THE EFFECTIVENESS OF iSTEAM MODULE IN IMPROVING PROBLEM-SOLVING AND CREATIVE THINKING SKILLS IN GEOMETRY PROBLEM-SOLVING AMONG YEAR FOUR PUPILS

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by

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LIST OF ABBREVIATIONS

ANCOVA	Analysis of Covariance
CA	Conventional Approach
CTST	Creative Thinking Skills Test
CVI	Content Validity Index
DSKP	*Dokumen Standard Kurikulum dan Prestasi*
EJ	Expert Judgment
EPRD	Department of Educational Planning and Research
HOTS	Higher-Order Thinking Skills
ICT	Information and Communication Technology
iSTEAM	Integrated STEAM Approach
iSTEAM-m	Integrated STEAM Approach using the iSTEAM Module
JPN	*Jabatan Pendidikan Negeri*
JSU	*Jadual Spesifikasi Ujian*
KBSR	*Kurikulum Baru Sekolah Rendah*
KPM	*Kementerian Pendidikan Malaysia*
KSSR	*Kurikulum Standard Sekolah Rendah*
MOE	Ministry of Education
NCTM	National Council of Teachers of Mathematics
OECD	Organisation for Economic Cooperation and Development
PBL	Problem-Based Learning
PISA	Program for International Student Assessment
PPD	*Pejabat Pendidikan Daerah*
PPPM	*Pelan Pembangunan Pendidikan Malaysia*
PSST	Problem-Solving Skills Test
RPH	*Rancangan Pengajaran Harian*
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering, and Mathematics
TIMSS	Trends in International Mathematics and Science Study
TTCT	Torrance Tests of Creative Thinking
UASA	*Ujian Akhir Sesi Akademik*
UPSR	*Ujian Pencapaian Sekolah Rendah*

LIST OF APPENDICES

KEBERKESANAN MODUL ISTEAM DALAM MENINGKATKAN KEMAHIRAN PENYELESAIAN MASALAH DAN BERFIKIR KREATIF DALAM PENYELESAIAN MASALAH GEOMETRI DALAM KALANGAN MURID TAHUN EMPAT

ABSTRAK

Kajian ini menilai keberkesanan modul iSTEAM dalam meningkatkan kemahiran penyelesaian masalah dan berfikir kreatif dalam penyelesaian masalah geometri dalam kalangan murid Tahun Empat. Ramai murid menghadapi kesukaran dalam penyelesaian masalah geometri dan kurang memiliki kemahiran penting ini. Pengintegrasian Sains, Teknologi, Kejuruteraan, Seni, dan Matematik (STEAM) adalah penting untuk menangani cabaran ini. Dibangunkan menggunakan model ASSURE, modul iSTEAM menyediakan pendekatan pengajaran yang berstruktur. Menggunakan reka bentuk kaedah campuran penjelasan penerokaan berjujukan, kajian kuasi-eksperimen ini membandingkan pendekatan konvensional (kumpulan CA, n=35) dengan pendekatan STEAM bersepadu menggunakan modul iSTEAM (kumpulan iSTEAM-m, n=33). Analisis ANCOVA menunjukkan peningkatan yang signifikan dalam kemahiran penyelesaian masalah (p<0.001, saiz kesan = 28.0%) dan kemahiran berfikir kreatif (p<0.001, saiz kesan = 51.0%) dalam kumpulan iSTEAM-m. Dapatan kualitatif menunjukkan bahawa kumpulan iSTEAM-m memperlihatkan peningkatan kemahiran penyelesaian masalah melalui pemahaman masalah yang lebih baik, perancangan strategi, pelaksanaan strategi, dan pengesahan jawapan. Mereka juga menunjukkan peningkatan kemahiran berfikir kreatif termasuk kelancaran idea, keluwesan, dan keaslian. Dapatan ini menunjukkan bahawa modul iSTEAM merupakan sumber pengajaran yang berkesan untuk meningkatkan

kemahiran penyelesaian masalah dan kemahiran berfikir kreatif murid dalam penyelesaian masalah geometri. Kajian ini juga mencadangkan bahawa pelaksanaan modul iSTEAM dalam pendidikan matematik dapat memupuk pemahaman yang lebih mendalam dan menyokong pembangunan kemahiran abad ke-21 dalam kalangan murid sekolah rendah.

THE EFFECTIVENESS OF ISTEAM MODULE IN IMPROVING PROBLEM-SOLVING AND CREATIVE THINKING SKILLS IN GEOMETRY PROBLEM-SOLVING AMONG YEAR FOUR PUPILS

