (Informant A)

Besides that, informant B claimed that most pupils' misconception is caused by their misunderstanding of 3D shapes characteristics of, i.e., (1) Name of shapes, (2) Faces, (3) Edges, and (4) Vertices. Informant B also claims that lack of understanding of the basic concept of shape is the factor that led to the misunderstanding in learning Geometry.

> *"Pupils can remember the name of 2D shapes, but not 3D. To understand the characteristics of the shapes. They can't remember well, for example naming the shapes, explain the faces, edges, and vertices".* (Informant B)

In addition, informant B claimed that most pupils are still confused and cannot identify the 3D shapes according to the nets given.

> "*The biggest problem for them is that when I teach recognizing 3D nets shapes, for example, when giving the cuboid nets, they get confused recognizing the 3D shape according to the nets given".* (Informant B)

For informant C, most pupils have limited knowledge of shapes, especially in identifying the 2D and 3D shapes, like cubes and cuboids. The lack of basic knowledge among pupils may lead to problems in learning other Geometry subtopics.

> *"Basically, the pupils can't visualize the shapes without hands-on activity and guidance… it will affect pupils' performance and understanding of next subtopic in Geometry. When I ask what is the name of this shape? They said… box!".* (Informant C).

Figure 2 shows the weaknesses faced by second-grade pupils in learning geometry based on the teachers' perspectives.

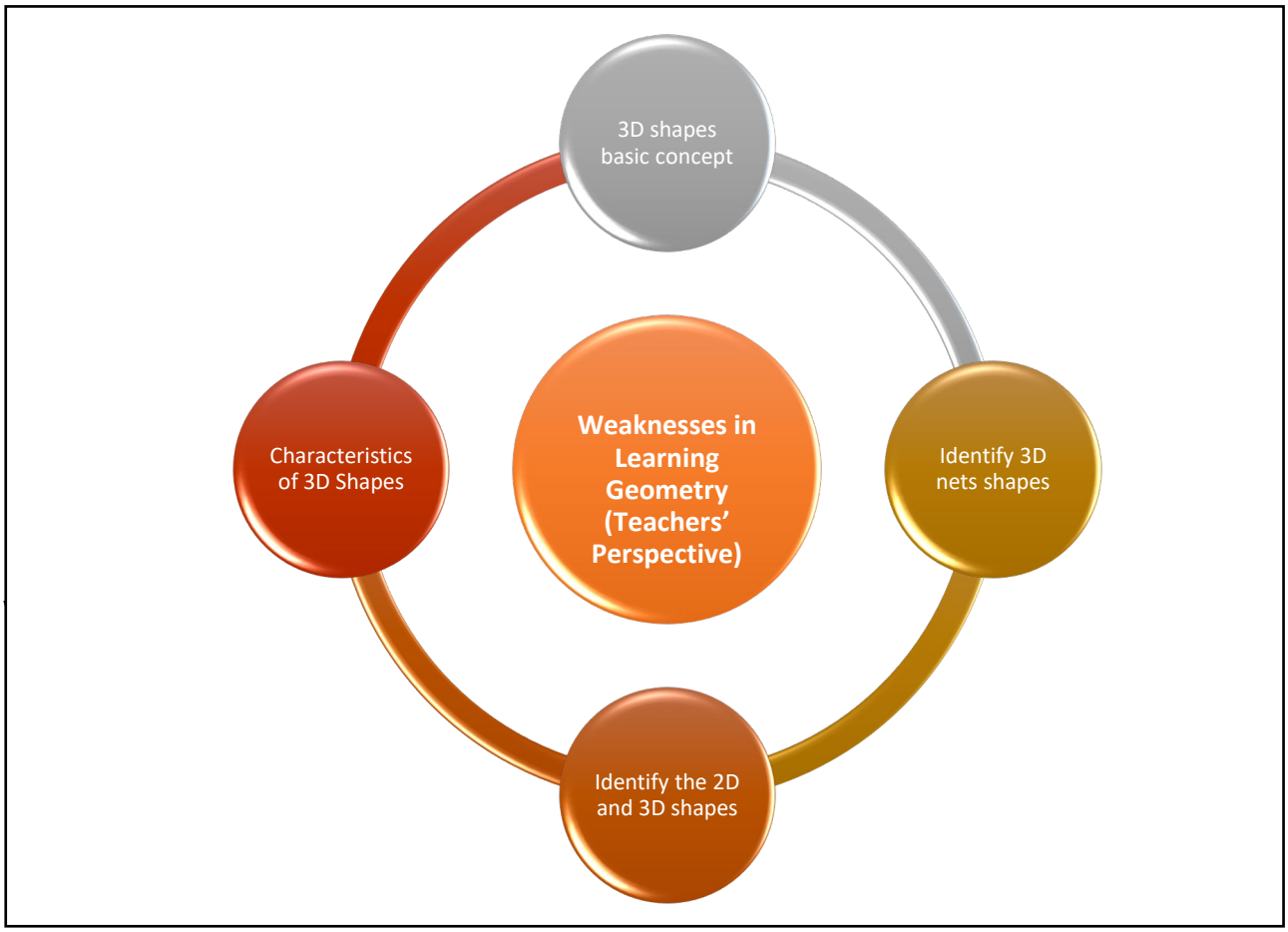

Fig. 2 - Weaknesses in learning geometry (teachers' perspective)

