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# The Effectiveness of Blended Project-Based Learning (PBL) in Enhancing Spatial Visualization Skills and Computational Thinking among Year 4 Students in Learning Scratch

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**Abstract**

The integration of technology in education and the growing need for computational expertise have significantly influenced and transformed current educational trends. In Malaysia, traditional teaching methods have been replaced by various student-centered approaches that incorporate ICT both inside and outside the classroom. For instance, the Malaysian Ministry of Education has launched the DELIMa learning platform, offering a range of learning tools, educational materials, and digital resources for educators and students starting from Year 1. As a result, it is unsurprising that entrance exams for specialized schools now include questions that assess computational thinking and spatial visualization skills, serving as benchmarks for evaluating students' intellectual capabilities. Therefore, developing this computational thinking and spatial vision abilities is critical in this rapid technology breakthroughs era. This study analyses the impact of Blended Project-Based studying (BPjBL) on developing these important competencies among Year 4 students while studying Scratch, a visual programming language. This research study uses a quantitative research design, specifically a pre-experimental approach with a one-group pre-test and post-test method. The data collection process took about three weeks with 30 students that were selected among Year 4 students in a primary school in Kedah as the sample of this research study that are selected by using purposive sampling. Data were obtained by using two types of instruments which include Mental Rotation Test and Computational Thinking Test. The students are required to answer both assessment test before and after the intervention process is done. Data were analysed by using descriptive analysis, normality test and inferential analysis which is Wilcoxon Signed-Rank Test. Data analysis process is done by using version 29 of SPSS software. The findings of the study show that the blended project-based learning is effective to the students' spatial visualization skills based on the positive marks difference of pre, and post Mental Rotation test (MRT) taken by the students. Descriptive analysis shows that there is a significant mean difference of students' marks between pre-assessment tests (m=14) and the post-assessment test (m=32). Wilcoxon Signed-Rank Test is done to further analyse the assessment tests data. The results indicate a significant difference between pre-MRT score

and post-MRT score. Therefore, it can be concluded that there is a significant mean difference of students' marks between pre-MRT and post-MRT. Additionally, the CT on the same sample showed that blended project-based learning also enhanced students' computational thinking, with a significant increase in scores from the pre-CTt (m=19) to the post-CTt (m=41). In conclusion, the researcher found that blended project-based learning is effective towards spatial visualization skills and computational thinking among Year 4 students in learning Scratch.
**Keywords:** Blended Project-Based Learning, Digital Learning, Computational Thinking, Spatial Thinking

## Introduction

Nowadays, digital platforms are becoming increasingly popular among users, especially in the digital ecosystem that is growing rapidly today. (Ha et al., 2023). Along with the evolution of the Fourth Industrial Revolution (IR4.0) in Malaysia, the national schooling system also takes a drastic approach to extend the existing system so that it does not fall behind. Digital Educational Learning Initiative Malaysia, DELIMa, is a learning management system provider for all teachers in Malaysian government schools. This educational digital learning platform was launched in 2020 with three main strategic partners: Google, Microsoft, and Apple. The development of this platform aims to equip educators with advanced technology for comprehensive education management inside and outside the school. It includes a variety of approaches to delivering and implementing curriculum activities, co-curriculum, and co-academics.

The integration of DELIMa is one of the efforts to realize the seventh shift in the transformation of the national education system, which is to utilize ICT to improve the quality of learning as outlined in the Malaysian Education Development Plan (PPPM) 2013-2025. DELIMa contributes to learning with unlimited methods and resources. It covers every subject, including design and technology, that has been taken up by all Malaysian students since they were in Year 4. These include interactive learning experiences, access to diverse resources, facilitating collaboration and communication between students and teachers, personalized learning paths, and adaptive assessments. (Adnan & Husnin, 2024). The DELIMa platform, being a digital learning environment, requires a deliberate pedagogical approach to effectively facilitate student learning. A study by Nkomo et al. (2021) mentioned that educators can engage their learning, foster students' critical thinking, and promote flexible learning by implementing instructional strategies with digital platform features.

Blended Project-Based Learning (BPBL) is one of the innovative learning approaches that can be applied in the DELIMa platform. BPBL is a combination of project-based learning models with blended learning. Through BPBL, students enhance their ability to tackle real-world challenges within an efficient learning timeframe (Bruggeman et al., 2019; López-Pellisa et al., 2020). Blended project-based learning (PBL) is an educational method that integrates traditional face-to-face instruction with computer-based instruction, producing benefits of both. The BPBL model aims to empower students in their creative works, enabling them to produce meaningful products without the limitations of space or time. (Husamah, 2018). The effectiveness of technology integration in education becomes clear through the ability of teachers to design teaching materials. The strategic implementation of the pedagogical model in the classroom context operates as a key factor in achieving learning objectives. (Sun et al., 2018).

Spatial visualization skills refer to the ability to mentally manipulate and understand spatial objects and visualize their movements and transformations in space. Spatial visualization skills are identified as a critical competence for academic achievement, particularly in science, technology, engineering, and mathematics (STEM) fields, including computer science subjects. In Malaysia education, the curriculum transformation introduced Design and Technology subject as a Science, Technology, Engineering, and Mathematics (STEM) domain that supports students' critical thinking skills in problem-solving as students create, assess, and redesign projects (Bahagian Pembangunan Kurikulum, 2019).

Hence, in design and technology subjects, specifically Scratch learning, spatial visualization skills are essential for learning and solving problems involving visual-spatial information, such as block arrangement, manipulating sprites' motions, understanding the coordinate system in Scratch, and improving 3D visuals. Thus, spatial visualization skills are fundamental to understanding and excelling in various STEM subjects, as they allow students to mentally manipulate and visualize spatial information, which is often a key component of problem-solving in these fields. (Pilato et al., 2023). High spatial visualization skills among students can help them improve problem-solving skills and support students in developing conceptual understanding in learning.

Computational thinking (CT) was first introduced in higher education in the 1990s, but not in K-12 schools due to a lack of computers and related hardware problems. In addition, only a few teachers have experience using computers. (Denning Tedre, 2019). Later, following the advent of the Internet, there has been an increased emphasis on fostering information technology skills and information literacy. Therefore, computational thinking (CT) has been included in the primary school curriculum. (Kong et al., 2018; Lindberg et al., 2019). Computational thinking (CT) has been recognized as a valuable skill for primary school learning that helps students develop problem-solving abilities, understand human behaviour, and design systems through basic computer science concepts. (Wing, 2006). Additionally, game-based learning platforms have been used to develop CT in primary school students, guiding them to boost motivation and confidence in practicing computational thinking.

Teachers and students can conduct learning activities both online and offline by using the DELIMa platform. It allows flexibility in the learning process (Adnan & Husnin, 2024). Additionally, the platform offers access to applications that can facilitate teaching and learning, such as Google Classroom, Google Drive, Jamboard, Quizziz, Padlet, Scratch, Kahoot, and Canva. Investigating the effectiveness of Blended Project-based Learning to enhance students' spatial visualization skills and computational thinking in Year 4 primary school students is essential to improve teaching practices. By using various tools and resources that can improve learning efficacy in this study, teachers can create more interesting and interactive learning experiences, encourage student-centered learning, and improve their spatial visualization skills, which ultimately leads to better teaching practices and student learning outcomes.

Scratch is an instructional tool and a free visual programming language developed by the Lifelong Kindergarten group at the MIT Media Lab that has been used to teach computational thinking (CT) in K-12 education. It offers more than 100 programming blocks, enabling users to create interactive stories, games, and simulations. Scratch is designed to be user-friendly, allowing children to think creatively and collaboratively using colourful blocks to create scripts. It is aimed at engaging young learners and providing an accessible starting point for learning programming with limited or no background in programming (Sáez-López et al., 2016). It is accessible and usable, yielding positive outcomes for students learning programming and developing problem-solving skills (Oyelere et al., 2022).

Scratch has been used as a tool for teaching computational thinking skills to students in the primary school age range (Zhang & Nouri, 2019). In Malaysia, we are also using Scratch as a learning tool in our primary school that had been embedded as a part of the Design and Technology subject for Year 4 students as an introduction to basic computer science learning. The basis of students' computational thinking that was first introduced through learning Scratch will be further developed with programming in year 5 and the basics of robotics in year 6 at the primary school level. Therefore, the selection of Scratch learning for year 4 that this study will carry out is expected to prove the effectiveness of Scratch learning on students' computational thinking, thus detecting its connection with students' spatial visualization skills.

This research is poised to make several important contributions. Firstly, it will shed light on the effectiveness of merging DELIMa into the existing educational framework. By investigating academic performance, the study can provide insights into whether this digital initiative learning platform can impact student learning outcomes positively. Secondly, the investigation will explore spatial visualization skills, a crucial aspect of design and technology subject. Understanding how DELIMa influences these skills can improve curriculum development and teaching strategies. Overall, this research aims to enhance educational practices and foster innovation in Malaysian schools.