ABSTRACT

This research evaluates the effectiveness of the iSTEAM module in improving problem-solving and creative thinking skills in geometry problem-solving among Year Four pupils. Many pupils struggle with geometry problem-solving and lack these essential skills. The integration of Science, Technology, Engineering, the Arts, and Mathematics (STEAM) is crucial to address these challenges. Developed using the ASSURE model, the iSTEAM module provides a structured approach to teaching. Using an explanatory sequential mixed-methods design, this quasi-experiment compared the conventional approach (CA group, n=35) with the integrated STEAM approach employing the iSTEAM module (iSTEAM-m group, n=33). ANCOVA analysis showed significant improvements in problem-solving (p<0.001, effect size = 28.0%) and creative thinking skills (p<0.001, effect size = 51.0%) in the iSTEAM-m group. Qualitative findings revealed that the iSTEAM-m group demonstrated enhanced problem-solving skills through improved problem understanding, strategy planning, strategy implementation, and answer verification. They also showed strengthened creative thinking skills, including improved fluency, flexibility, and novelty. These results indicate that the iSTEAM module is an effective instructional resource for enhancing pupils' problem-solving and creative thinking skills in geometry. The findings further suggest that implementing the iSTEAM module in mathematics education can foster deeper understanding and support the development of 21^{st} century skills in primary school pupils.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Geometry is a significant field of mathematics, and it has long been recognised as an area of mathematics with the potential to invigorate the study of mathematics (Chambers, 2008). Learning geometry may help learners develop the abilities to analyse, question, hypothesise, and experiment they will need in the real world. Since geometry is taught in primary school, how learners learn to reason and make sense of them will significantly impact their future learning experiences in high school and college (National Council of Teachers of Mathematics, 2006).

In mathematics, geometry is one of the subfields that focuses on problem-solving. Within the framework of KSSR (Kurikulum Standard Sekolah Rendah) or the Primary School Standards-Based Curriculum for primary mathematics, problem-solving is emphasised as an essential component within the geometry topic. It is essential to get pupils to understand and grasp the knowledge of geometry concepts to solve geometry problems. However, pupils often report that geometry problem-solving is the subject's most challenging topic (Sulistiowati et al., 2019).

The challenges in geometry arise largely from the abstract nature of geometric concepts such as shapes, angles, lines, and spatial relationships, which pupils often find difficult to visualise and comprehend without the aid of concrete materials or real-life examples (Zaipul Bahari & Saleh, 2024). Geometry tasks also become problematic when pupils are required to apply geometric formulas accurately, especially when their understanding of the underlying geometric principles is weak. In addition, many pupils struggle with geometry due to limited spatial reasoning and an inability to engage meaningfully with geometric content. Geometry learning is further hindered by pupils' lack of problem-solving skills, which affects their ability to extract relevant information, interpret geometry problems correctly, and draw appropriate conclusions (Idris, 2009). These persistent difficulties in geometry not only impede pupils' immediate performance but also affect their readiness to engage with more complex geometry concepts in higher levels of education.

In the realm of education, the terms "problem-solving" and "creative thinking" have become well-known. There's no denying that mathematics classes teach pupils how to solve problems and think creatively. According to Khalid (2017), one of the most critical aspects of learning mathematics is problem-solving. Problem-solving skill refers to an individual's mental processes to make progress toward a goal (Martinez, 1998; Mayer & Wittrock, 2006) by understanding a problem, developing solution processes based on real-life situations, and designing various solution strategies to solve a given problem (Organisation for Economic Co-operation and Development (OECD), 2014). Problem-solving requires learners to act or try to discover the most optimal solution (Sutama et al., 2021). This process is inextricably linked to the cognitive process in a very significant way (Flavell, 1979). In order to solve problems, pupils must think and decide using suitable methods (Zakaria & Yusoff, 2009). Therefore, pupils may improve their skills to acquire and apply mathematical information and reflect on the process of problem-solving (Anggo, 2011) in learning geometry problem-solving.

Problem-solving is a core component of the mathematics curriculum under the Primary School Standard-Based Curriculum (KSSR), as it enables pupils to apply mathematical concepts to real-life situations. Polya's problem-solving model consists of four phases: comprehending the problem, planning a strategy, implementing the strategy, and verifying the answer (Polya, 1945). This structured process guides pupils in understanding abstract concepts and strengthens their ability to solve problems systematically. Polya's problem-solving strategy is not only useful for guiding pupils through the problem-solving process but also plays an important role in developing and strengthening their problem-solving skills (Zaipul Bahari & Saleh, 2023).

In the context of 21st century education, nurturing creative thinking skills through mathematics learning has become increasingly important. Pupils' ability to think creatively is greatly enhanced when they study geometry (Darmawan & Wantika, 2020). Creative thinking skill is an individual's mental processes to produce innovative, intuitive, and distinctive problem solutions (Yaftian, 2015) or to create something novel (Chen et al., 2019; Torrance, 1970) by generating new ideas or thoughts (Chen et al., 2019; Fauzi et al., 2021) in a variety of ways (Wonganu et al., 2019) using multiple cognitive skills (Birgili, 2015).

Creative thinking skills is viewed through three important dimensions: fluency, flexibility, and novelty (Utami et al., 2019). Fluency refers to the ability of pupils to solve problems with ease and accuracy, reflecting their capacity to generate multiple relevant ideas efficiently. Flexibility is demonstrated when pupils approach a single problem using various strategies or perspectives, indicating adaptability in thought. Novelty, on the other hand, highlights the uniqueness of a pupil's solution when their responses differ from the norm or introduce original methods of solving a problem. These dimensions are essential in capturing the breadth, adaptability, and innovativeness of pupils' thinking when engaging with mathematical tasks.