4.2 Questionnaire

Table 3 below shows the questionnaire analysis results on the respondents' demography, including gender, race, and type of school.

Table 3 - Respondents' demography

Item	Category	Frequency	Percentage (%)
Gender	Male	124	56.4
	Female	96	43.6
Race	Malay	207	94.1
	Chinese	9	4.1
	Indian	4	1.8
Categories of School	Urban	130	59.1
	Rural	90	40.9

As shown in table 3, 124 (56.4%) of the respondents are males, and 96 (43.6%) are females. Meanwhile, in terms of race, most of the respondents are Malays (207; 94.1%). 9 respondents are Chinese, 9 (4.1%), and 4 (1.8%) are Indians. The respondents' schools are divided into two categories; 130 respondents (59.1%) are from urban schools, and 90 (40.9%) are from rural schools. Next, Table 4 and Figure 2 show the weaknesses in learning Geometry based on the pupils' perspectives.

Table 4 - Weaknesses in Learning Geometry (Pupils' Perspective)

No	Item	Pupils' Responses			
		Yes	Percentage (%)	No	Percentage (%)
1	I feel that learning Geometry is difficult to understand	167	75.9	53	24.1
2	I find it difficult to draw two-dimensional (2D) shapes	157	71.4	63	28.6
3	I find it difficult to draw three-dimensional (3D) shapes	171	77.7	49	22.3
4	I find it difficult to remember the names of two-dimensional (2D) shapes	157	71.4	63	28.6
5	I find it difficult to remember the names of three-dimensional (3D) shapes	171	77.7	49	22.3
6	I find it difficult to remember the characteristics of two-dimensional (2D) shapes without guidance from the teacher	144	65.4	76	34.6
7	I find it difficult to remember the characteristics of two-dimensional (2D) shapes without guidance from my peers	177	80.4	43	19.6
8	I find it difficult to remember the characteristics of three-dimensional (3D) shapes without guidance from my teacher	170	77.3	50	22.7
9	I find it difficult to remember the characteristics of three-dimensional (3D) shapes without guidance from the peers	170	77.3	50	22.7
10	I find it difficult to draw three-dimensional (3D) shape nets if there is no example of a real object in front of me	185	84.1	35	15.9
11	I find it difficult to combine two-dimensional (2D) shapes into three-dimensional (3D) shapes	183	83.2	37	16.8
12	I find it difficult to solve problems under the Geometry topic	160	72.7	60	27.3

