Analysis of Misconceptions on Learning Geometry for Second-Grade Primary School Pupils

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Abstract: The aim of this study is to identify the weaknesses of second-grade primary school pupils in learning Geometry topic. Based on the Mathematics Standard-Based Curriculum for Primary School, the Geometry topic consists of three content standards which are three-dimensional shapes, two-dimensional shapes and problem solving. Numerous studies have found that pupils have difficulties in learning geometry and lack of basic skills in mathematics. Thus, to fulfil this aim, a questionnaire was developed and administered to 30 pupils of Kerian District Primary School and supported by interview with three primary school teachers. The questionnaire data were analysed using the Statistical Package for Social Sciences and the results of the interviews will be analysed using ATLAS.ti. The results of this study revealed that the second-grade primary school pupils have several misconceptions especially on understanding the concept of three-dimensional shapes. It is believed that this study will help teachers develop and provide appropriate teaching and learning aids for pupils to improve their geometry understanding.

Keywords: Misconceptions, Learning Geometry, Second-Grade Pupils, Primary School

1. Introduction

Mathematics education is a field of knowledge based on concepts, facts, properties, rules, patterns, and processes. In general, mathematics emphasizes conceptual and practical understanding (Hiebert et al., 2017). Therefore, a clear understanding of concepts needs to be mastered by pupils and practiced in their learning. Teachers need to plan the learning activities carefully as well as combining a variety of learning strategies that allow pupils to understand the content and stimulate high-level thinking skills. However, certain pupils face difficulties in learning Mathematics. The difficulty to understand specific mathematics topic notably in Geometry will affect the pupils' mark in their examination (Ismail et al., 2020).

Geometry is one of the topics of learning in mathematics. It is related to the study of two-dimensional (2D) and three-dimensional (3D) shapes as well as the descriptions of the shapes (Aktaş & Aktaş, 2012; Prabowo et al., 2017; Hamdi, 2018). In addition, understanding of geometry concepts should be developed in geometry learning among pupils because it is one of the basic skills that pupils need to achieve in mathematics (Özerem, 2012). Therefore, the Mathematics Standard Document for Curriculum and Assessment (DSKP) has been developed by the Ministry of Education Malaysia (MOE) for teachers to ensure that the teaching and learning of mathematics is carried out properly. It consists of three content standards and six learning standards that second-grade primary school pupils must grasp in the topic of geometry. Table 1 shows the content standard and learning standard of learning Geometry for second-grade pupils (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

The difficulties and misunderstandings that occur among pupils for the Geometry topic is the lack of basic skills in Mathematics where most of the mistakes made by them are from pupils' own mistakes (Luneta & Makonye, 2010; Özerem, 2012). Therefore, serious attention to pupils' misunderstandings should be taken by teachers other than addressing the cause or type of errors committed by pupils while learning this topic.

Based on the findings of previous studies on pupils' misunderstanding on learning Geometry states that four difficulties faced by pupils namely in remembering the names of geometric shapes, understanding the descriptions of geometric shapes, identify the actual shape of the geometry based on the net, and traditional learning in the classroom (Özerem, 2012; Mackle, 2016). Marchis (2012) also argues that pupils often face conflicts between the process of imagination and visualization of geometric shapes. Meanwhile, low visual skills were a major factor influencing the understanding of geometric concepts for pupils in primary schools (Berna, 2014; Gunčaga & Žilková, 2019). Besides that, the visualization skills on identify the net of 3D shapes and features of geometric shapes are very important skills in this topic (Ibli et al., 2019).

In addition, a case study in Malaysia on 40 second- grade primary school pupils found that there were six types of misconceptions that led to difficulty factors faced by primary school pupils in Geometry i.e. (1) Recognizing the types of 2D and 3D shapes, (2) Drawing 2D and 3D shapes, (3) Calculate the number of sides of 2D and 3D shapes, (4) Identify straight sides, curved sides and the number of surfaces of 2D and 3D shapes, (5) Draw 3D shape nets, and (6) Combine 2D shapes into nets. Furthermore, the study also found that there were multiple difficulties faced by pupils in learning Geometry (Ismail et al., 2020).

