

Research Article

Impact of Elements in C++ Maze Board on Student Engagement and Learning in Programming Fundamentals Course

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Abstract:

The focus of this paper is to determine the impact of a C++ Maze Board as a physical board game to enhance students' understanding of topics in a Programming Fundamentals course at Politeknik Muadzam Shah. Based on observations, students often fail in practical assignments, quizzes, and exams due to confusion over basic concepts and terms in C++. This game is adapted from the traditional game of Snake and Ladder. An online survey using Google Form of 63 students had been conducted and a quantitative study on how the students perceived the activity. The data was analysed using IBM Statistical Package for Social Sciences (SPSS) Statistics for reliability tests and descriptive analysis. The analysis of overall mean scores are for both sections include the perception of elements in C++ Maze Board with ($M=4.45$) and impact of learning with ($M=4.40$) indicate positive respond from the students. The results show that students strongly agreed they were able to learn from their own and their friends' mistakes during the game, which helped them understand the correct answers and improve their programming skills through reflection and observation. Game components, including coins system for collecting points, balance between challenges and learning as well as suitable programming topics were seen as factors that led to a more engaging and reflective learning experience. These results provide evidence for the validity of C++ Maze Board as the gamification tools for enhancing conventional teaching in fundamentals of C++ programming.



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1. INTRODUCTION

The C++ Maze Board has been developed in order to address phubbing issues in programming fundamentals classes. Moreover, this can also be used as an alternative tool or as a group assignment activity for students to prepare for their lessons and review information before exams (Suhaimi, Sidek, & Razali, 2024). It can also help students learn the C++ Programming Language in a casual and enjoyable manner. C++ Maze Board is a modification of the Snake and Ladder board game. The important component of the board game was its mechanics, which encouraged students to learn via play (Suttiwan & Anupan, 2024). This type of board game promotes direct social interaction amongst the players which are the students themselves, imagination and self-driven analysis, evaluating, problem solving skills and making decisions. The present study extends this foundation by introducing

the C++ Maze Board, a board game adaptation designed to support conceptual understanding in programming fundamentals courses.

Table 1 shows the elements in the C++ Maze Board that had been designed and implemented in the programming fundamentals courses (Suhaimi, Sidek, & Razali, 2024). The elements include cards such as three levels of questions, ask a friend and information card. Besides, the coin system as a point collection is used as a reward system. Meanwhile, there are challenges provided in the game which are snakes and crocodiles cards that will cause losing points. Additionally, stick and axe cards are the advantages provided in the game to help players to remove the challenge card.

Table 1. C++ Maze Board elements

Elements	Description
Level 1, 2 and 3 question cards	Yellow card (Level 1) for easy questions, blue card (Level 2) contains the medium level and red card (Level 3) for high level questions.
Coin system and points collection	Coins represent the amount of points earned.
Response time	One minute is allocated to answer one question.
Ask a Friend card	Players can use the card to get help from the friend to read the information card.
Information card	This card contains information related to the random question.
Snakes and crocodiles	Challenges in the game. A snake will cause one point to be deducted. While the crocodile will cause three points to be rejected.
Stick and axe cards	Advantage tools in the game. If the player gets a stick, then the player can kill a snake. If three sticks are collected, then they can kill the crocodile. While one axe can kill a crocodile or two snakes.

2. RESEARCH OBJECTIVES

This study aims to:

1. Evaluate students' perceptions of the impact of the C++ Maze Board on their conceptual understanding of basic programming.
2. Identify which game-based elements are most influential in supporting learning C++ programming.

2. RESEARCH OBJECTIVES

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3. RESEARCH METHODOLOGY

3.1 Research Design

This research was conducted using a quantitative design through a survey method. To study the quality of the impact of the C++ Maze Board, the elements found in this game board will be tested. The study instrument was conducted through an online questionnaire using a Google Form. The aim was to gather quantitative data from respondents and assess descriptive statistics to evaluate the perceived effect of the game on students' engagement and impact in learning C++ programming.

3.2 Population and Sample

The population of this study consists of 71 students enrolled in the Programming Fundamentals course at Politeknik Muadzam Shah. Using the Krejcie and Morgan (1970) sample size determination table, the recommended sample size for a population of 70–75 is approximately 62 respondents. Therefore, this study selected a sample of 63 students through simple random sampling, which is considered sufficient and representative of the population size.

This sampling approach ensured that the findings are generalizable to the broader group of students within the course. The participants had all been exposed to the C++ Maze Board activity prior to completing the survey.