## Literature Review

### *Pedagogical Approach in Blended Learning*

Blended learning (BL) is an educational approach that integrates traditional face-to-face instruction with online learning. It is a comprehensive system involving the learner, teacher, technology, content, learning support, and institution (Li and Yoon, 2024). This approach also refers to a model that combines various learning styles, environments, and teaching methods to improve the effectiveness of traditional education (Marsh, 2012). Additionally, it offers flexibility and a range of pedagogical approaches, such as the rotation model, flex model, a la carte model, and enriched virtual model.

However, to ensure successful implementation and the achievement of objectives, it is crucial to carefully design and consider learning content, incorporating the perspectives of both students and teachers (Tayag, 2020). To support this, Martín-García (2020) has proposed a theoretical framework and pedagogical tools. Additionally, Astudillo (2020) suggests a pedagogical model that effectively structures the teaching-learning process to promote student autonomy and active participation. Collectively, these studies highlight the necessity of a competent and context-specific approach to blended learning, with a focus on alignment, technical support, and pedagogical tools.

*Station Rotation Model of Blended Learning*

In blended learning, the station rotation model has students move between different learning stations to complete their activities. These stations can be inside or outside the classroom, based on the teacher's arrangements. The teacher plans and organizes these stations to give students various learning experiences, helping them understand the material better. By using this method, at least one of these stations must incorporate an online learning approach. This flexible model lets students switch stations during the learning period as directed by the teacher. Studies show this model improves student achievement and helps teachers enhance their teaching quality, making it a promising approach for future implementation.

Research by Mahalli (2019) and Lonigro (2021) demonstrates the application of the station rotation blended model in blended learning. This approach is found to boost students' interest and motivation in their studies. Additionally, it supports personalized learning and fosters collaborative relationships among students. Ayob (2020) indicates that the station rotation model positively impacts student achievement. He also recommends in his study that this learning method should be utilized and refined for future educational practices. Collectively, these studies suggest that the station rotation model enhances the blended learning experience.

*Project-based Learning*

Project-based learning (PBL) is an approach that engages students in the real world with challenging projects to enhance knowledge and encourage skill development that promotes critical thinking, communication, and collaboration skills while enhancing student autonomy and responsibility (Shpeizer, 2019). PBL has positively affected student learning outcomes, including cognitive, affective, and behavioural aspects (Guo et al., 2020). However, the implementation of this learning method also faced several challenges including limited technological knowledge and difficulties in producing innovative design ideas (Handrianto & Rahman, 2019). Despite the previously discussed challenges, project-based learning remains a promising pedagogical approach that encourages an engaging learning experience as well as maintains students' attention and motivation.

*Spatial Visualization Skills in Learning*

Spatial visualization skills are crucial for primary school students as they provide the basic concepts in science, technology, engineering, and mathematics (STEM). These skills help students to understand and solve problems related to shapes, spatial relationships, and geometry (Burte et al., 2017). Additionally, the findings of this study show that spatial visualization skills are necessary for interpreting and creating visual representations, understanding maps, and understanding spatial information in real-world contexts. Therefore, developing these skills at a young age can enhance students' future success in STEM subjects and help them for future studies and careers, especially in the STEM field.

Research by Epler-Ruths (2020) found that middle school students with higher spatial skills tended to notice and interpret details in a plate tectonics computer simulation, leading to increased understanding. This suggests that spatial skills are necessary in learning from computer simulations. Atit (2020) showed that spatial skills and motivation interact together to predict middle school students' mathematics performance. These findings underscore the importance of spatial skills in STEM learning, particularly in the context of computer simulations. Wang (2017) demonstrated that mobile applications can help in reducing the performance gap between students with different levels of spatial ability, mainly by multi-touch interfaces.

Table 1
*Meta-Analysis of Spatial Visualization Skills among Students*

| Author | Objectives | Samples | Finding | Journal |
|---|---|---|---|---|
| Epler-Ruths et al. (2020) | to investigate the differences in what high and low-spatial-skilled middle school students notice and interpret while using a plate tectonic computer visualization, and to examine the differences in the quantity and quality of students' spatial language. | 119 seventh-grade students | There are differences in the use of spatial words between high and low-spatial students. | Focus on the notice: evidence of spatial skills' effect on middle school learning from a computer simulation |
| Atit et al. (2020) | To examine the relationship between spatial skills and motivation for mathematics.<br><br>To investigate how spatial skills and motivation interact to predict students' mathematics performance. | 1056 7th grade students (530 males, 526 females) from the state of Michigan in the United States | This research shows that Spatial skills and motivation interact to significantly predict students' mathematics performance, contributing to middle school students' mathematics achievement. | Examining the role of spatial skills and mathematics motivation on middle school mathematics achievement |
| Lowrie et al. (2019) | to determine the effectiveness of a spatial visualization intervention program on increasing student spatial reasoning and mathematics performance, and to provide new insights about the aspects of mathematics performance that are | 327 students from 17 classrooms across ten schools with nine experimental and eight control classes. | The spatial visualization intervention program significantly improved student spatial reasoning performance, particularly in spatial visualization and | The Influence of Spatial Visualization Training on Students' Spatial Reasoning and Mathematics Performance |

| | | | | |
|---|---|---|---|---|
| | most affected by spatial visualization training. | | spatial orientation. | |
| Taylor et al. (2023) | To investigate the impact of spatial visualization skills on the transfer of learned concepts across different domains and disciplines. | students, educators, and researchers in the fields of cognitive psychology, educational technology, and STEM disciplines. | This research integrates knowledge from cognitive psychology, educational technology, and STEM disciplines, providing a comprehensive and interdisciplinary understanding of spatial thinking and its relevance to STEM learning | Connecting spatial thinking to STEM learning through visualizations |

Based on the studies above, we can conclude that educators should consider the interplay of spatial skills, motivation, and effective interventions to promote spatial thinking among students. By embracing an interdisciplinary perspective, we can create more robust educational practices that empower learners in STEM fields.

*Mental Rotation Test*

The Mental Rotation Test (MRT) is a tool for assessing spatial visualization skills, which are the ability to mentally manipulate and rotate two-dimensional or three-dimensional objects within one's mind. The test first introduced by Shepard and Metzler (1991), involves mentally transforming a visual stimulus into a new orientation to determine whether it matches a standard stimulus. Their classic investigation examined how quickly participants could recognize congruence between pairs of rotated objects, which provides an understanding of their spatial visualization abilities. The ability to perform mental rotations of objects in three-dimensional space is a critical component of spatial visualization skills. Therefore, the mental rotation test evaluates individuals' ability to mentally rotate and manipulate spatial information, measuring their spatial visualization abilities.

Arıkan and Çetin (2024) used the Mental Rotation test (MRT) consisting of 24 items in their study to evaluate the intrinsic dynamic dimension of spatial skills. Nolte et al. (2022). Peters and Battista (2008) adopted the test into their research to briefly cover the nature and applications of three-dimensional cube figure mental rotation figures. Meanwhile, Beckham et al. (2023) adapted the mental rotation test by Shepard and Meltzer. They created a dataset called CLEVR Mental Rotation Tests (CLEVR-MRT) in their research to understand the ability of modern deep neural architectures to perform mental rotation tasks and to build architectures better suited to 3D inference and understanding.

The Mental Rotation Test (MRT) has good internal reliability, and its psychometric characteristics support its use in research and pedagogical objectives. So, this research will use the Mental Rotation Test to assess students' spatial visualization skills in this study before and after implementing the blended project-based learning into Scratch. The test will also be adapted carefully to ensure it is suitable for assessing 11-year-old students.

*Spatial Visualization Skills among Students*

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*Computational Thinking in Learning Scratch*

Teaching computational thinking to primary school students means helping them think logically, break down problems into smaller parts, and solve them using programming languages. It also involves developing skills like algorithmic thinking, teamwork, critical thinking, and problem-solving (ISTE, 2018; Zhang et al., 2024). This approach prepares children to handle real-world challenges effectively, rather than just using computational tools. The importance of developing computational thinking in children is increasingly recognized in educational policies and curricula, showing its value for the future.

Computational thinking is a key skill that involves a systematic way of solving problems and is valuable for all students. It can be used to solve both simple and complex problems, making it useful for younger students. Structured, problem-based curricula, along with guided inquiry teaching methods, help develop this skill. For example, activities like programming floor robots or using an iPad app help nurture computational thinking skills.

*Challenges in Improving Computational Thinking Ability among Primary School Students*

The difficulties in enhancing computational thinking skills among primary school students involve incorporating computational thinking into the curriculum, using effective teaching methods, and addressing age-related misunderstandings about programming and computational thinking (Wing, 2006).

Improving computational thinking skills among primary school students presents several challenges. Firstly, there is limited research on how to effectively implement computational thinking in primary schools. Secondly, educators need practical and effective methods for introducing computational thinking concepts to young learners. Thirdly, concerns arise regarding the appropriate use of technology with children, especially at a young age. Additionally, empirical studies exploring structured approaches to teaching computational thinking to very young students are lacking. Lastly, developmental limitations must be considered when integrating technology into the learning process for children of this age group (Chalmers, 2018; G. Falloon, 2024).