Based on the findings of past research, it is undeniable that misconception is a major issue. Misconceptions in mathematics can be a serious problem because the error of the basic concepts can lead the pupil to make persistent errors and will have an impact on pupil's learning outcomes (Sujarwo & Kurniawan, 2020). The misconceptions problem for second-grade pupils at primary school in mathematics learning needs to be analysed. Teachers are responsible for taking pupils' misconceptions seriously. Therefore, 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 in mathematics.

3. Research Objective

Specifically, the objective of this study is to identify the misconceptions or the weaknesses on learning geometry for second-grade primary school pupils based on the Mathematics Standard-Based Curriculum for Primary School.

4. Methodology

4.1 Research Design

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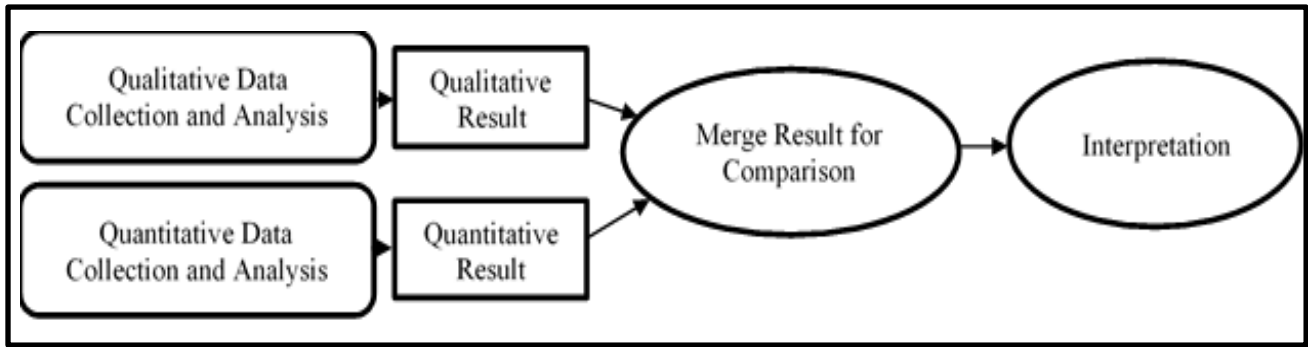
Figure 1: Diagram of the applied convergent parallel design (Creswell & Clark, 2011)

4.2 Semi-Structured Interview

A semi-structured interview was subsequently conducted to three primary school teachers. The informants who were in the field of education who have more than five years of teaching experience were selected to describe the misconceptions 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. Transcripts were also validated by all the informants in advance before being analysed, classified, and coded (Cohen et al., 2017). The interviews were conducted to deepen the cause of misconceptions reviewed by teachers.

4.3 Questionnaire

The misconception data were gathered from an adapted questionnaire by Lee Abdullah and Wei (2017), and it was based on the learning standard in DSKP. Dichotomous items with 'yes' or 'no' were used where the respondents would choose one of the two options given. The questionnaire consists of 13 items and was validated by experts in Mathematics Education before it was used. The Cronbach's Alpha value for this questionnaire is 0.893. 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 sample of the study comprised 30 second-grade pupils from a primary school in Kerian District. The data collected were then processed and analysed using SPSS descriptively.

5. Research Findings and Discussions

5.1 Semi-Structured Interview

A total of three informants who have more than five years of experience in mathematics education were selected in this study. The demographics of the informants are shown in Table 2.

Table 2: Informants' Demography

Item	Category	Frequency
Teaching Experience	5 – 10 years	1
	11 – 15 years	1
	16 – 20 years	0
	21 - 25 years	1
Expertise Field	STEM Coach	1
	Master Teacher	2

Based on Table 2, it was found that a total of three informants involved in the interviews of this study are experts who have experience in education for five years. All the informants who were interviewed had expertise in specific areas which is STEM coach and master teacher. According to the results of the interviews, it was found that there were misconceptions faced by the pupils. Informant 1 claims that the pupils had difficulties in understanding the concept in 3D due to lack of visual skills and limited teaching materials especially identify 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 lot of time to think and draw*". (Informant_1)

Besides that, informant 2 claims that the most misconception faced by pupils is understanding the characteristics of 3D shapes i.e. (1) Name of shapes, (2) Faces, (3) Edges, and (4) Vertices. Informant 2 also claims that lack of understanding 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 3-D. To understand the characteristics of the shapes, they can't remember well for example naming the shapes, explain the faces, edges and vertices*". (Informant_2)

For informant 3, most of the pupils had limited knowledge on shapes especially identify the 2-D and 3-D shapes mainly. Thus, the basic knowledge of pupils may lead to the problems in learning another subtopic in Geometry.

