Universiti Teknologi MARA
Cawangan Melaka

# PCMJ

## Progress in Computing and Mathematics Journal

## volume 1

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Progress in Computing and Mathematics Journal
College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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# EDITORS



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# PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

**Editors**
**Progress in Computing and Mathematics Journal (PCMJ)**
**College of Computing, Informatics, and Mathematics**
**UiTM Cawangan Melaka**

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# FIGURE SPRINTER: EDUCATIONAL ENDLESS RUNNING GAME TO LEARN 2D AND 3D SHAPE

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**Abstract**

Learning about two-dimensional and three-dimensional shapes is essential in mathematics but it can be boring and less motivating for many students, especially those who are in primary school. This project, Figure Sprinter, tries to solve these problems by making an effective educational game to teach primary school students about the characteristics of two-dimensional shape and three-dimensional shape. This mathematical sub-topic is freshly introduced to standard three and below of primary school students where they need to learn about the simple characteristics of two-dimensional and three-dimensional shapes before going to the more advanced lesson. The methodology used for this project is Rapid Application Development (RAD). Three elements from MDA Framework will also be implemented in this project which are mechanics, dynamics, and aesthetics. After the development of this project is complete, it is essential to do the testing and gather evaluation results from the targeted end-user through a questionnaire. For the testing, participants will have to answer pre-test and post-test questionnaires to evaluate the effective learning experience of the project. The result of the evaluation shows that this project is effective for the participants to use as the mean value of the result shows the increment of 7.8 from 19.47 to 27.27. To improve this project, the future work needs to be implemented to make it usable for everyone of different ages and be able to play the game on any platform.

**Keywords**: Two-Dimensional, Three-Dimensional, Mechanic, Dynamic, Aesthetic, Rapid Application Development

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## INTRODUCTION

The study of 2D and 3D shapes is a fundamental concept of geometry in mathematics education. It involves the identification, naming, and classification of geometric shapes, as well as understanding their properties and relationships. A 2D shape is one that may be found on a flat surface, such as a sheet of paper. It is entirely flat since it lacks any depth or thickness while 3D shape has length, width, and height. A 3D shape has depth and takes up space as opposed to a 2D shape, which is flat. It resembles a solid object that you can hold and feel. Despite that, understanding the difference between two-dimensional and three-dimensional geometric shapes can be challenging for primary school students (Demitriadou, E., Stavroulia, K. E., & Lanitis, A., 2020). This phenomenon is related to several factors: low visual skills influence primary school students' understanding of geometric concepts (Gunčaga & Žilková, 2019) and misconceptions that led to difficulty factors faced by primary school students (Nadzeri et al., 2022).

Research conducted by Cambridge Mathematics (2020) has shown that teaching 2D and 3D shapes in early mathematics education can help develop important spatial skills, such as mental rotation and visualization. Therefore, it is important to use effective teaching methods that enhance students' learning of 2D and 3D shapes (Dr Sue G., 2020). Game technology has the potential to transform education by providing engaging, interactive, and personalized learning experiences (Powell, K., 2019). With the advancement of technology, educational games are becoming more sophisticated and can be used to teach a wide range of subjects and skills (Lo & Miller, 2020). There are few learning based game already invented such as kahoot! and Monster Physic which available on the internet and ready to use by anyone.

Therefore, this project of creating an educational game based on 2D and 3D shapes will utilize game technology to provide an interactive and engaging learning experience for students. This project will provide a fun and effective way to teach geometry concepts related to 2D and 3D shapes, helping students to develop a deeper understanding of the subject matter.

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## LITERATURE REVIEW

Shapes are an important part of our everyday lives. They are all around us, from the objects we use to the buildings we see. In primary school, students begin to learn about shapes and their characteristics by recognizing basic shapes like squares, circles, triangles, and rectangles. They learn to name these shapes and understand their different properties. Students engage in activities where they sort and classify objects based on their shapes, helping them develop their understanding of shape. They also learn to create three-dimensional shapes by combining basic shapes together. By exploring shapes, students improved their visualization skills.