Furthermore, Sun et al. (2022) state that there is a critical need for robust evaluation tools to assess students' computational thinking skills. Simultaneously, integrating computational thinking into the curriculum necessitates the adoption of varied teaching strategies. And these strategies aim to enhance students' academic achievement by engaging them in meaningful computational thinking activities. Based on previous research findings, we can conclude that integrating computational thinking across subjects, fostering positive perspectives, and emphasizing skill development can lead to meaningful learning outcomes for primary school students. When students develop a positive perspective on computational thinking, it contributes to their sense of identity as capable problem solvers and creators.

**Digital Learning Platform**

Digital platforms facilitate collaboration beyond physical classroom boundaries. Students can engage in discussions, share resources, and collaborate asynchronously. After all, blended PBL leverages both face-to-face interactions and online platforms, allowing students to collaborate effectively regardless of their location. In this digital era, online learning has become increasingly popular and widespread. Students' preferences are shifting towards ICT- and web-based tools tailored to their educational needs. Consequently, educational institutions must adapt by embracing online teaching methodologies (Petrolo et al., 2023). Effective visualization of online learning is crucial for assessing learner performance, evaluating the efficacy of online learning platforms, and anticipating potential dropout risks (Zhang et al., 2022). Therefore, good digital platforms provide access to a wealth of resources, including online libraries, tutorials, and multimedia content.

A digital learning platform refers to an online environment or software system designed to facilitate the delivery of educational content, interaction, and collaboration. These platforms support various forms of learning, including formal education, professional development, and informal skill-building. Digital learning platforms often incorporate features such as content delivery, assessment tools, communication tools, and interactive resources to create a comprehensive learning experience. Amidst the Industrial Revolution 4.0, employing digital learning platforms has become essential to enhance the quality and effectiveness of teaching and learning (Hui & Mahmud, 2022).

*Challenges in Adapting Digital Learning Platforms to Teaching and Learning*

The transition to digital learning platforms in today's education offers advantages and challenges to our educational trends. The challenges in adapting digital learning platforms to teaching and learning include technical skills, teacher attitudes toward educational change, limited technical readiness, time limitations, and workload. This statement is supported by

Subban et al. (2022) and İbili et al. (2024), both acknowledged limited e-learning infrastructure, financial limitations, and time limitations as challenges, while assisted performance and sharing of ideas were highlighted as ways to resolve these challenges.

Sinaga & Pustika (2021) additionally highlight the challenges of the need to promote access to digital tools and learning materials, as well as to address any negative perceptions or attitudes towards virtual learning. Furthermore, the role of teachers in leading and managing online classes effectively is essential, and they may face challenges in adapting their teaching methods to the online environment. So, teachers may first need help mastering the technical aspects of digital learning platforms and adapting to the changes in educational practices.

Additionally, limited technical infrastructure and support, time constraints, and heavy workloads can pose challenges to effectively integrating digital learning platforms into teaching and learning. The teachers might commonly face those challenges as educators. Research by Quraishi et al. (2024) indicates that students show strong confidence in using digital tools for academic purposes, influenced by prior experience and training. Furthermore, the study highlights the impact of incorporating digital literacy within higher education curricula, providing valuable insights into its efficacy and underscoring its importance in equipping students to face future digital challenges. However, this study's findings may not reflect the entire level of learning and educational institutions, especially at the primary schools in Malaysia. For early education, teachers need to ensure that digital learning platforms are age-appropriate and align with the subject's content. Furthermore, teachers may need to find ways to integrate digital learning content effectively into the curriculum to successfully achieve their learning objectives.

*Scratch Learning for Primary School Students*

Scratch is an application that teaches various subjects, such as computer science, programming, language, and mathematics (Zhang & Nouri, 2019). It is a visual programming language commonly used for educational purposes, particularly in teaching children and beginners the coding basics and computational thinking. Its user-friendly design allows learners to create interactive stories, games, and animations by snapping together code blocks. Scratch is widely used in primary schools and educational workshops to introduce programming concepts to young learners (Ismail et al., 2016). The review by Zhang and Nouri (2019) also highlights that Scratch projects in primary school settings have included games, animation, storytelling, picture collages, art and music projects, and web adverts. The systematic review by Zhang and Nouri (2019) mentioned that Scratch benefits primary school students in developing computational thinking (CT) skills. The review identified that Scratch helps students explore and learn different levels of knowledge of CT skills, depending on their cognitive difficulties. Additionally, the review included studies conducted with primary school students, indicating that Scratch is suitable for this age group. Therefore, the evidence shows that Scratch works well for teaching computational thinking to primary school students

*Challenges in Scratch Learning for Primary School Students*

Even though many schools teach programming, more research is needed to show how teaching and learning programming affects students, especially in early education, because programming requires different ways of thinking and covers different areas of knowledge that are important for kids to learn 21st-century skills. Fagerlund et al. (2022) state that students face challenges in learning Scratch, including difficulties managing high loads of information, an inability to generalize computational abstractions, and encountering bugs that may represent misconceptions.

Additionally, the review suggests that the learners' age and cognitive development level can impact the difficulty of learning specific computational thinking skills through Scratch. It also mentions that specific skills, such as predictive thinking, can be particularly challenging for young learners. These challenges underscore the importance of addressing potential barriers to learning computational thinking in primary education. Therefore, this research aims to design a practical learning process to ensure students can understand and apply complex programming concepts effectively to create a Scratch project ideally.

Table 0
*Meta-Analysis of Scratch Learning for Primary School*

| Author | Objectives | Samples | Finding | Journal |
|---|---|---|---|---|
| Fagerlund et al. (2022) | to examine computational thinking among fourth-grade students engaged in pair programming using Scratch specifically four interconnected dimensions of computational thinking and investigate how different roles in pair programming influence the design processes. | fourth-grade students (10 to 11 years old) and their regular teachers from three classes in an average-sized Finnish primary school. | the study highlighted various computational and social factors that shaped the programming processes of fourth-grade students. | Fourth-grade students’ computational thinking in pair programming with Scratch: A holistic case analysis |
| Zhang and Nouri (2019) | To systematically examine the computational thinking (CT) skills that can be obtained through Scratch in K-9, based on empirical evidence. | the sample sizes varied from fewer than 20 participants to more than 100, | The review highlighted the challenges faced by students in learning Scratch, such as difficulties with complicated loops, cognitive load in mastering the use of variables, and struggles with making predictions. | A systematic review of learning computational thinking through Scratch in K-9 |
| Topali and Mikropoulos (2021) | To explore the quality of Scratch-based learning objects for teaching and learning programming in primary education, investigate evaluations by teachers and students, and address the research gap in using learning objects for teaching computer programming in primary education. | 25 teachers and 91 students from two Greek primary school | both teachers and students perceived the Scratch-based Learning Objects, LOs positively in terms of quality, learning effectiveness, and student motivation. | Scratch-based learning objects for novice programmers: exploring quality aspects and perceptions for primary education |

Previous research had recognized several challenges in teaching Scratch to primary school students, including the abstract nature of programming concepts (Topali, 2021), the need for effective teaching methods (Sue, 2014), and the complexity of developing computing-electronic competencies (Silva, 2019). To address these challenges, the use of learning objects (LOs) has been proposed as a way to foster the learning (Topali, 2021), and the gamification of Scratch has been shown to improve students' knowledge (Prykhodchenko, 2020). Additionally, an Annotation-based Scratch Programming (ASP) tool has been found to enhance students' performance (Sue, 2014). These findings indicate that a variety of effective teaching methods, using learning objects, and the gamification of Scratch could help overcome the challenges in teaching this programming language to primary school students.

*Blended Project-based Learning*

Blended Project-Based Learning (BPBL) is an educational approach that involves the use of ICT-based multimedia learning, which delivers material both in class and online and is designed to improve student activities and learning outcomes (Mursid et al., 2021). It integrates the advantages of blended learning environments with project-based learning to improve student engagement and develop crucial skills such as communication, collaboration, critical thinking, and creativity.

Several studies have explored the design and implementation of blended project-based learning (BPBL) models. Saputra (2019) and Zhi (2016) highlight the need to customize learning activities to accommodate different learning styles and individual needs. The research by Saputra specifically focusses on the use of learning applications, while Zhi proposing a framework for blended project-based learning in his study. Meanwhile, Alfaro (2019) integrates project-based learning into an adaptive e-learning environment, utilizing artificial intelligence to align projects with student characteristics. Lam (2011) offers a project management model for developing blended learning courses, applicable to BPBL design. All together, these studies demonstrate the potential of blended project-based learning models to enhance student learning and engagement.

However, the successful implementation of blended project-based learning may face challenges related to technology integration, teacher training, and student engagement. These challenges can include issues with access to technology, the need for professional development for educators, and ensuring that students are motivated and equipped to engage with the online and project-based components of the learning environment.