"*Basically, the pupils can't visualize the shapes without hands-on activity and guidance… it will affect pupils' performance and understanding next subtopic in Geometry. When I ask what is the name of this shape? They said… box!*". (Informant_3).

5.2 Questionnaire

The analysis for the questionnaire in Table 3 below is pertaining to the respondents' demography including gender and race.

Table 3: Respondents' Demography

Item	Category	Frequency	Percentage (%)
Gender	Male	19	63.3
	Female	11	36.7
	Total	30	100.0
Race	Malay	24	80.0
	Chinese	3	10.0
	Indian	3	10.0
	Total	30	100.0

According to Table 3, the distribution of genders shows that 63.3% of the respondents are males and 36.7% are females. As for race, the Malay respondents recorded the highest percentage of 80.0% while the Chinese and Indian respondents recorded 10.0%. Next, Table 4 and Figure 2 show the outcome of misconceptions in learning Geometry regarding the pupils' perspectives.

Table 4: Misconceptions in Geometry (Pupils' Perspective)

No	Item	Pupils' Responses (%)	
		Yes	No
1	I feel that learning Geometry is difficult to understand.	50.0	50.0
2	I feel that learning Geometry is boring.	43.3	56.7
3	I find it difficult to draw two-dimensional (2D) shapes.	43.3	56.7
4	I find it difficult to draw three- dimensional (3D) shapes.	63.3	37.7
5	I find it difficult to remember the names of two-dimensional (2D) shapes.	56.7	43.3
6	I find it difficult to remember the names of three-dimensional (3D) shapes.	73.3	26.7
7	I find it difficult to remember the characteristics of two-dimensional (2D) shapes without guidance from the teacher.	63.3	37.7
8	I find it difficult to remember the characteristics of two-dimensional (2D) shapes without guidance from my peers.	56.7	43.3