The ability to think creatively is incredibly crucial for everyday problem-solving, which includes tackling mathematical problems at the primary school level (Ndiung et al., 2019). Furthermore, problem-solving that involves 21st century problems will necessitate creative thinking, and pupils are required to think creatively to find suitable solutions to the problems (Faiziyah et al., 2020). Pupils must build and strengthen their problem-solving skills throughout their mathematics education since problem-solving is regarded to be the most effective method of practising thinking in general (Murni et al., 2017).

The challenges of the 21st century require individuals to apply creative thinking and effective problem-solving strategies in both academic and real-life contexts (Hamid et al., 2024). Hence, a new teaching and learning approach should be introduced to improve pupils' problem-solving and creative thinking skills in geometry problem-solving. The integrated STEAM is a revolutionary approach to education that integrates STEAM (Sciene, Technology, Engineering, the Arts, and Mathematics) subjects into a single holistic approach in the classroom (Yakman, 2008). The notion of integration or a holistic approach appears most appropriate for current education. It can be used in a mathematics lesson, especially in teaching and learning problem-solving in geometry problem-solving. Lehrer (2021) and Martín-Cudero et al. (2024) suggest that integrating mathematics with other disciplines encourages the exchange of knowledge across fields, and therefore, incorporating science, technology, engineering, and the arts into the mathematics curriculum can benefit learners.

Research on STEAM education is gaining popularity worldwide. However, studies focusing on STEAM education in the context of teaching and learning mathematics in Malaysia remain limited. Although some early initiatives acknowledged the shift from STEM to STEAM, they lacked empirical evidence of real classroom practice, particularly within mathematics lessons (Bahrum et al., 2017). Malaysian studies have shown the benefits of STEAM in enhancing computational thinking (Tan et al., 2021), but these mainly concentrate on technology-based subjects rather than on geometry problem-solving or the development of problem-solving and creative thinking skills. Additionally, a primary-level case study by Bahrum and Ibrahim (2018) integrated STEM elements into visual arts lessons through a STEAM module. While the approach was found to be beneficial in promoting creativity and interdisciplinary learning, it was limited to the arts domain and did not explore its relevance or impact in mathematics, especially in geometry-related problem-solving.

Similarly, international studies have demonstrated the potential of STEAM-based and culturally relevant approaches in mathematics education. For example, digital STEAM inquiry modules have been shown to improve mathematical literacy (Susanta et al., 2025), while ethnomathematics-based learning in Indonesia has enhanced pupils' creative thinking and geometric understanding (Supriyadi et al., 2024). In addition, Wahba et al. (2022) reported cognitive gains from STEAM integration in the geometry topic for Grade Three pupils. However, these findings are not directly applicable to the Malaysian context, as they focus on different educational settings and do not specifically target Year Four pupils. These gaps highlight the need for empirical research applying an integrated STEAM approach within Malaysia's primary mathematics curriculum, particularly in geometry problem-solving. Therefore, this study aims to address the gap by developing and evaluating the effectiveness of the iSTEAM module in improving Year Four pupils' problem-solving and creative thinking skills in geometry.

1.2 Research Background

The background of the study highlights six subtopics: (i) the teaching and learning of geometry, (ii) the teaching and learning of geometry problem-solving, (iii) problem-solving skills among pupils, (iv) creative thinking skills among pupils, (v) integrated STEAM and (vi) integrated STEAM and mathematics learning.

1.2.1 The Teaching and Learning of Geometry

The Malaysian Primary School Standard-Based Curriculum (KSSR), which is being implemented in stages beginning in 2011, has been revised to align with the new policy outlined in the Malaysian Education Development Plan (PPPM) 2013-2025, ensuring that the quality of the curriculum implemented in primary schools is equivalent to international standards. The Standard-Based Curriculum for Primary School requires all pupils to study mathematics following the National Education System as a foundational skill.

Geometry is one of the topics of mathematics that is explicitly covered in the Malaysian mathematics school curriculum from the very beginning of primary school education (Abu et al., 2012). In Malaysia's primary education system, pupils begin their journey in geometry by exploring the visual aspects of shapes for the initial three years. Subsequently, in years four through six, they progress to the descriptive level, where they are introduced to calculating the perimeter and area of two-dimensional shapes, as well as determining the volume of three-dimensional solids. The Curriculum and Assessment Standards Document (DSKP) for Year Four mathematics, Primary School Standard-Based Curriculum (KSSR) encompasses various space-related topics in geometry, which are as follows: (i) Angles, (ii) Parallel lines and perpendicular lines, (iii) Perimeter and area, (iv) Volume of a solid, and (v) Problem-solving (Curriculum Development Centre, 2018).

Within the context of the Malaysian KSSR Mathematics syllabus, pupils in Year Four undergo an in-depth exploration of geometric concepts (Curriculum Development Centre, 2018). By delving into topics such as symmetry, parallel and perpendicular lines, and angles, pupils develop a robust understanding of geometric shapes and their properties. Pupils are given an introduction to the processes involved in computing the area and perimeter of a variety of geometric shapes. They learn how to precisely calculate the lengths of borders as well as the amount of space that is encompassed by shapes by using various formulae and procedures. This knowledge empowers them to address problem-solving scenarios that involve the practical applications of perimeter and area, encompassing both mathematical contexts and real-life situations.