**Methods**

A quantitative research method by using a pre-experimental one-group pre and post-test research design will be employed in this research study. There is no treatment group involved to avoid the communication that might occur between the control group and the treatment group. Quantitative data will be obtained through an online Spatial Reasoning Instrument (SRI) and Project assessment. The results from the assessment tests and SRI will be analysed and presented in tabulated data and statistical values.

The participants of this research study consist of Year 4 students from selected schools in the northern part of Malaysia. It will involve 30 students. The selection of participants from these specific schools and the assignment of students based on their availability and willingness to participate indicates the use of convenience sampling. The sampling technique used in this research study is purposive sampling.

To ensure that the research study is conducted clearly and strategically, the procedure for this research is carried out in three different phases. Figure 3.1 below shows the phases involved in this research study.

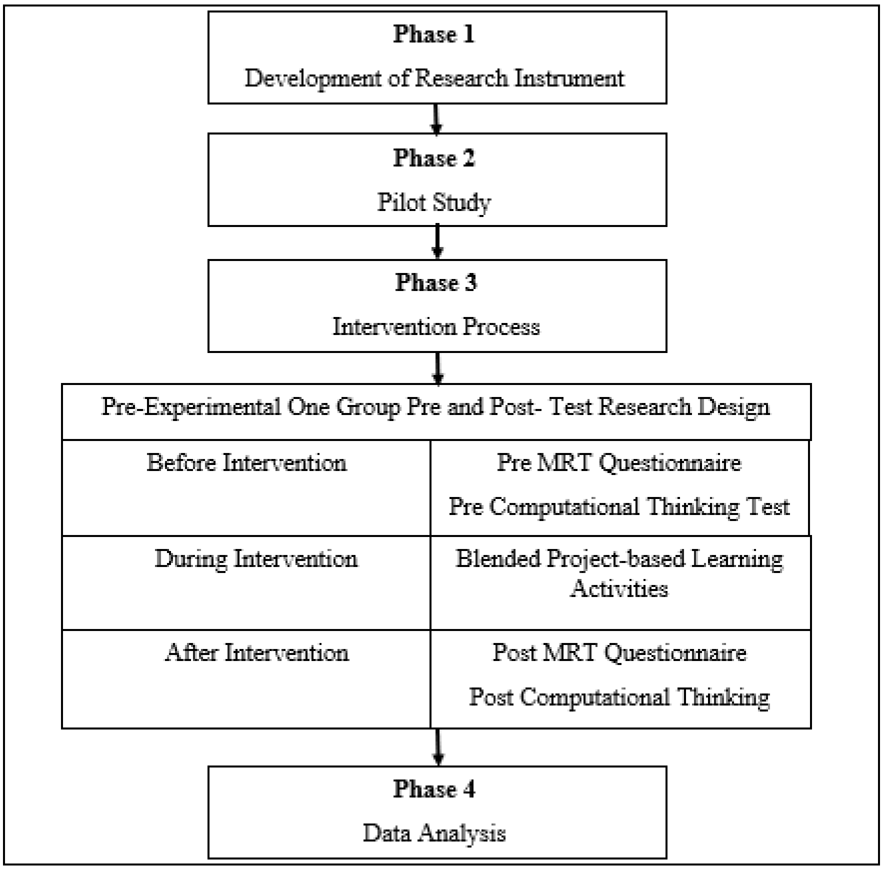


Figure 1 Research Procedure

This first phase of the research study is the development of instruments that will be used in the research. The second phase is the stage pilot test followed by the intervention process in the third phase. The fourth phase of the research study is data analysis.

*Phase 1: Development of Research Instruments*

In this phase, the research instruments are prepared and developed by the researcher. Two types of research instruments are developed in this research study, which will be further explained in section 3.5. The research instruments developed consist of the Computational Thinking Test form and Mental Rotation Test (MRT) that will be distributed to the sample of the research. There will be two versions of the instruments which consist of pre- and post-MRT and Computational Thinking Test forms.

*Phase 2: Pilot Study*

A pilot study is being conducted in this phase to ensure the validity and reliability of the instruments that are developed in the first phase. The instruments include both MRT and Computational Thinking test assessment forms.

*Phase 3: Intervention Process*
In this phase, the intervention process will be done with the real sample. Data collection and learning activities are being conducted in this phase.

*Before Intervention*
The researcher distributes the instruments which include the MRT and Computational Thinking test questionnaire for the students before intervention. The students are required to answer the tests through Forms. A total number of 28 questions must be answered by the students in 45 minutes for the Computational Thinking Test and 15 questions for the Mental Rotation Test (MRT). Data collected during this phase will be recorded for the analysis process in the next phase.

*During Intervention*
To design and develop an online learning environment in DELIMa for the samples of the research study, the researcher will apply the station rotation blended Learning for the Project-based activity in learning Scratch. Pedagogically, the blended learning model encourages the creation of an active, learner-centered learning atmosphere and good interaction in the learning process. The station rotation model of blended learning involves students rotating among different learning modalities, including teacher-led instruction, independent work or collaborative activities, and online learning. The researcher will design and develop blended learning that integrates these three modalities of station rotation for Scratch.

Table 3
*Blending Station Rotation Model with Project-based Learning in Scratch*

| Modalities | Learning Activities |
|---|---|
| Online Learning | • Teacher creates engaging and interactive online content for self-paced learning that includes videos, quizzes, and exercises related to Scratch programming.<br>• Teacher scaffolds student learning provides guidance and facilitates discussions in the DELIMa Platform.<br>• Teacher plans suitable assessments to monitor student progress in DELIMa. |
| Teacher-led Learning | • Teacher prepares lesson plans for in-person instruction that complement online modules.<br>• This station focuses on deepening understanding, clarifying doubts, and providing hands-on support. |
| Independent Work or Collaborative Projects | • Teacher designs group activities that encourage peer learning and teamwork.<br>• Students collaborate, set goals, and create a storyboard for the digital storytelling project.<br>• Students use Scratch to build the digital storytelling. |

The intervention will be conducted in four weeks. The students will be getting the tutorials, self-learning materials, and online discussion on the DELIMa platform. They are required to complete the task assigned individually. The students will be working on the tasks given both online and face-to-face. They are expected to upload the Scratch project to DELIMa, share their progress, and problems, and conduct active discussions with classmates and the teacher for feedback. For face-to-face, the students will have in-class presentations of Scratch storyboard, peer review sessions, and reflection on the learning process. Figure 3.2 below shows the screen capture of the Google Classroom via the DELIMa platform where materials will be uploaded for the students' reference.

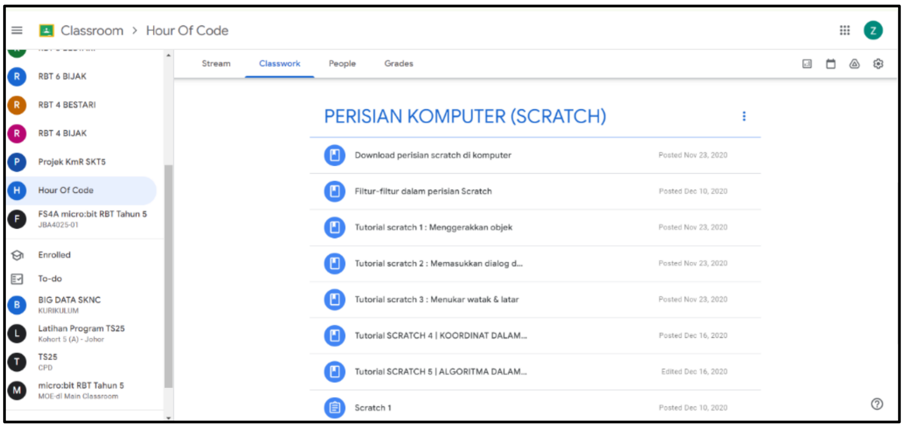


Figure 2 Google Classroom through DELIMA Learning Platform

*After Intervention*

After students have participated in all learning activities, a post-assessment and a Mental Rotation Test (MRT) are administered via a Form. This process aims to evaluate the effectiveness of Blended Project-based Learning activities carried out by the students during the intervention. The assessment questions are identical to those answered by the students before the intervention, allowing us to determine if there has been any improvement. The collected data will be analyzed in the next phase.

*Phase 4: Data Analysis*

In this phase, we analyze all the data collected during the intervention process. The data is tabulated and presented in statistical form. Specifically, the results from the pre-and post-Mental Rotation Test (MRT) assessments are subjected to descriptive analysis, where we calculate frequencies and percentages. Additionally, the pre-and post-assessment test results undergo both descriptive analysis and inferential analysis, specifically using the Paired Sample T-Test.

*Research Instruments*

In this research, we utilize two types of instruments: Computational Thinking Test and Mental Rotation Test (MRT) questionnaires. Both instruments will have pre- and post-assessments. The research sample will engage in PBL activities, which will be assessed by the teacher. Additionally, participants will complete the MRT and Computational Thinking Test assessments before and after the research study. These instruments were carefully chosen to address the research questions outlined in the study. Table 3.1 provides an overview of the instrument types used, aligned with the research questions.