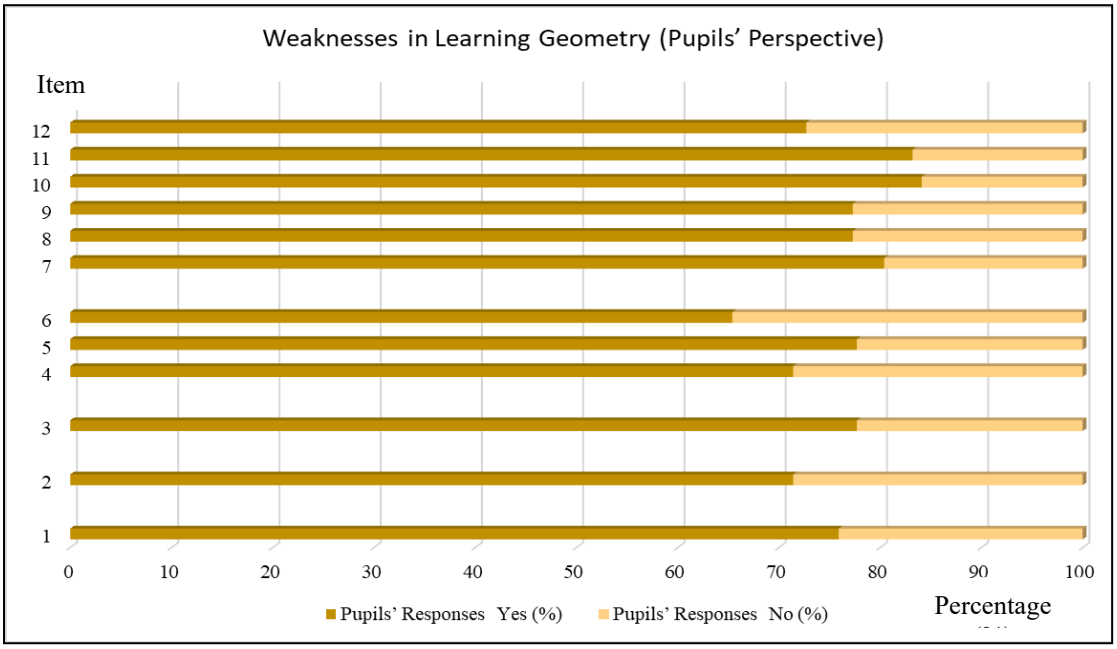

Fig. 3 - Weaknesses in learning geometry (pupils' perspective)

Based on the analysis results in table 4 and figure 3, out of 220 respondents, 167 (75.9%) find it difficult to understand Geometry Topics (item 8). Hence, more than half of the pupils face problems learning this topic. The greatest number of pupils (185; 84.1%) agreed that they have difficulties drawing 3D shape nets if real object examples are not given to them (item 10). This is followed by item 11, where 183 (83.2%) pupils agreed they face difficulties combining 2D shapes into 3D shapes. Findings from both items indicate that pupils' main problem in learning geometry is related to the nets of 3D shapes. Similar to the research conducted by Mackle (2016) and Özerem (2012), these findings clearly show that pupils often face problems in identifying the original geometric shape based on the presentation of problems.

On the other hand, the least number of pupils (144 pupils; 65.4%) agreed with item 6 that they have difficulties remembering the names of 2D shapes if there is no guidance from their teacher. This is followed by Items 2 and 4 where 71.4% agreed that they face difficulties drawing and remembering 2D shapes. These two items clearly show that most second-grade pupils have a clear and good understanding of 2D shapes compared to 3D shapes. Meanwhile, 177 pupils (80.4%) agreed with item 5, which states that students also had problems remembering the names of 3D shapes. This finding is supported by Mackle (2016) and Özerem (2012), who stated that one of the pupil's problems in learning this topic is remembering the names of geometric shapes.

In the meantime, a total of 170 pupils (77.3%) agreed with items 8 and 9, which state that pupils have problems remembering the characteristics of 3D shapes without guidance from friends and teachers. This shows that students need help and guidance when learning this topic to improve their understanding. According to Iva Sarifah and Endang (2019), a teacher needs to plan and design creative lessons to help pupils learn the objects contained in geometry. 160 pupils (72.7%) agreed on item 12, which indicates that they face difficulties in problem-solving especially involving long sentences. This shows that pupils have a limited understanding and skills in solving geometry problems. Table 5 shows the ranking of weaknesses faced by pupils in learning geometry from the highest to the lowest.

Table 5 - Weaknesses in learning geometry by ranking

Rank	Item	Percentage of Yes Response (%)
1	I find it difficult to draw three-dimensional (3D) shape nets if there is no example of a real object in front of me	84.1
2	I find it difficult to combine two-dimensional (2D) shapes into three-dimensional (3D) shapes	83.2
3	I find it difficult to remember the characteristics of two-dimensional (2D) shapes without guidance from my peers	80.4
4	I find it difficult to draw three-dimensional (3D) shapes	77.4
5	I find it difficult to remember the names of three-dimensional (3D) shapes	77.4
6	I find it difficult to remember the characteristics of three-dimensional (3D) shapes without guidance from my teacher	77.3
7	I find it difficult to remember the characteristics of three-dimensional (3D) shapes without guidance from the peers	77.3
8	I feel that learning Geometry is difficult to understand	75.9
9	I find it difficult to solve problems on Geometry topic	72.7
10	I find it difficult to draw two-dimensional (2D) shapes	71.4
11	I find it difficult to remember the names of two-dimensional (2D) shapes	71.4
12	I find it difficult to remember the characteristics of two-dimensional (2D) shapes without guidance from the teacher	65.4

4. Conclusion

Geometry learning requires in-depth knowledge among students. Thus, teachers must use a strong pedagogical approach to provide a fun learning environment (Hamdi, 2018). In this light, a teacher is responsible for guiding pupils during Geometry lessons to stimulate their thinking, solve problems and prevent misunderstanding of mathematical concepts during the learning process (Ibli et al., 2019). Misconceptions may be caused by the pupil's inability to master the required topic, insufficient reasoning skills, or misunderstanding of the basic concept. Teachers should use interactive and appropriate teaching aids suitable for pupils' cognitive level to improve their understanding of geometry.

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