### Two – Dimensional Shape and Three – Dimensional Shape

The understanding of 2D shapes has been developed over time by mathematicians and academics. They found new shapes, categorized them, and created tools to determine their attributes. In addition, they are frequently employed in real-world settings including graphic design, architecture, and physics simulations, where a grasp of and proficiency with 2D shapes is essential. It has always been difficult to define architectural shapes and then explain how their geometrical characteristics differ (Chang & Park, 2022).

With the introduction of analytical geometry, which established coordinate systems to describe and manipulate 3D models, our understanding of 3D shapes has grown. Further developments in mathematics, such as vector calculus and trigonometry, gave the development of strong tools for the analysis and solution of 3D shape-related problems (Umamaheswari et al., 2019).

### Learning Method for 2D and 3D Shape

In early school, understanding 2D and 3D shape is an essential skill. The foundation for geometric reasoning, spatial reasoning, and critical thinking is laid by an understanding of these topics. Pre-schooler can be introduced to 2D and 3D shapes most effectively through hands-on activities. Giving them shape-making tools like blocks or clay enables them to sculpt and manipulate shape physically. They also can build buildings out of 3D forms and stack blocks to create 2D shapes, helping them develop a visual understanding of their properties.

Additionally, it enhances their ability for geometric and spatial reasoning as well as general mathematical and cognitive skills (Mohamed et al, 2022).

Furthermore, students understanding of shape also can be improved by using visual representation. Teacher can convey 2D and 3D shape in an interesting way by using vibrant poster, flashcard, or digital material. It helps them recognize and identify shapes as well as comprehend their characteristics. According to Mohamed and Kandeel (2023), adding element of colour and movement to children's study material makes them more attractive and engaging.

However, traditional learning method has their flaws. It depends on the teacher to provide suitable learning methods for their pupil to achieve the required goal (Nishat Zafar, Muhammad Hafeez, 2021). It is crucial for teachers to use a proper strategy in classrooms as it influences students' motivation and engagement in the learning process (Raja & Khan, 2018).

According to a case study about Ideating and Developing a Visualization Dashboard to Support Teachers Using Educational Games in the Classroom conducted by Ruiperez-Valiente et al. (2021), the use of an educational game called Shadowspect give a huge positive impact in motivating and engaging students to learn 3D shape which the data collected involve 31 students that made approximately 54,829 events with an average of 1,768 events per student. All the students were actively using the video game for 33 hours which was an average of 65 active minutes per student, and the student solved a total of 448 puzzles with an average of 14 puzzles per student.

**Education Game Design**

Education has traditionally been associated with textbooks, lectures, and structured classrooms. However, designing instructional video games has become a dynamic and cutting-edge method of teaching in the past few decades. These interactive experiences engage and inspire learners while delivering information, skills, and ideas by combining entertainment with educational material. It has been demonstrated that games have powerful encouragements that increase a person's motivation to do uninteresting activities like studying theoretical material (Laine & Lindberg, 2020).

Designing educational games has the potential to have an influence outside of the traditional classroom. With the development of digital technologies and the availability of mobile devices, students may access educational games whenever and wherever they choose. They provide chances for independent study, enhancing traditional schooling, and encouraging

lifetime learning. These games can also help players build crucial contemporary abilities like cooperation, digital literacy, critical thinking, and problem-solving. Education game design will continue to innovate and support the change in education as technology advances (Ruiperez-Valiente et al., 2021).

**MDA Framework**

The MDA (Mechanics, Dynamics, Aesthetics) framework is a theoretical tool used in game design to analyse and understand various elements of the aesthetics and user experience of video games. It was first discussed by Robin Hunicke, Marc LeBlanc, and Robert Zubek in their 2004 paper "MDA: A Formal Approach to Game Design and Game Research.".

**A. Mechanics**

These are the primary fundamentals that guide the game's operations. The game's physics, controls, goals, interactions, and any other tangible elements that specify the parameters of the game's universe are all considered to be mechanics. The fundamental building blocks on which the game is built are its mechanics.

**B. Dynamics**

Dynamics are the spontaneous actions that appear as a result of a player's interaction with the mechanics. Players interact with the game's mechanics and have these experiences. The many player actions, plans, and reactions that develop during games are referred to as dynamics. They are frequently particular to each player's preferences and playstyle.