Table 4
*Blending Station Rotation Model with Project-based Learning in Scratch*

| No. | Research Question | Research Instrument |
|---|---|---|
| 1 | How effective is Blended Project-based Learning toward year 4 students' spatial visualization skills in learning Scratch? | Pre- and post-Mental Rotation Test |
| 2 | How effective is Blended Project-Based Learning for year 4 students' computational thinking in learning Scratch? | Computational Thinking Test |

*Instrument 1: Pre and Post- Mental Rotation Test (MRT)*
In this research study, the researcher uses the Mental Rotation test (MRT), developed by Steven G. Vandenberg and Allan R. Kuse in 1978. This test was widely used to assess spatial visualization ability. The Pre- and Post-Mental Rotation Test (MRT) is administered to the student sample before and after the intervention. Both the pre- and post-assessment tests contain identical questions and aim to analyze the mean difference in students' spatial visualization skills before and after Blended Project-Based Learning is conducted. This test measures an individual's ability to mentally rotate three-dimensional objects presented in two-dimensional drawings. The assessment comprises 24 questions. Each question carries one mark, resulting in 24 marks for the assessment. Table 3.4 below shows the examples of the Mental Rotation Test (MRT) based on the constructs. Students will respond to the assessment questions using Microsoft Forms. Please refer to Appendix B for the complete set of assessment test questions.

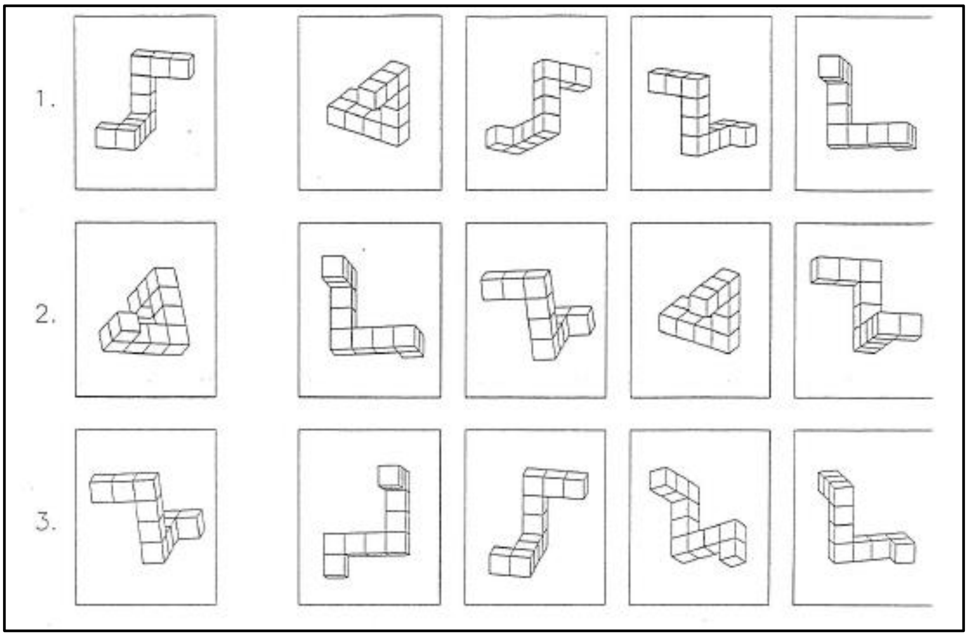


Figure 3 Example of Mental Rotation Test (MRT)

*Instrument 2: Computational Thinking Test*
In this research study, the researcher uses a Computational Thinking test (CTt) by Roman-Gonzalez et al. (2017). In this term of research, students' Scratch project on digital storytelling animation will be their assignment that needs to be evaluated by the teacher. Students will complete project assignments before and after the intervention is implemented. The

assessment of student work will be conducted before and after the intervention. This assessment aims to evaluate the effectiveness of blended project-based learning activities on students' computational skills by assessing whether there are differences in student performance before and after the intervention. The assessment consists of 10 components and is divided into three main elements to be assessed, which are technical elements, multimedia elements, and content elements. The highest score of each element is 10 marks, hence the total marks for the PBL assessment is 100. Each component will be evaluated based on the rubric shown in Table 3.5. The teacher will evaluate the projects in the Microsoft Form.

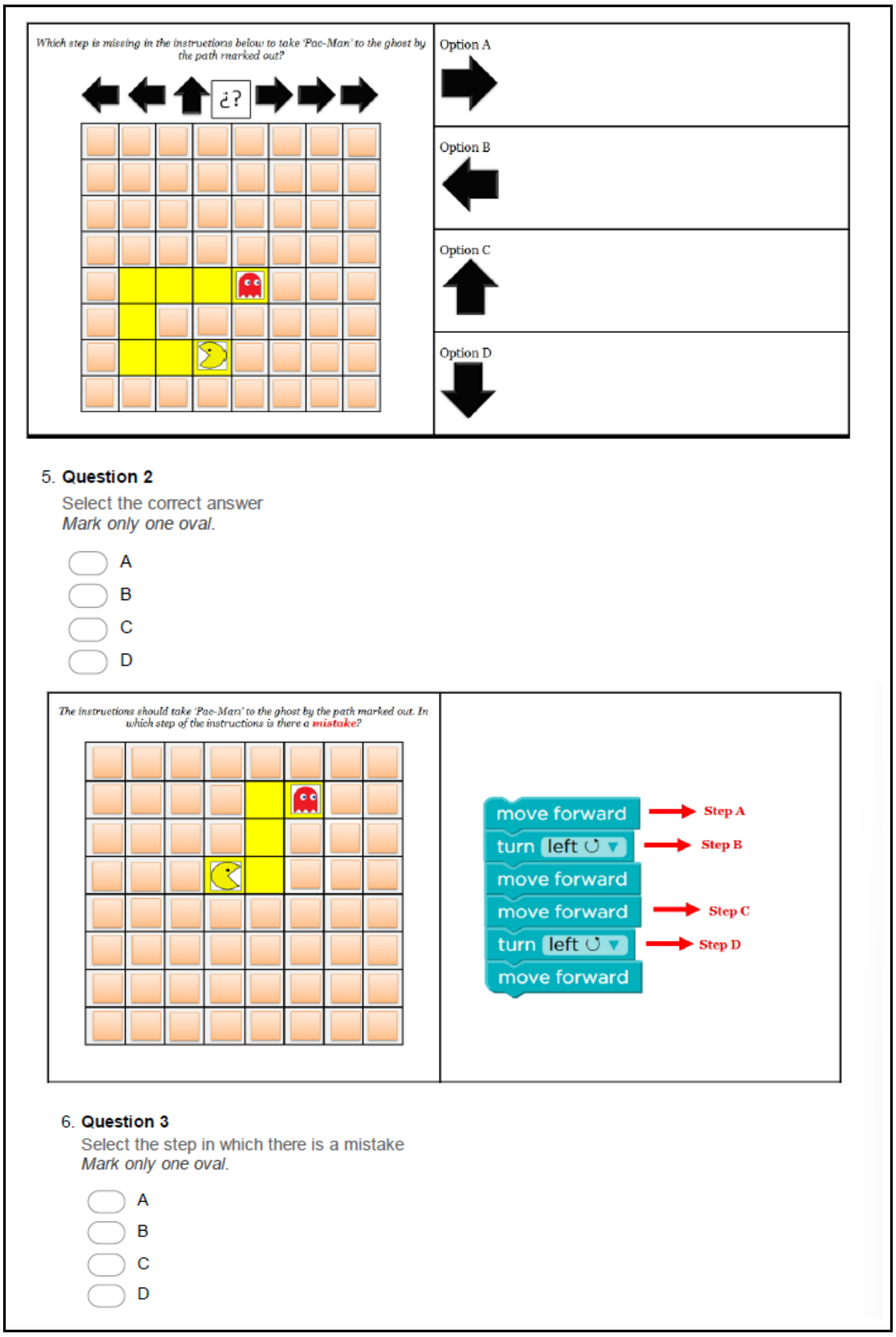


Figure 4 Example of Computational Thinking test (CTt)

*Pilot Study*

The researcher conducts a pilot study to assess the validity and reliability of the developed research instruments. This step ensures that the instruments are suitable for collecting and analyzing data from actual samples. For the pilot study, ten Year 5 students from a primary school in the Northern Region of Malaysia, who are already familiar with Scratch programming, participated in the PBL activity and answered the MRT and Computational Thinking Test. It's important to note that these selected students are not part of the main research sample.

The selected students are required to complete the task given for the PBL activity using Scratch and answer the MRT and Computational Thinking Test before learning activities are conducted. The learning activities are conducted within a week. After that, the students will complete the post-PBL task using Scratch, MRT, and Computational Thinking Test. The researcher distributes both tests to the students through Microsoft Forms.

*Validity of Instrument*

A test is deemed valid when it accurately measures what it purposed to measure. Consequently, the validation process ensures that the instruments used for data collection are appropriate for student assessment. To meet these criteria, the researcher will engage two Computer Science lecturers as content experts to validate the Computational Thinking Test and Mental Rotation Test (MRT). According to the feedback from both experts, the MRT and CTt instruments are appropriate for use with the sample in this study.