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9	I find it difficult to remember the characteristics of three-dimensional (3D) shapes without guidance from my teacher.	73.3	26.7
10	I find it difficult to remember the characteristics of three-dimensional (3D) shapes without guidance from the peers.	80.0	20.0
11	I find it difficult to draw three-dimensional (3D) shape nets if there is no example of a real object in front of me.	83.3	16.7
12	I find it difficult combining two-dimensional (2-D) shapes into three- dimensional (3D) shapes.	83.3	16.7
13	I find it difficult to solve problems in Geometry topic.	73.3	26.7
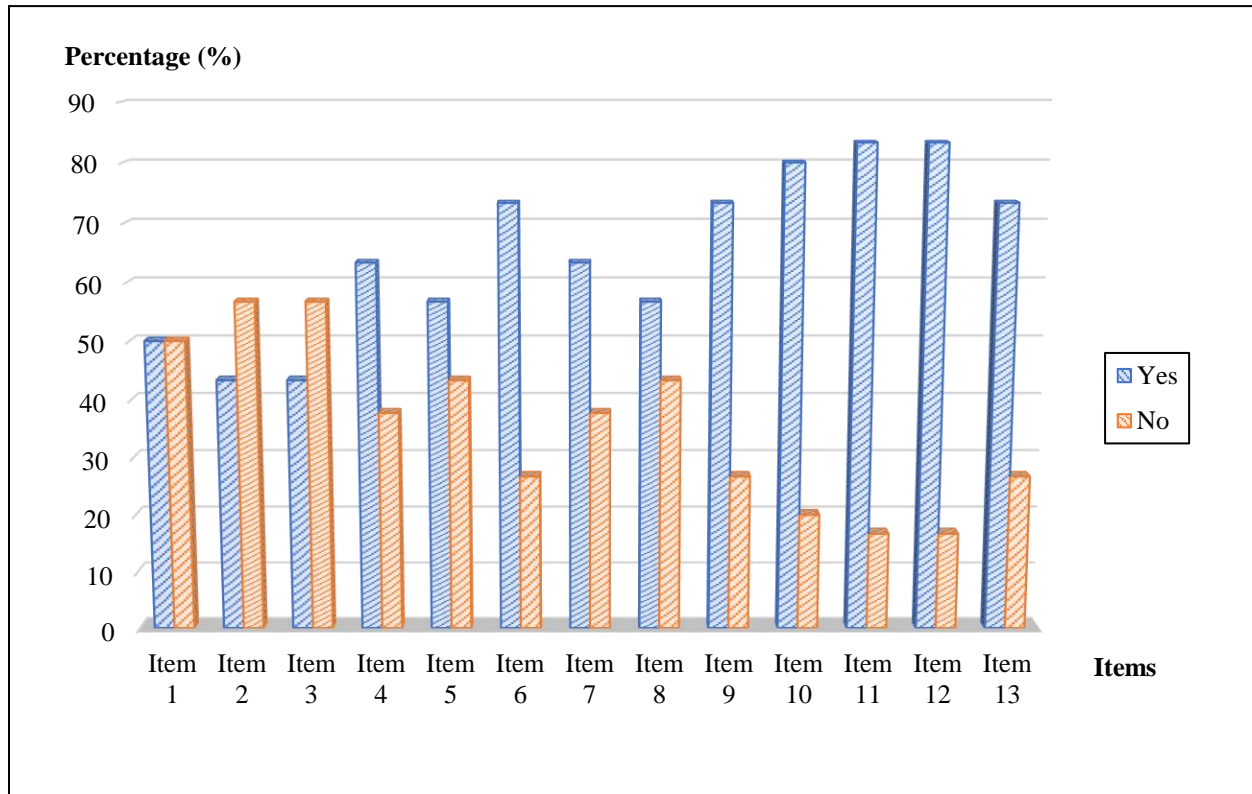
Figure 2. Misconceptions in Geometry (Pupils' Perspective)

Based on Table 4 and Figure 2, half of the pupils which contributes 50.0%, were facing the difficulties to understanding the Geometry topic in general. However, most pupils who encountered misconception in learning Geometry were on item 11 and item 12. Both items contribute 83.3%. This result confirmed the result of previous study that, identify the actual shape of the geometry based on the net is one of the problems in learning Geometry (Özerem, 2012). Meanwhile, the lowest items which contribute 43.3% are items 2 and 3. The two items show that most of the second-grade pupils have better understanding in 2-D shapes and less difficult to draw 2D shapes.

Next, 80.0% of the pupils have difficulty in remembering the characteristics of 3D shapes without guidance from their peers. It shows pupils need guidance in learning Geometry. Furthermore, the other misconceptions in learning Geometry contribute 73.3% for items 6, 9 and 13. Pupils may have problems in 3D shapes where they face difficulties in naming the shapes and remembering the characteristics of the shape without guidance by teacher. Besides that, pupils also have limited understanding in problem solving in Geometry topic. The other misconceptions which are 56.7% for items 5 and 6 in remembering the names and characteristics of 2D shapes.

5. Conclusion

Geometry learning requires a strong pedagogical approach and in-depth knowledge in providing a fun learning environment (Hamdi, 2018). Furthermore, the teacher is responsible to guide pupils in teaching and learning Geometry to stimulate their thinking to solve the problems and prevent the misunderstanding in mathematical concepts during the learning process in the classroom (Ibli et al., 2019). Misconceptions may be caused by the pupil's inability to master the required idea, insufficient reasoning skills, or incorrect understanding of basic concept. Therefore, teachers need to provide teaching aids that are appropriate to the cognitive level of pupils to improve their understanding of geometry.

Acknowledgement

References

Aktaş, M. C., & Aktaş, Y. D. (2012) Investigating High School Students' Attitudes Towards Geometry According to Different Variables: Sample of Ordu City. *Dicle University Journal of Ziya Gökalp*, *18*, 156–167.

Berliner, D. C. (2014). Describing the Behaviour and Documenting the Accomplishments of Expert Teachers. *Bulletin of Science, Technology and Society, 24*(3), 200–212. https://doi.org/10.1177/0270467604265535.