**C. Aesthetics**

Aesthetics are a representation of the emotional responses, feelings, and experiences that players have when playing a game. They are the feelings and experiences, whether intentional or not, that the game's mechanics and dynamics elicit in players. Excitation, difficulty, curiosity, satisfaction, and a host of other emotions can all be categorized as aesthetics.

## METHODOLOGY (HEADING 1)

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Rapid Application Development (RAD) is a method of software development that emphasizes the rapid creation of applications using incremental and iterative processes.in your current template. There are generally four main phases involved in rapid application development (RAD). The first phase is Requirement Planning. In this phase, user requirements, project goal and scope are identified. Then, User Design as second phase. To improve the functionality and user interface of the program, interactive prototypes are made, and user input is obtained in this phase. The third phase is Construction. This is the phase where the real coding and development are done using tools for automation, quick prototyping, and code reuse. The final phase is Cutover. The application is tested, deployed, and made ready for production use in this phase.

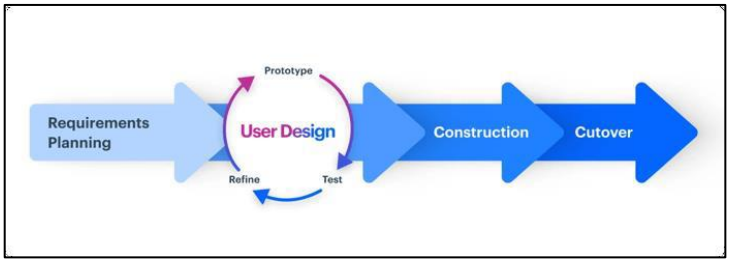


Figure 1 Rapid Application Development (RAD)

**Project Overall Process**

RAD Methodology is being adopted for this project development process which allows for faster development and quicker release of software applications. All the information required for the development of this project was collected via literature review and guides and tutorial from Unity as well as YouTube videos. The development of this project has several phases: storyboard, character and environment development, gameplay development, Ui development and project deployment. This project also implemented MDA frameworks.

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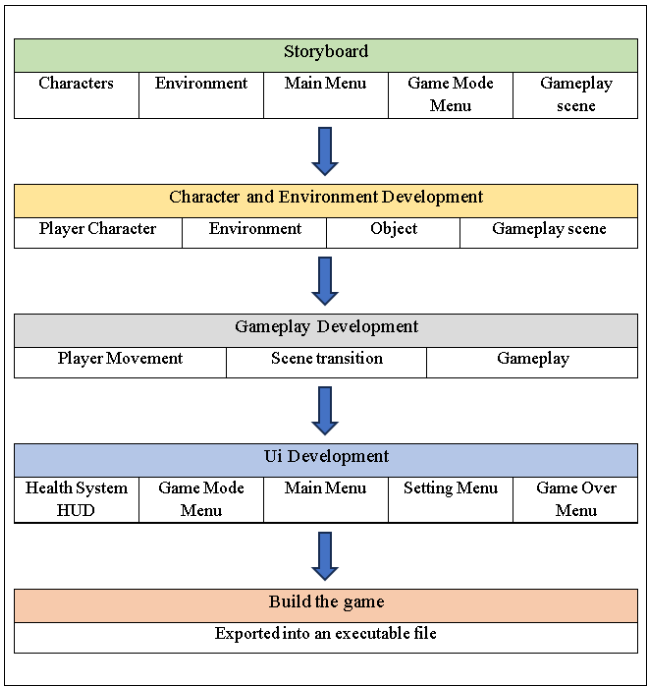


Figure 2 Flowchart of game development

## Flowchart

First, the game starts with the main menu which allows users to choose whether to play the game or quit by clicking the provided button. By choosing the play button, users will be directed to the Game Mode scene where they will have to choose between two modes that they want to play. Users can also choose to go back to the main menu by choosing the back button. After users choose any level provided, they will be directed to in-game mechanics to start playing the game. Users are required to collect dedicated shape that represented before the gameplay to gained points and create new high score while avoiding other shape and obstacle as it will decrease character health by 1 which will invoke the Game Over Menu if character health is 0.