*Reliability of PBL-Assessment Form and Mental Rotation Test (MRT)*

When choosing an instrument for use in a research study, the researcher must verify its validity and reliability to ensure consistent replication of findings across multiple instances within the same context and population.

To enhance the reliability of the assessment test, a test-retest reliability analysis is conducted using the assessment test scores obtained before conducting the pilot study. This analysis aims to assess the consistency of students' scores between the test and re-test over a specific time. A strong test-retest reliability indicates the test's internal validity and ensures that data collected in a single session are both representative and consistent over time.

The time frame for students to complete the MRT and CTt test for the reliability test is one week. Their scores are then analyzed using SPSS version 29. Figure 3.11 below displays the correlation results of the assessment test scores. Based on the result, the Pearson Correlation value is 0.874 for MRT and 0.917 for CTt. This value is the test-retest coefficient for reliability. An instrument with a correlation value exceeding 0.7 is deemed reliable and suitable for use with the actual sample in the research study.

Table 5
*Correlation result for MRT and CT Test*

| | **MRT** | | **CT test** | |
|---|---|---|---|---|
| | MRTtest | MRTretest | CTttest | CTtretest |
| Pearson Correlation | 1 | 0.817 | 1 | 0.917 |
| Sig. (2-tailed) | | <.001 | | <.001 |
| N | 15 | 15 | 15 | 15 |
| Pearson Correlation | 0.817 | 1 | 0.917 | 1 |
| Sig. (2-tailed) | <.001 | | <.001 | |
| N | 15 | 15 | 15 | 15 |

*Data Analysis*

This quantitative research study involves collecting data, which will be analyzed using both descriptive and inferential methods. The data will address the research questions outlined in Chapter 1. Specifically, the analysis will focus on the second and third research objectives, as these objectives guide the data collection process. The researcher will employ Descriptive Analysis (including frequency and percentage), conduct a Normality Test, and utilize Inferential Analysis (specifically, the Paired Sample T-Test). These methods will be applied to assess Computational Thinking Test (pre and post) and the Mental Rotation Test (MRT) scores (pre and post). Data recording and analysis will be performed using SPSS software version 27. Refer to Table 6 for a summary of the data analysis methods corresponding to each research question.

Table 6
*Data Analysis Methods*

| **No.** | **Research Question** | **Data Analysis Method** |
|---|---|---|
| 1 | How effective is Blended Project-based Learning toward year 4 students' spatial visualization skills in learning Scratch? | a) Descriptive analysis (mean, median, standard deviation)<br>b) Inferential analysis (Paired sample t-test) |
| 2 | How effective is Blended Project-Based Learning for year 4 students' computational thinking in learning Scratch? | a) Descriptive analysis (mean, median, standard deviation)<br>b) Inferential analysis (Paired sample t-test) |

## Results

*Analysis of Effectiveness of Blended Project-Based Learning Towards Spatial Visualization Skills among Year 4 Students in Learning Scratch*

The second purpose of this research is to evaluate the effectiveness of Blended Project-based Learning in relation to spatial visualization skills among Year 4 students in learning Scratch. This assessment question is adopted from the Mental Rotation Test introduced by Vandenberg & Kuse in 1978, which evaluates spatial visualization skills. All the students will answer this test before and after intervention. This assessment test is conducted to evaluate the effectiveness of Blended Project-Based Learning activities in Scratch education on students' spatial visualization skills, particularly for Year 4 primary school students in Malaysia.

Therefore, the researcher analysed the pre-test and post-test results of the 34 students by using both descriptive and inferential analysis methods. The MRT assessment includes 24 questions, with a total score of 100% for both the pre-test and post-test. The same set of questions was used for both assessments to measure the students' improvement after completing all the activities in the Blended Project-Based Learning.

*Descriptive Analysis of Pre- and Post- Mental Rotation Test*

Descriptive analysis is conducted to show the difference in marks between the pre-test and post-test assessments of the students. As shown in table 5.1, the lowest mark in pre-test MRT assessment was 4% recorded by S30, while the highest mark was 28%, achieved by S22. In the post-test assessment, S10 scored the highest mark of 88%, and S30 scored the lowest mark of 8%.

All 30 students showed improvement in their post-test assessments after the intervention, since all the post-test scores show a slight improvement compared to the pre-test scores. S10 demonstrated significant improvement, where the score was increased from 16% in pre-test assessment to 88% in post-test assessment. The second highest improvement was recorded by S26, with a 40% increase. None of the 30 students showed a decline in marks from the pre-test to the post-test assessment.

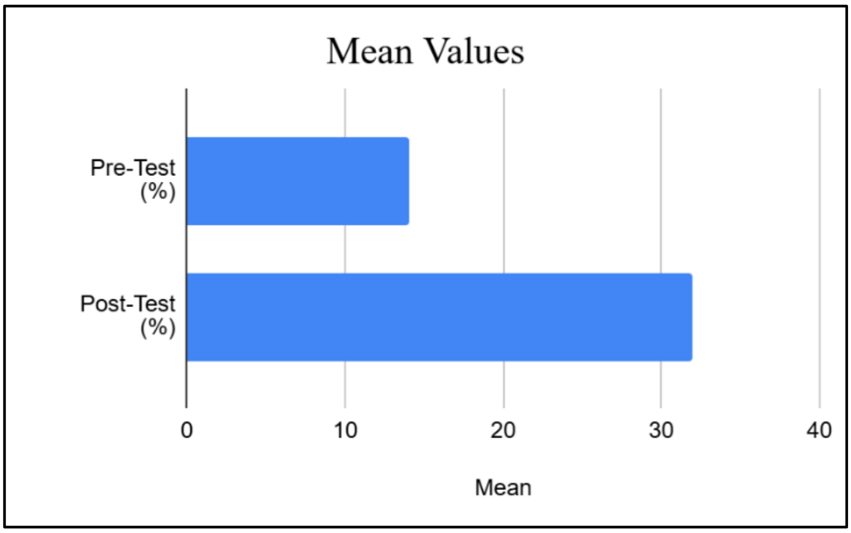


Figure 5 Bar Chart of Mean Values on Pre and Post Test MRT Assessment

Figure 5 above shows the mean values for pre and post-test assessment. Pre-test recorded 14% mean values meanwhile post-test recorded 32% of mean values. There is a total difference of 18% marks between pre and post-test MRT assessment, which means that the scores of the students are increasing by 18%. This can prove that the Blended Project-Based Learning activities in Scratch are effective towards the spatial visualization skills among Year 4 students, as they can show a good improvement from before and after intervention is completed.

*Inferential Analysis of Pre- and Post Mental Rotation Test*

The researcher also analyzes the data of pre- and post- Mental Rotation Test data by using inferential analysis in addition to descriptive analysis. To evaluate the effectiveness of blended project-based learning in Scratch, the data must be examined to find the mean difference of students' marks between pre-assessment test and post-assessment of the Mental Rotation Test. Inferential analysis is performed using SPSS version 29. This research study includes two hypotheses as mentioned below:

H_0: There is no significant mean difference of students' marks between pre-MRT and post-MRT.
H_1: There is significant mean difference of students' marks between pre-MRT and post-MRT

*Normality Test of Mental Rotation Test*
Before selecting the appropriate test to analyze the data, the normality test is conducted to determine whether the data is normally distributed.

Table 7
*Normality Test of MRT*

| | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| prescore | 0.939 | 30 | 0.085 |
| postscore | 0.904 | 30 | 0.010 |

Table 7 presents the normality test conducted on the pre- and post-Mental Rotation Test data. To confirm the normal distribution of the data, the p-value must be greater than 0.05. Based on the data, the p-value of pre score is 0.085 which means that the pre score data is normally distributed. Meanwhile, the p-value for post-test score is 0.010 which is less than 0.05. For this data, the post score data shows that the date is not normally distributed. Hence, the researcher considers using non-parametric test which is the Wilcoxon Signed-Rank Test as the next statistical test since the post score data is not normally distributed.

*Wilcoxon Signed-Rank Test of MRT*
Below is the non-parametric test which is the Wilcoxon Signed-Rank Test that had been done in SPSS version 29 to compare the two related samples in this study, which are the pre-score and post-score of MRT, to identify if their population mean rank differ.

Table 8
*Wilcoxon Signed Rank Test of MRT*

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| postscore - prescore | Negative Ranks | 0[a] | .00 | .00 |
| | Positive Ranks | 30[b] | 15.50 | 465.00 |
| | Ties | 0[c] | | |
| | Total | 30 | | |

Table 8 shows the result of the Wilcoxon Signed Rank Test of MRT. Based on the result shown, there are no cases in negative ranks where the post-MRT score is lower than the pre-MRT score. The mean rank and sum of rank shows a value of 0, means there are no negative differences between the scores. The result also shows that all 30 cases are in the positive ranks where all the post-MRT score are greater than the prescore. The 0 value of ties means there are no cases where the post-score is equal to the pre-score. Since all the ranks are positive, it can be concluded that the post-MRT scores are consistently higher than the pre-MRT scores for all participants.