Berna, C. G. (2014). An Investigation of Pre-Service Elementary School Teachers' Knowledge Concerning Quadrilaterals. *Gukurova University Faculty of Education Journal, 43*(2), 137–154.

Cohen, L., Manion, L., & Morrison K. (2017). *Research Methods in Education* (8th Ed.). London: Routledge. https://doi.org/10.4324/9781315456539.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and Conducting Mixed Methods Research* (2nd Ed.). CA: Sage.

Gay, L. R., Mills, G. E., & Airasian, P. W. (2012). *Educational Research: Competencies for Analysis and Applications* (10th Ed). Pearson.

Gunčaga, J., & Žilková, K. (2019). Visualization as a Method for the Development of the Term Rectangle for Pupils in Primary School. *European Journal of Contemporary Education, 8*(1), 52–68. https://doi.org/10.13187/ejced.2019.1.52.

Hiebert, J., Miller, E., & Berk, D. (2017). Relationships between Mathematics Teacher Preparation and Graduates' Analyses of Classroom Teaching. *Elementary School Journal, 117*(4), 687–707. https://doi.org/10.1086/691685.

Ibili, E., Çat, M., Resnyansky, D., Şahin, S., & Billinghurst, M. (2019). An Assessment of Geometry Teaching Supported with Augmented Reality Teaching Materials to Enhance Students' 3D Geometry Thinking Skills. *International Journal of Mathematical Education in Science and Technology, 51*(2), 224–246. https://doi.org/10.1080/0020739X.2019.1583382.

Ismail, H., Abdullah, A. H., Syuhada, N. & Noh, N. H. (2020). Investigating Student's Learning Difficulties in Shape and Space Topic: A Case Study. *International Journal of Psychosocial Rehabilitation, 24*(5), 5315–5321. https://doi.org/10.37200/ijpr/v24i5/pr2020238337–351.

Lee Abdullah, M., & Wei, L. (2017). Learning Form One Geometry: Validity and Reliability of a Self-Evaluation Instrument. *Malaysian Journal of Learning and Instruction, 14*(1), 211–265. https://doi.org/10.32890/mjli2017.14.1.9.

Luneta, K., & Makonye, P. J. (2010). Analysing Grade 12 Learner Errors and the Misconceptions in Calculus. *Acta Didactica Napocensia, 3*(3), 35–46.

Mackle, K. (2016). *Tackling Misconceptions in Primary Mathematics: Preventing, Identifying and Addressing Children's Errors* (1st ed.). London: Routledge. https://doi.org/10.4324/9781315695570.

Marchis, I. (2012). Pre-Service Primary School Teachers' Elementary Geometry Knowledge. *Acta Didactica Napocensia, 5*(2), 33-40.

Ministry of Education Malaysia (2016). Primary School Standard Curriculum Standard Document for Curriculum and Assessment: Year Two Mathematics. Kuala Lumpur: Curriculum Development Division.

Özerem, A. (2012). Misconceptions in Geometry and Suggested Solutions for Seventh Grade Students. *Procedia - Social and Behavioral Sciences, 55*, 720–729. https://doi.org/10.1016/j.sbspro.2012.09.557.

Prabowo, A., Anggoro, R. P., Astuti, D., & Fahmi, S. (2017). Interactive Multimedia Based Teaching Material for Dimensional Geometry. *Journal of Physics: Conference Series, 943*, 2. https://doi.org/10.1088/1742-6596/943/1/012047.

Serin, H. (2018). Perspectives on the Teaching of Geometry: Teaching and Learning Methods. *Journal of Education and Training, 5*(1), 1. https://doi.org/10.5296/jet.v5i1.12115.

Serin, H. (2018). A Comparison of Teacher-Centered and Student-Centered Approaches in Educational Settings. *International Journal of Social Sciences & Educational Studies, 5*(1), 164–167. https://doi.org/10.23918/ijsses.v5i1p164.

Sujarwo, M., Kurniawan, S. B. (2020). Analysis on Mathematics Learning Misconceptions of the Second-Grade Students of Elementary School in Addition and Subtraction Integer Topics. *Advances in Social Science, Education and Humanities Research, 397*, 757–764. https://doi.org/10.2991/assehr.k.200129.095.