Additionally, pupils delve into the topic of volume of a solid, broadening their understanding beyond two-dimensional shapes. They investigate the concept of solids that have three dimensions and learn how to determine the volume of such objects. Pupils can ascertain the volume occupied by objects such as cubes and cuboids by employing the appropriate formulas and techniques. Overall, the Malaysian KSSR Mathematics for Year Four gives pupils a good idea of geometric forms, their properties, and how to measure them (Curriculum Development Centre, 2018). By teaching pupils these basic skills, the mathematics curriculum improves their ability to think and solve problems in the area of geometry, putting them on the path to learn more about mathematics and become better at it in later years.

As highlighted in the Trends in International Mathematics and Science Study (TIMSS) 2019 Report, Malaysian pupils' overall performance in mathematics, including geometry, is below the global average, with Malaysia ranking 28th out of 39 participating countries. Specifically, the average score in geometry is 466, placing Malaysia significantly behind the top five Asia-Pacific countries: Chinese Taipei (623), Singapore (619), the Republic of Korea (617), Japan (610), and Hong Kong (596). In addition, Malaysian pupils' performance in geometry is not significantly higher than the TIMSS midpoint scale (500). Therefore, it is necessary to identify the cause of the gaps and implement proactive measures to bridge them.

Although TIMMS 2019 reports that Malaysia shows an increasing trend in geometry in TIMSS 2019 with an average score of 466 compared to TIMMS 2011 (432) and TIMSS 2015 (455), the average geometry score in TIMSS 2007 (474) is still higher than TIMSS 2011, 2015, and 2019 (Kementerian Pendidikan Malaysia (KPM), 2020). The results indicate that pupils' geometry achievement in TIMSS 2019 is low compared to the pupils' geometry achievement in TIMSS 2007. In addressing the low performance of Malaysian pupils in TIMSS tests, especially in geometry achievement, it is imperative to teach primary school pupils a strong foundation in geometry to enhance their geometric thinking. Mastering geometry at the primary school level will enable pupils to apply knowledge of geometry at secondary school level and higher levels more efficiently (Clements & Sarama, 2009; Nuriswaty et al., 2020).

Meanwhile, according to the Malaysian Examination Syndicate's Answer Quality reports in 2010, 2012, 2013, 2014, 2017, pupils continue to struggle with understanding the basic concepts of geometrical measurement, suggesting persistent conceptual gaps in foundational mathematics (Nasser & Lim, 2022). Although the reports focus on Year Six pupils, typically aged twelve, the challenges they highlight, particularly those related to geometrical measurement, are directly relevant to Year Four. This is because key topics such as perimeter, area, and volume of a solid are introduced and developed between Years Three and Five. Difficulties recorded in Year Six often stem from foundational misunderstandings that begin earlier. Therefore, referencing the Examination Syndicate's findings remains appropriate when discussing challenges faced by Year Four pupils, as these reports reflect cumulative learning issues rooted in the lower primary years.

In the context of mathematics education, according to Ng and Rosli (2023), the teaching and learning of geometry continues to pose significant challenges at the primary level. A common issue encountered by pupils is the lack of cognitive skills and limited conceptual understanding, particularly in topics such as basic polygons. This difficulty is largely attributed to the abstract nature of geometric concepts, which are often not easily accessible to young learners. Moreover, pupils tend to perceive geometry as disconnected from real-life experiences, as its application is rarely observed in their daily activities. This perceived lack of relevance further contributes to low engagement and weak mastery of geometric content in the classroom.

In addition, several previous researchers in Malaysia focus on pupils' struggles while learning geometry (Boo, 2016; Hock et al., 2015; Nadzeri, Musa, et al., 2022; Tyng et al., 2021). Research highlights that Malaysian primary school pupils face significant challenges in learning geometry. A study by Nadzeri et al., (2022), for instance, found that second-grade pupils demonstrated clear weaknesses in problem-solving related to 2D and 3D shapes, struggling not just with identification but with the application of concepts. Such difficulties often stem from a combination of weak basic mathematical skills, poor visualisation abilities, and traditional teaching methods. These underlying issues can lead to persistent misconceptions that hinder mastery, underscoring the critical need for teachers to identify and address these geometric challenges through improved instructional strategies.

According to Hock et al. (2015), Malaysian pupils had trouble accurately recognising a square as a certain sort of rectangle. This suggests that these pupils had a lack of understanding of the link between squares and rectangles, which may have been related to misunderstandings or insufficient information about geometric forms. It is important to point out that while squares have all the characteristics of rectangles, such as having four sides and four right angles, the distinctive quality of squares, which is that all of their sides are the same length, often leads to misunderstandings among the pupils in Malaysia. This is something that should be highlighted.