Table 9
*Wilcoxon Signed Rank Test Statistic of MRT*

| | postscore - prescore |
|---|---|
| Z | $-4.784^{b}$ |
| Asymp. Sig. (2-tailed) | <.001 |

Table 9 shows the Wilcoxon Signed Rank Test Statistic of MRT. From the result above, the Z-value of -4.784 shows a significant difference between the pre-MRT and post-MRT scores. Since the significance p-value is lower than 0.05, specifically 0.001, the null hypothesis is rejected. Therefore, it can be concluded that there is a significant mean difference of students' scores between pre-MRT and post-MRT.

Hence, it can be concluded that interventions process that is done for blended project-based learning by researcher is effective towards the students' spatial visualization skills.

*Analysis of Effectiveness of Blended Project-Based Learning Towards Computational Thinking Among Year 4 Students in Learning Scratch*

The third objective of this research is to examine the impact of computational thinking on Year 4 students in learning Scratch. To achieve this objective, the students are required to take a Computational Thinking Test (CTt) before and after the intervention is done. This question is taken from the revised version of Computational Thinking Test, created by Marcos Roman González in 2014, which designed to evaluate various aspects of computational thinking, including algorithmic thinking, pattern recognition, abstraction, and problem decomposition.

To examine the impact of blended project-based learning in Scratch on computational thinking among Year 4 students, this research study analysed the pre- and post-test assessment results of 30 students using descriptive and inferential analysis. The CT test assessment contains 28 questions, with a total score of 100%. The same set of questions was used for both pre- and post-tests to measure the students' improvement after participating in the blended project-based learning activities.

*Descriptive Analysis of Pre- and Post-Computational Thinking test*

Descriptive analysis was conducted to show the difference in marks between the pre- and post- test assessments of the students. The mean score for each test was also calculated. According to the statistical analysis in Table 4.1, the lowest pre-test score was 19% recorded by S21, while the highest pre-test score was 56% that was achieved by S6. In the post-test assessment, 4 students scored 67% as it was the highest marks for the test, while the lowest score was 41% % achieved by S13.

From the tests scores results, all students improved in the post-test after the intervention, as they all increased their marks compared to the pre-test. S4 and S28 showed the highest improvement with a 41% increase, while S21 and S29 had the second highest improvement with a 47% increase. None of the 30 students' scores declined from the pre-test to the post-test.

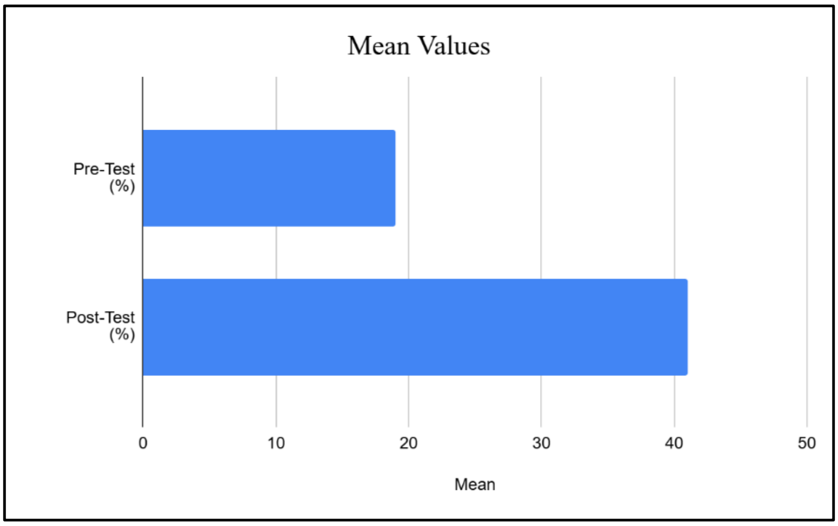


Figure 7 Bar Chart of Mean Values on Pre and Post CTt

Figure 7 above shows the mean values for pre and post CTt. Pre-test recorded 19% mean values meanwhile post-test recorded 41% of mean values. There is a total difference of 22% marks between pre and post Computational Thinking tests, which means that the scores of the students are increasing by 22%. This can prove that blended project-based learning conducted in this research study is effective towards the computational thinking among Year 4 students, as all of them show a very good improvement from before and after the intervention is completed.

*Inferential Analysis of Pre- and Post- Computational Thinking test*

In addition to descriptive analysis, the researcher also conducted inferential analysis on the pre- and post- Computational Thinking test data. All the data collected needs to be analyzed to find the mean difference of students' scores between pre-CT test and post-CT test to evaluate the effectiveness of blended project-based learning towards students' computational thinking. To do that, inferential analysis is done in version 29 of SPSS. There are two hypotheses identified in this research study:

$H_0$: There is no significant mean difference of students' marks between pre-CTt and post- CTt.
$H_1$: There is significant mean difference of students' marks between pre-CTt and post-CTt.

*Normality Test of Computational Thinking Test*

Before selecting the appropriate test for data analysis, a normality test is conducted to determine whether the data is normally distributed or not.

Table 10
*Normality Test of CTt*

| | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Pre-test | .970 | 30 | .528 |
| Post-test | .913 | 30 | .017 |

Table 10 shows the normality test that is conducted on the pre and post computational thinking test data. To determine the normal distribution of the data, the p-value (Sig.) for each test must be more than 0.05. Based on the data, p-values for pre-test are 0.528. Meanwhile, p-values for post-test are 0.017. The researcher is choosing Shapiro-Wilk values to determine the normal distribution of the data. So, for this data, it can be concluded that the data is normally distributed since the p-value of pre-test score is greater than 0.05. For the postscore of CTt, since the p-value is less than 0.05, we must reject the null hypothesis that indicates the scores of the posttest are not normally distributed. Hence, the non-parametric test can be used for data analysis to compare paired samples is Wilcoxon Signed-Rank test.

*Wilcoxon Signed-Rank Test of CT Test*

The Wilcoxon Signed-Rank Test was selected to analyze the data. It is used to evaluate the population mean rank difference between two related samples, specifically the prescore and the postscore of the Computational Thinking test.

Table 11
*Wilcoxon Signed Rank Test of CTt*

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| postscore - prescore | Negative Ranks | 0[a] | .00 | .00 |
| | Positive Ranks | 30[b] | 15.50 | 465.00 |
| | Ties | 0[c] | | |
| | Total | 30 | | |

Table 11 presents the result of the Wilcoxon Signed Rank Test of CT test. Based on the results shown, there are no negative rank, meaning no post-CT test scores are lower than the pre-CT test scores. Both the mean rank and sum of rank shows a value of 0, means there are no negative differences between the scores. Additionally, all 30 cases are in positive ranks where all the post-CT test scores are greater than the prescore. The 0 value of times means there are no cases where the post-score is equal to the pre-score. Therefore, it can be concluded that the post-CT test scores are consistently higher than the pre-CT test scores for all participants.

Table 12
*Wilcoxon Signed Rank Test Statistic of CTt*

| | postscore - prescore |
|---|---|
| Z | -4.787[b] |
| Asymp. Sig. (2-tailed) | <.001 |

Table 12 shows the Wilcoxon Signed Rank Test Statistic of CTt. From the result above, the Z-value of -4.787 shows a significant difference between the pre-CTt and post-CTt scores. Since the significance p-value is lower than 0.05, which is 0.001, the null hypothesis is rejected. Therefore, it can be concluded that there is a significant mean difference of students' scores between pre-CTt and post-CTt.

According to the results above, it can be concluded that the intervention process that is done in Scratch learning toward Year 4 students by researcher is effective towards students' computational thinking.

**Discussions**

In this research study, there are two questions presented:

a) How effective is Blended Project-based Learning toward year 4 students' spatial visualization skills in learning Scratch?
b) How effective is Blended Project-Based Learning effective towards year 4 students' computational thinking in learning Scratch?

Based on the questions, two instruments are being used in this study to answer the question, which include Mental Rotation test and Computational Thinking test. Blended project-based learning activities were designed and developed for the students to complete all the task assigned, in about 3 weeks' time. The students were required to answer the tests before and after the intervention process. The following are the discussions on each of the research questions.

**The effectiveness of Blended Project-based Learning toward year 4 students' spatial visualization skills in learning Scratch?**

The first research question in this study is "How effective is Blended Project-based Learning toward year 4 students' spatial visualization skills in learning Scratch?". To answer this question, the researcher used the Vandenberg and Kuse Mental Rotation Test to be answered by the students. This test contains 24 objective questions that display two-dimensional images of three-dimensional objects. To answer these questions, students need to identify two out of four answer choices that are rotated images of the target object. The objects are presented at various angles to evaluate the students' ability to visualize and interpret these rotations. The students are required to answer the MRT assessment questions twice, which were before and after blended project-based learning activities are conducted.