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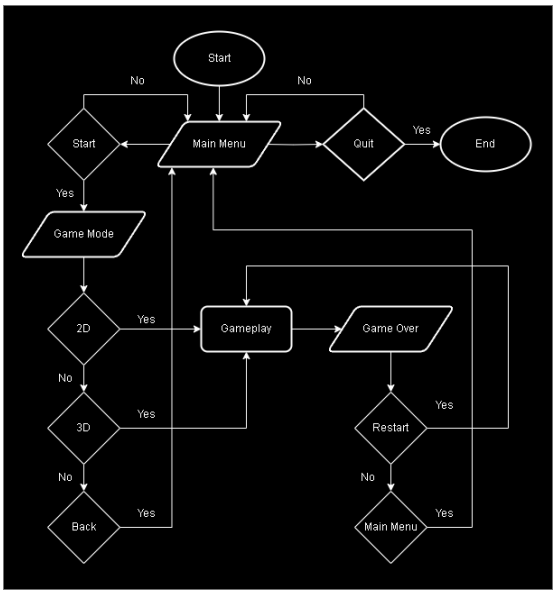
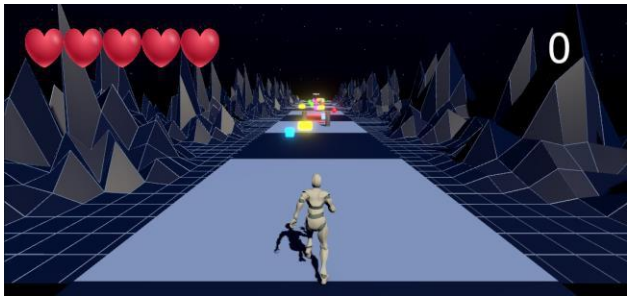



Figure 3 Educational Endless Running Game Based On 2d and 3d Shape Flowchart

**MDA Framework**

Table 4.2 shows the implementation of the MDA framework in Figure Sprinter.

Table 1 Description of MDA framework implementation

| Elements | Description |
|---|---|
| **Mechanics**   | Player can move left and right to collect specific shape and avoid other shape and obstacle |
| **Dynamics**   | When player move left and right, they can collect shape to gain points as well as avoid other shape and obstacle that can lessen the player health |

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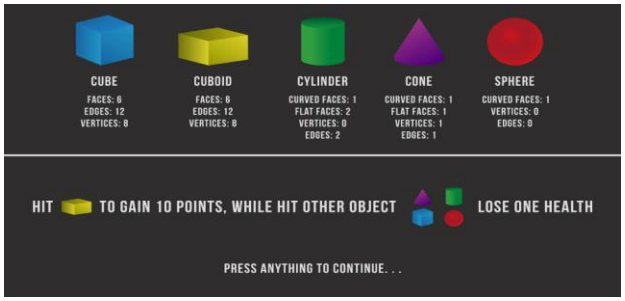
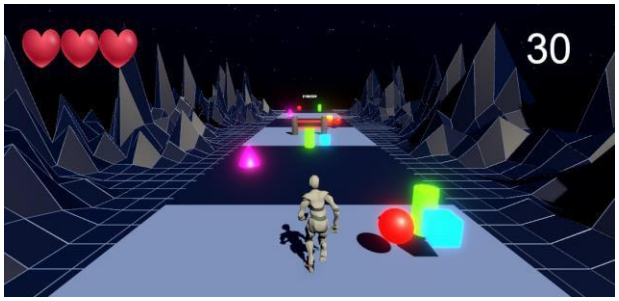
| | |
|---|---|
| **Aesthetics**<br>  <br>  | When player movement becoming more faster each time, it creates a challenge feeling toward the user as they had to be more precise in the movement to collect specific shape and avoiding others because if the health is 0, the game will invoke game over menu and user must restart the game from the start. |

## RESULT AND DISCUSSION

The evaluation of this game project is carried out to accomplish the third objective that has been proposed which is to evaluate an effective learning experience in learning the 2D and 3D shapes. The evaluation will have pre-evaluation and post-evaluation that will be given to users before and after they play Figure Sprinter. The answers will be compared to see if there's an improvement to the user's knowledge regarding the learning subject.