According to the results of a recent preliminary research done by Tyng et al. (2021), many pupils have significant difficulties while studying geometry especially in the topic of Shape and Space at three primary schools in Malaysia. The researchers find that abstractive phenomena and concepts, as well as a lack of imagination, contribute to pupils' difficulty in grasping the learned topics. The researchers also state that the notion of Shape and Space is complex for primary school pupils to master because there aren't enough teaching tools and reference materials on the topic accessible in classrooms and schools.

Boo (2016) conducts a study on the teaching and learning of geometry using GeoGebra among Year Six pupils. The researcher discovers that an inadequate understanding of geometry concepts often causes pupils in primary schools to get frustrated, resulting in lower performance while learning geometry. The results show that the usage of GeoGebra encourages pupils to think more abstractly, able to explain what they are doing and why they are doing it in order to arrive at a mathematical answer. In addition, according to the results of the survey, pupils express satisfaction with the use of GeoGebra to study the concept of angle in Geometry.

Furthermore, research indicates that a significant number of Malaysian pupils do not exhibit the expected level of geometric thinking, despite the inclusion of geometry as an essential component within the mathematics curriculum (Hock et al., 2015; Pui et al., 2022; Yunus et al., 2019). The use of van Hiele theory to geometry instruction was studied by Hock et al. (2015). Findings indicate fifth graders have difficulty conceptualising two-dimensional shapes. However, Van Hiele levels might be used to help pupils better understand geometric shapes. There is further evidence from the study showing that pupils in primary schools have trouble recognising two-dimensional shapes, and that the ability to recognise these shapes is correlated with prior understanding of geometry. In addition, the results of the study state that the pupils' geometric understanding is at the lower level based on Van Hiele's theory. The findings of the research indicate that the majority of pupils seem to work at the levels of L0 (Visualisation) and L1 (Analysis) when studying shapes and spaces, which show significant indicators of the major shortcomings among pupils in terms of the nature of geometry learning. This is supported by the findings of the research by Idris (2007) which demonstrates that the majority of Malaysian pupils appear to be functioning at a lower level of Van Hiele geometry thinking and are not thinking at the higher Van Hiele geometry levels.

Besides, based on Van Hiele's theory, it has been observed that primary pupils in Malaysia have not yet attained the intended learning outcomes in primary mathematics, specifically corresponding to Level 2 (Yunus et al., 2019). At Level 2, which is Informal Deduction, pupils are expected to demonstrate various skills including problem-solving, abstract reasoning, hypothesising, and utilising informal reasoning to draw conclusions and explain arithmetic concepts. However, it has been noted that primary pupils in Malaysia have not yet reached the proficiency expected at this level. This observation highlights the importance of addressing and enhancing pupils' proficiency in Informal Deduction within the Malaysian primary mathematics curriculum. In light of the discrepancy in achieving the desired learning outcomes in geometry teaching and learning, primary school teachers can take proactive steps to guide pupils through the different levels of geometric thinking outlined by Van Hiele (Pavlovičová & Bočková, 2021). This may result in a more comprehensive and effective mathematics education.

Research in Malaysia consistently shows that primary pupils operate at the very basic levels of geometric thought, which inherently limits their problem-solving skills. A study by Yunus et al. (2019) found that Malaysian primary pupils were largely functioning at the lower levels of the Van Hiele model of geometric thinking

(Visualisation and Analysis). This means they could recognise shapes but could not properly understand their properties or see relationships between them, a crucial skill for solving non-routine problems. The study points out that traditional, teacher-centered instruction fails to provide pupils with the experiences needed to develop higher levels of geometric reasoning, which is essential for problem-solving.

The long-term impact of early geometric learning on later academic success is further illuminated by the research of Abdullah et al. (2014). While their study focused on secondary pupils, its findings serve as a crucial diagnostic tool, revealing how foundational gaps from primary education mature into significant challenges. They established a clear correlation between a pupil's Van Hiele level of geometric thinking and their capacity to handle non-routine problems. The research detailed how pupils operating at the lower, more basic levels of geometric understanding were largely incapable of navigating tasks that required creative and multi-step reasoning. This powerfully demonstrates that the difficulties observed in secondary school are not new problems, but rather the predictable outcome of an insufficient foundation, reinforcing the argument that a strong start in geometry is essential for future problem-solving competence. Overall, these findings underscore the pressing need to address the challenges in geometric thinking among Malaysian pupils and promote a deeper understanding of geometry through the effective implementation of instructional approaches aligned with the Van Hiele theory.

The Malaysian school curriculum (KSSR) emphasises creative thinking skills. Studies show that geometry is an important subject for developing these skills, but many students struggle with it. A recent literature review by Zainuddin and Abdullah (2023) specifically explores the creativity of pupils in learning geometry at the primary level in Malaysia. They argue that learning geometry is crucial for developing skills like visualisation, critical thinking, and logical reasoning, which are components of creative thinking skills. Their work suggests that a lack of creative engagement in geometry teaching is a significant issue, hindering pupils' ability to think flexibly and solve problems effectively.