The effectiveness of the blended project-based learning towards students' spatial visualization can be evaluated by the marks difference of pre- and post- MRT taken by the students. The result from pre and post assessment test can be referred in Table 5.1 in Chapter 5. Based on the result, the mean value of post-MRT is 32% compared to 14% in pre-MRT. There is an increase of 18% from pre-MRT result to post-MRT result. Among the 30 students as a sample in this study, some of them show a dramatic increase in the post-test scores from the pre-test scores which are S10 with 72% and S26 with 40%. Meanwhile, there are also some students that show smaller improvements from both tests scores which is S17 and S28 with only 2% of increment. On top of that, all the 30 students are showing an improvement in terms of scores where there is none of them are having declining in marks when answering the same question before and after the intervention done. It means that the blended project-based learning is effective towards the spatial visualization and computational thinking skills among the year 4 students in learning Scratch.

Moreover, the researcher also conducted an inferential analysis to strengthen the finding. The collected data is tabulated and analysed by using version 29 of SPSS. A normality test is done to determine the normal distribution of the data. Since the data is not normally distributed, a non-parametric test which is the Wilcoxon Signed-Rank test is selected to be used to analyse the pre and post-tests result of the students. Based on the results of the analysis that can be referred in Table 5.4 in Chapter 5, the significance p-value is less than 0.001. The lower p-value means that the null hypothesis is rejected. Hence, it can be concluded that there is a significant difference of students' scores between pre-test and post-test of MRT.

The significant median difference between the pre-test scores and post-test scores is proving that there in an improvement of the students' spatial visualization skills. During the intervention, students learn skills using all the tools in the Scratch application following the structured provided learning modules. They need to watch the instructional videos and demonstration videos uploaded by the teacher on the Google Classroom learning platform before completed their Scratch projects in pairs. Learning Scratch involves students using visual blocks to create interactive stories and creative animations, which requires them to apply their visualization skills to produce meaningful projects.

The results of this study align with previous study conducted by Sari et al. (2022). Both studies indicate that the blended project-based learning is effective in improving students' spatial visualization. Sari et al. (2022) discovered that the blended project-based learning approach led to more significant improvements in mathematical spatial literacy than the problem-based blended learning method. Another study conducted by Putra et al. (2021) was also found a significant impact of Blended Project-Based Learning (BPjBL) with a STEM approach on spatial thinking and geography skills, along with changes in students' attitudes towards these skills. Although the studies conducted by Sari et al. (2022) and Putra et al. (2022) focused on different subjects, their main objective was to examine the effectiveness of blended project-based learning within their respective scopes, both showing positive results. Moreover, both studies employed quasi-experimental methods, where each of them had a control group to compare with the sample using the proposed learning method.

Consequently, working on Scratch projects can help students improve their spatial visualization abilities by engaging in phases of planning, organizing, and progressively drawing, which are crucial for their project-based learning process in this study. Students can enhance their spatial visualization skills through various methods, including practice, training, and exposure to visual and spatial activities (Ismail, 2015). This research study also mentions that participating in activities involving spatial reasoning, such as drawing, puzzles, and hands-on projects, can help improve these skills. Therefore, it can be concluded that the blended project-based learning done is effective to help improving their scores in mental rotation test (MRT), and at the same time help to enhance their coding and programming skills in Scratch. This finding can answer the first question posed in this research study.

**The effectiveness of Blended Project-based Learning toward year 4 computational thinking in learning Scratch?**

The second research question in this study is "How effective is blended project-based learning toward year 4 computational thinking in learning Scratch?". According to Tsarava et al. (2021), enhancing students' computational thinking from primary school is essential due to current educational trends, including increasing and growing research focused on preparing young learners for digital technologies, especially in our rapidly advancing digital era. As we are already aware, the computational thinking (CT) is considered as an essential element of 21st-century skills, alongside other abilities such as communication, digital literacy, critical thinking, and creativity.

To evaluate computational thinking towards students, the researcher used the Computational Thinking test by Roman Gonzalez to be answered by the students. The test is based on a cognitive definition of computational thinking and aims to assess students' skills in areas such as variables and assignments, selection statements, definite and indefinite loops, function/method parameters, syntax, data, algorithms, representations, and efficiency. The students are required to answer the test questions twice, which is before and after blended project-based learning activities are conducted.

The effectiveness of the blended project-based learning towards students' computational thinking can be evaluated by the marks difference of pre and post computational thinking assessment test taken by the students. The result from pre and post CT test can be referred in Table 5.5 in Chapter 5. Based on the result, the mean value in post-assessment test is 41% compared to 19% in pre-assessment test. This result shows that the average improvement in scores is 22%, indicating that the intervention that had been used by the students helped them improve their computational thinking significantly. Among the 30 students in this study, there were 4 students, which were S4, S14, S23 and S29 shows the most considerable improvements in their scores with the range difference of 26% to 41% from both pre and post assessment test. However, there were also students that showing minimal improvement in range 4% to 7% difference score from the pre-assessment test such as S19, S6 and S22. Despite that, all 30 students have shown an improvement in their scores, with none experiencing a decline when answering the same questions before and after the intervention. This indicates that the blended project-based learning approach is effective in enhancing the computational thinking skills of the Year 4 students learning Scratch.

. Additionally, the researcher was also conducted an inferential analysis to strengthen the findings. The collected data was tabulated and analysed using SPSS version 29. A normality test was performed to determine the data's distribution. Since the data was not normally distributed, the Wilcoxon Signed-Rank test, a non-parametric test, was used to analyse the pre-test and post-test results. Based on the results of the analysis that can be referred Table 5.8 in Chapter 5, the significance p-value is less than 0.001. This low p-value indicates that the null hypothesis is rejected, concluding that there is a significant difference in students' scores between the pre-test and post-test of CT test.

The significant median difference between the pre-test scores and post-test scores is proving that there in an improvement of the students' computational thinking. Scratch helps students improve their computational thinking by providing a platform to explore and master different computational skills (Zhang et al., 2019). The Raspberry Pi learning module that had been use in this study provides a beginner-friendly guide to coding with Scratch. It encourages the learners learn how to add code, costumes, and sound to sprite in Scratch, that also helps students to create animations, games, apps, and digital books. The pathway of this modules includes several projects that designed to helps students develop their coding skills progressively. In this research study, students must follow the learning path provided in the modules that includes with step-by-step instructions of Scratch learning. After that, they need to practice their skills in the projects developed before inventing their own project which is digital storytelling. Since they are doing the project in pairs, the students can brainstorm the idea and guide each other complete the projects. This blended project-based learning method has proven effective in enhancing their scores in computational thinking and developing their Scratch programming abilities. This finding addresses the second research question posed in this study.

Piedade and Dorotea (2022) had found that Students who had programming experiences with Scratch showed higher results in the computational thinking test (BCTt) than students who did not participate in these activities. Although the study was also included the creation of small Scratch-based projects to facilitate in learning computational concepts and computational thinking, it did not explicitly mention the use of blended-project based learning. However, the finding of this study mention that the students with programming experience using Scratch scored higher on the computational thinking test (BCTt) compared to those who did not engage in these activities. Similar findings were also portrayed in the study by Fagerlund et al. (2020). The study's findings show a positive result into the programming content of 4th grade students' Scratch projects and highlight their conceptual engagement with computational thinking (CT). However, there are some differences when compared to those study. Both previous studies did not explicitly mention the use of blended project-based learning methods in Scratch learning in their research. Nevertheless, the delivery method using teacher guidance and project-based activities is not much different from the blended project-based learning method used in this study. The result remains the same, which is that Scratch learning can help improve computational skills in primary school students.

## Conclusion

The conclusion that can be drawn from the research study is that blended project-based learning has proven to be effective in enhancing spatial visualization skills and computational thinking among fourth-grade students in primary schools. This is clearly evidenced by the improvement in scores before and after the MRT and CTt tests. Both tests have been validated and are relevant for assessing the level of spatial visualization and computational skills among students. Therefore, it is highly recommended that the blended project-based learning technique be adopted for delivering project-based learning, as it has shown positive effects on improving students' skills, specifically spatial visualization and computational skills, particularly through Scratch learning for fourth-grade students at the primary school level.

## Limitations and Future Studies

While conducting this research, the researcher encountered a lot of challenges and limitations. However, these limitations may highlight several areas that can be improved in future research.

First, this study was conducted on only one experimental group as the sample. As a result, the findings may not adequately represent all fourth-grade students in the entire population. Therefore, future studies could be conducted on several groups of students representing different districts or states to obtain more comprehensive findings.

Additionally, the intervention in this study required around three weeks to complete all the learning modules with the assessment primarily targeting the cognitive aspects of the students. Consequently, the researcher suggests that future studies should also consider affective and social dimensions, such as student motivation and collaborative relationships with peers. Thus, we can assess how blended project-based learning impacts students' emotions and social behaviours.

Lastly, the blended project-based learning approach can also be extended to other subjects. This not only facilitates the implementation of blended teaching methods but also enhances project-based learning, thereby providing an effective educational strategy that can be optimally utilized by both teachers and students.
All the above-mentioned points are recommendations for improvements that can be implemented by future researchers. It is hoped that these enhancements will help improve the quality of teaching methods and student learning.

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