### Effectiveness Findings

Based in the questionnaire results, the total of participant who took part in this evaluation are 36 participants from Sekolah Kebangsaan Jasin. It consists of students aged 8 years old with the percentage of 38.9% while the rest are aged 9 years old with the percentage of 61.1%. Figure 5.1 below shows the participant's demography.

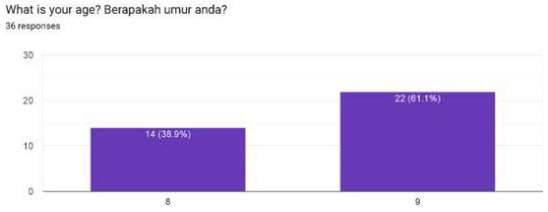



Figure 4 Participant's Demographics

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## Demography Findings

Table 2 shows an example of the questionnaire question. There are a total of 15 questions provided for participants to answer before and after playing Figure Sprinter. This is to measure the effective learning experience in learning the 2D and 3D shapes via playing Figure Sprinter.

Table 2 Effective learning experience in learning the 2D and 3D shapes questionnaire.

| Code | Question |
|---|---|
| Q1 | How many edges does a square have? |
| Q2 | How many curved sides does a circle have? |
| Q3 | How many sides does a triangle have? |
| Q4 | How many edges does a circle have? |
| Q5 | How many sides does a pentagon have? |
| Q6 | Which one of the following is a rectangle? |
| Q7 | Which one of the following is a triangle? |
| Q8 | How many flat surfaces does a cube have? |
| Q9 | How many edges does a cuboid have? |
| Q10 | How many flat surfaces does a cylinder have? |
| Q11 | How many curved surfaces does a cone have? |
| Q12 | How many squares are needed to make a cube? |
| Q13 | Which of the following is sphere? |
| Q14 | Which three-dimensional shape represents the picture below? |
| Q15 | Which three-dimensional shape represents the picture below? |

## Effectiveness Findings

In the data gathered from the Google form survey results, each criteria have an individual value assigned to it. A questionnaire explaining the information gathered from the Google form must be completed by the user both before and after they play the game. Following that, the results are computed. Table 3 shows the result calculated of mean average for pre and post evaluation.

Table 3 The calculation of mean average for pre and post evaluation

| Question | Total Participants answered right (pre-evaluation) | Total Participants answered right (post-evaluation) | Total mean average for pre-evaluation | Total mean average for post-evaluation |
|---|---|---|---|---|
| 1 | 29 | 32 | | |

| | | | | |
|---|---|---|---|---|
| **2** | **16** | **23** | **Sum of correct answer = 29+16+31+13+5+19+35+6+16+11+20+13+24+26+28 = 292** | **Sum of correct answer = 32+23+33+22+26+26+36+23+19+26+25+25+29+30+34 = 409** |
| **3** | **31** | **33** | | |
| **4** | **13** | **22** | | |
| **5** | **5** | **26** | | |
| **6** | **19** | **26** | | |
| **7** | **35** | **36** | | |
| **8** | **6** | **23** | | |
| **9** | **16** | **19** | | |
| **10** | **11** | **26** | | |
| **11** | **20** | **25** | **Mean average = 292 /15 = 19.47** | **Mean average = 409 /15 = 27.27** |
| **12** | **13** | **25** | | |
| **13** | **24** | **29** | | |
| **14** | **26** | **30** | | |
| **15** | **28** | **34** | | |

## Conclusion

Figure Sprinter is a 3D endless running game that educates users about 2D, and 3D shape. Users will have to play the game by moving left and right to collect objectives while avoiding obstacles. The completion of this project has been made with three stated objectives in Chapter 1. Pretest-posttest design is adept in the effective learning experience in learning the 2D and 3D shapes questionnaire. The project has significantly improved participants ranging from 8 to 9 years old in learning about 2D and 3D shape.

To summarize, learning 2D and 3D shapes can be more fun and interesting by the usage of Figure Sprinter. This has been proven in the pretest-posttest effective learning experience questionnaire. This project was able to help improve the understanding about the learning subject for the participants. Despite having several limitations, it can be refined and improved in the future by applying what has been stated in 6.3 so that more people can be used by everyone.

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