Meanwhile, many researchers find that many mathematics teachers teach geometry solely in a conventional way. They note that mathematics education in Malaysia is dominated by teacher-centred instruction, and pupils have few opportunities to develop their ideas in classrooms and other learning spaces (Hock et al., 2015; Idris, 2007; Yunus et al., 2019). Additionally, conventional methods of teaching geometry focus more on memorisation than on developing pupils' critical thinking and reasoning skills resulting in pupils finding studying to be a chore and seldom looking forward to it (Idris, 2009). Alex and Mammen (2012) agree that pupils' difficulties with geometry might be an outcome of teachers' inability to use efficient and comprehensive teaching approaches that actively involve pupils and assist them in adequately using their thinking abilities. Besides, the majority of teachers in Malaysian schools place the most importance on completing the syllabus as their top priority when it comes to teaching and learning, and both Hock et al. (2015) and Idris (2007) completely share this stance.

Thus, with all the teaching and learning styles practised in Malaysian schools, it is desirable to conduct research to introduce a new effective method of teaching and learning, especially for Year Four pupils in primary school, to improve pupils' understanding and performance in geometry. Teachers in Malaysia should utilise innovative teaching methods in both teaching and learning to align with the Ministry of Education's (MOE) emphasis on national education transformation, which prioritises the integration of 21st century skills (Sulaiman & Ismail, 2020). By doing so, they can effectively deliver lessons that address the changing requirements of pupils and the evolving educational environment to promote active learning, problem-solving and creative thinking skills as well as be able to contribute to the holistic development of Malaysian pupils. Moreover, it is crucial to conduct this research as there is a significant gap in the existing studies focusing on geometry problem-solving specifically among Year Four pupils in Malaysia.

1.2.2 The Teaching and Learning of Geometry Problem-solving

Problem-solving in geometry is included in the Primary School Standard-Based Curriculum (KSSR), outlined in the Curriculum and Assessment Standards Document (DSKP) for Year Four mathematics. Geometry problem-solving for Year Four relies heavily on the learning of space topic. The subtopics that include in the teaching and learning of problem-solving in geometry consist of: (i) Perimeter and area, and (ii) Volume of a solid. It is suggested that teachers use various problem-solving strategies such as diagrams, models, and physical objects to help and enable pupils to solve problems in different ways (Curriculum Development Centre, 2018).

Pupils' performance in geometry topics can be assessed and examined based on the performance standard provided in the Curriculum and Assessment Standards Document (DSKP) for Year Four mathematics, Primary School Standard-Based Curriculum (KSSR). There are six performance levels altogether (Curriculum Development Centre, 2018). Specific descriptors are provided for each performance level. The assessment of geometry problem-solving for Year Four pupils only involves performance level 4 to performance level 6. The descriptors for level 4 to level 6 are listed as follows:

1. Performance Level 4 - Solve daily routine problems involving space.
2. Performance Level 5 - Solve daily routine problems involving space using various strategies.
3. Performance Level 6 - Solve daily non-routine problems involving space creatively and innovatively.

Pupils in Malaysia perform poorly in geometry and are unsatisfactory worldwide, according to the TIMSS 2019 Report. The poor performance in the geometry area in the TIMSS test signifies that pupils fail to use their prior knowledge and skills to solve geometry problems involving real-world context, where the TIMSS test items involve the application of pupils' existing knowledge and abilities in real-world problem-solving situations (Kasim, 2019). It is vital to expose pupils to world-based problem-solving learning that can indirectly strengthen and develop pupils' problem-solving and creative thinking skills. With the exposure of problems related to real-world context from an early age such as in primary school level, pupils can readily solve problems as they go through their mathematics education, for example, in solving geometry problems.

Geometry problem-solving poses significant challenges for many Year Four pupils in Malaysian primary schools. Research has shown that pupils at this level often struggle with understanding abstract geometric concepts, such as shapes, angles, lines, and spatial relationships (Zaipul Bahari & Saleh, 2024). One key difficulty is that these concepts are hard to visualise, especially when pupils lack prior experience with physical representations or real-world examples. Besides, when it comes to solving geometry problems, pupils also have difficulties in applying mathematical formulas effectively. These challenges are compounded when pupils are required to apply these formulas accurately during problem-solving tasks. Many primary pupils find geometry problem-solving difficult due to limited spatial reasoning and a lack of meaningful engagement with the content. These obstacles can negatively affect pupils' overall performance in mathematics and their ability to progress to more complex mathematical ideas in later years.

In adddition, one of the studies on geometry problem-solving in Malaysia is conducted by Idris (2009). According to the researcher, many pupils struggle with geometry learning because they lack an adequate comprehension of geometry concepts and have trouble solving geometry problems. The researcher further states that learning geometry is a complex undertaking, with many pupils failing to grasp the concepts of geometry and geometric reasoning as a result. The researcher also confirms that pupils lack problem-solving skills in geometry throughout their time in school. Pupils' poor thinking skills are one factor that contributes to the failure of the learning because they are unable to extract the required information from the data provided, unable to interpret responses, and incapable of drawing conclusions. The findings of the research indicate that pupils' achievement improves when pupils interact with the objects of study in circumstances that promote geometric thinking and solving geometry problems resulting in effective learning.

In order to align with the educational reform envisioned by the Malaysian Ministry of Education, teachers should incorporate interactive and hands-on learning activities to promote pupils' geometric thinking and enhance their problem-solving skills in geometry. By integrating these engaging activities into their teaching and learning sessions, teachers can foster a deeper understanding of geometric concepts among pupils (Tessema et al., 2024). This approach emphasises active participation and practical application, enabling pupils to actively explore and manipulate geometric shapes and problems. By implementing such interactive and experiential learning strategies, teachers can effectively align their teaching practices with the educational reform goals set forth by the Malaysian Ministry of Education. Consequently, given the scarcity of research involving geometry problem-solving in Malaysia, it is critical to perform this investigation into geometry problem-solving topic. Aside from that, studies involving Year Four pupils in Malaysia are also very few and limited, especially in the field of geometry problem-solving. Taking into account the lack of these studies, the researcher is interested in conducting this study to increase research reference resources for researchers and educators, especially in the Malaysian context.

1.2.3 Problem-Solving Skills Among Pupils

Problem-solving is one of the most important components of the mathematics curriculum, which is not only being embraced in Malaysia but also all around the globe today (Hafizi & Kamarudin, 2020) because it is an essential skill in daily life (Karatas & Baki, 2013). Problem-solving is a fundamental process in mathematics education, serving not only as a goal of learning but also as a key method through which mathematical understanding is developed. It involves applying prior knowledge, logical reasoning, and critical thinking to explore and resolve unfamiliar tasks. Through problem-solving, pupils learn to make sense of mathematical concepts, identify relationships, and apply strategies effectively in various contexts (Mustafa, 2018). This process encourages deeper engagement with mathematical ideas and promotes transferable skills such as perseverance, creativity, and reflective thinking. As such, problem-solving is widely recognised as an essential component in the learning and teaching of mathematics, forming the basis for cultivating both conceptual understanding and higher-order thinking skills.

According to National Council of Teachers of Mathematics (2000), problem-solving refers to the process of solving mathematical problems. It is a cognitive process in which information, skills, and life experiences are mobilised in order to identify issues, develop solutions, and resolve problems in an efficient and effective manner (Fitriani et al., 2020; Hong et al., 2014). Problem-solving is considered a cornerstone of mathematics education, with one of its primary goals being the development of learners' abilities to tackle complex tasks. For those proficient in mathematics, the discipline is often synonymous with solving a variety of problems, ranging from word problems to theorem proofs. In contrast, individuals who are less engaged in the subject may perceive nearly all mathematical tasks as problem-solving activities (Wilson et al., 1993).

In mathematics education, researchers have long distinguished between routine and non-routine problems to better understand pupils' cognitive engagement during problem-solving. Routine problems are characterised by their predictable nature and reliance on well-practised procedures and familiar algorithms. As noted by Polya (1945), and supported by Bayazit (2013), these problems typically require the direct application of known methods and do not demand extensive reasoning or exploration. Pupils are usually confident in solving such problems, as they involve standard techniques and operations already taught in class (Arslan & Altun, 2007; Schoenfeld, 1992). These types of problems often have a single correct answer and serve to reinforce foundational mathematical skills. Schoevers et al.

(2022) explain that routine problems, such as identifying a correct cube net, usually involve straightforward steps and a fixed solution path.

Despite their widespread use in classroom instruction, there is a lack of research focusing on the use of routine problems to assess problem-solving skills in primary mathematics. Most existing studies place greater emphasis on non-routine problems when investigating or measuring problem-solving skills (Dangkulos et al., 2025; García-Moya et al., 2024; Sinniah et al., 2024; Wahyun et al., 2023). This gap highlights the need for further research to examine how routine problems can be systematically utilised to assess and support the development of problem-solving skills among primary school pupils.

In contrast, non-routine problems require pupils to think more creatively and critically, as the path to the solution is not immediately evident (Polya, 1945; Elia et al., 2009). These tasks typically involve unfamiliar or open-ended contexts that encourage the application of higher-order thinking skills, including reasoning, evaluation, and strategic decision-making (Shawan et al., 2021). Non-routine problems often resemble real-world scenarios that make mathematics more meaningful and relevant (Bayazit, 2013; Brown, 2001). They promote the use of metacognitive processes such as planning, monitoring, and reflection (Hartman, 1998). According to Inoue (2005), pupils must draw upon multiple representations and approaches to solve these problems effectively. However, as Carlson and Bloom (2005) point out, the classification of a problem as routine or non-routine is subjective and may vary based on the pupil's prior experience and knowledge. In some cases, repeated exposure may cause a non-routine task to become routine for a particular learner (Schoevers et al., 2022). Despite this fluidity, incorporating non-routine, real-life-based problems into instruction is widely encouraged for fostering deeper understanding and improving pupils' problem-solving skills.

Although numerous studies have investigated the effectiveness of non-routine problems in developing and assessing pupils' problem-solving skills, comparatively less attention has been given to the role of routine problems in this domain. Much of the existing research tends to focus on the use of complex, unfamiliar tasks to stimulate advanced problem-solving processes, often overlooking the ways in which routine problems can also contribute to the acquisition and demonstration of problem-solving skills, especially at the primary level. This gap suggests the need for further research into how routine mathematics problems can support, assess, or even enhance pupils' problem-solving skills within the curriculum.

The Curriculum and Assessment Standards Document (DSKP) for Year Four mathematics, Primary School Standard-Based Curriculum (KSSR) emphasises teaching and learning must holistically include problem-solving skills throughout the curriculum (Curriculum Development Centre, 2018), which underpins the whole mathematics curriculum, allowing ideas and abilities to be learnt in a more contextualised manner (Ismail, 1997). Problem-solving in the Malaysian mathematics curriculum outlines three essential aspects to consider:

1. Mathematical problem-solving as the primary emphasis.
2. Communication in mathematics enables pupils to explain the solution strategies they have established, resulting in increasing the pupils' problem-solving efficiency.

3. Develop pupils' ability to establish connections in mathematics, enabling them to link conceptual and procedural knowledge, as well as mathematics to everyday life.

A strong focus on the development of problem-solving skills is very important for pupils to be capable of efficiently tackling a wide range of problems efficiently (Curriculum Development Centre, 2018). Effective problem-solving can be done using problem-solving model proposed by Polya (1945). There are four steps of Polya' problem solving model, namely: (i) comprehend the problem, (ii) plan a strategy, (iii) implement the strategy, and (iv) verify the answer. The problem-solving skills proposed in the Curriculum and Assessment Standards Document (DSKP) for Year Four mathematics, Primary School Standard-Based Curriculum (KSSR) are in line with the problem-solving model developed by Polya (1945). Problem-solving skills include four steps, namely: (i) understand and interpret problems, (ii) plan solution strategies, (iii) implement strategies; and (iv) review answers (Curriculum Development Centre, 2018).

In 1999, Grade Eight (Form Two) students in Malaysia began participating in TIMSS. Malaysia has continued to participate in TIMSS since 2003, including TIMSS 2007, TIMSS 2011, TIMSS 2015, and, latest, TIMSS 2019. Malaysia's involvement in the TIMSS research aims to determine the efficacy of mathematics and science learning among Malaysian pupils in comparison to their international counterparts. In 2011, the average mathematics score for Malaysian students in TIMSS is 440. The average Mathematics score for Malaysian students in TIMSS 2015 shows an increase performance compared to TIMSS 2011, which is 465 with a difference of 25 scores. However, the average mathematics score for Malaysian students for TIMSS 2019 slightly decreases, which is 4 points lower than the achievement of Mathematics in TIMSS 2015, with an average score of 461.

According to the 2019 Trends in International Mathematics and Science Study (TIMSS) Report, Malaysian pupils' mathematics performance remains below par worldwide in mathematics achievement. Malaysia's average score in mathematics is 461, placing it in the 28th rank. Singapore, a neighbouring country, ranked at the top with an average of 616 mathematical achievements, showing a significant score difference of 155 points. Furthermore, Malaysia's average mathematics achievement falls below the TIMSS midpoint scale (500), with a score difference of 39 points, indicating that Malaysia is at a low level of international benchmarking.

The low mathematics achievement in the TIMSS test shows a lack of real-world-related mathematical problem-solving skills among pupils. Therefore, it is imperative to address the problem of low mathematical achievement among pupils, especially in problem-solving. The National Council of Teachers of Mathematics (NCTM) recommends that educators foster early development of pupils' mathematical problem-solving skills (Ahdhianto et al., 2020). Their skills to solve problems need to be polished and mastered as early as in primary school so that their knowledge and skills can be used at higher levels of education.

Some previous scholars in Malaysia focus their attention on pupils' difficulties in mastering problem-solving in mathematics. A study by Wen et al. (2020) emphasises pupils' difficulties in solving mathematical word problems among Year Five pupils. According to the researchers, pupils comprehend the word problems but could not use their knowledge to solve them. In addition, they find that the pupils are weak in solving word problems, even though they know how to do arithmetic quite well. Moreover, the inability of pupils to solve word problems in mathematics might be due to the use of the conventional teaching and learning method. The study's results indicate that pupils demonstrate increased comprehension and performance when solving mathematical word problems after the intervention compared to conventional teaching method, which stimulates pupils' ability to think critically while solving mathematical word problems.

Furthermore, when it comes to mathematical problem-solving, word problems are often considered one of the most challenging types of problems for pupils to handle. The study by Tambychik and Meerah (2010) addresses how primary school pupils in Malaysia lack linguistic proficiency making it difficult for them to understand the terminology used when learning problem-solving in mathematics. Meanwhile, secondary school pupils are reported to have difficulty comprehending mathematical language. These deficiencies result in difficulties in understanding the problems, which hinders their ability to solve them. Besides, pupils lack various mathematical skills, including number-fact, visual-spatial, and information skills. However, information skill is the most crucial skill faced by pupils out of the three mathematical skills mentioned. As a result, the weakness in mathematical skills indicate above and low cognitive skills in learning deter the ability to solve mathematics problems.

Another study on mathematical problem-solving conducted by Abdullah et al. (2017) focuses on non-routine mathematics problem-solving. The study discloses the pupils' performance in solving non-routine mathematical problems where 38.8% of respondents have a very low performance and 22.7% of respondents have a low