3.3 Research Instrument

The data collection instrument used in this study was a self-developed questionnaire. The questionnaire statement included three sections. Section A regarding the demographics of the respondents involving gender, and experience playing the game board. While section B included the variables studied, namely knowing the level of student perception of the C++ Maze Board elements and section C regarding the level of impact of the C++ Maze Board on student learning. The level of respondent agreement was measured using a Five-Point Likert Scale, from 1 (Strongly Disagree) to 5 (Strongly Agree).

3.4 Pilot study

A preliminary study was conducted on 30 respondents and analysed using IBM Statistical Package for Social Sciences (SPSS) Statistics software version 31.0.0.0. The reliability coefficient values of the survey questionnaire items are shown in Table 2 using Cronbach's Alpha. The outcome shows a strong reliability coefficient of 0.97, suggesting outstanding consistency between the items. As the reliability score surpassed the minimum acceptable limit of 0.70, no changes were implemented on the instrument prior to its application in the actual data gathering (Sekaran and Bougie, 2013). The 30 respondents are also included in the final analysis according to Avery et al. (2017) and Bond et al. (2023) emphasized that internal pilot data can be retained for final analysis when pre-specified trial protocols are maintained and no changes are introduced during or after the pilot stage. This strategy is considered both efficient and methodologically sound, as it reduces unnecessary participant recruitment and strengthens the overall statistical power of the study.

Table 2. Item reliability coefficient value

Sections	Number of items	Cronbach's Alpha
A. Perception of the C++ Maze Board elements	10	0.942
B. Impact of learning	10	0.951
Total	20	0.971

3.5 Data Analysis Technique

The information was analysed descriptively. The mean score was calculated for each item on the questionnaire in order to ascertain students' overall views of the game elements and their learning impact. The results helped us determine which parts of the board game were the most likely to engage students and help improve their understanding of programming constructs.

4. DATA ANALYSIS AND RESULTS

4.1 Demographic Analysis

The demographic analysis is mainly for the background of the respondent which is gender and experience playing board games. Table 3 shows the total respondents of 63 students involved in the online survey. There are 28 respondents (44.4%) who are male and 35 respondents (55.6%) who are female.

Table 3. Gender Analysis

Gender	Number of respondents	Percentage
Male	28	44.4
Female	35	55.6

Based on the data collected, Table 4 shows that 45 respondents (71.4%) had been exposed before to board games, and the other 18 respondents (28.6%) had no previous exposure to board games. This shows that the majority of respondents were already familiar with board games based on the study.

Table 4. Respondents had experience with board games

Had experience with board games	Number of respondents	Percentage
Yes	45	71.4
No	18	28.6

4.2 Perception of the C++ Maze Board elements

Table 5 shows the descriptive analysis of perception of the C++ Maze Board elements. The mean scores of all the 10 items are between 4.33 and 4.59 (in a 5-point Likert scale). This was due to the fact that the C++ Maze Board included to some extent a clear gaming aspect. Item 2 which is "The coin mechanism and point accumulation make the game more fun." scored the highest mean 4.59 indicating that the reward system is highly effective in increasing engagement and motivation derived from gamification studies. The dynamic adjustments in difficulty and rewards help sustain attention and

satisfaction in game-based learning as well as improves understanding of programming concepts. (Benachour & Zhao, 2024).

Both items 8 and 10 which are balance of challenge and learning, and suitability for basic programming topics show the same mean score of 4.51 indicating the strong agreement that the game was effective and enjoyable. Low standard deviations with range between 0.61 and 0.73 suggest participants generally agreed in their positive perceptions, with minimal variability. Time pressure based on Item 3 and challenges in Item 6 were slightly less favoured but still highly rated. Balancing game elements in educational games is challenging. Designers need to make sure the game is fun and educational. They must think about the feelings and thoughts of learners to improve learning results (Natucci, 2023). Well-made educational games can create interactive learning environments that accommodate various learning styles. This approach makes complicated subjects like programming easier and more enjoyable (Klimova et al., 2021).

Table 5. Perception of the C++ Maze Board elements

No	Item	Mean	Standard Deviation
1	Level 1, 2 and 3 question cards helped me assess my own level of understanding in C++.	4.44	0.64
2	The coin system and points collection make this game more fun.	4.59	0.61
3	The 1-minute response time limit helps me focus and think quickly.	4.33	0.72
4	The "Ask a Friend" card encourages me to interact and talk with friends.	4.41	0.71
5	The "Information" card helped me re-understand C++ concepts that I had forgotten.	4.43	0.73
6	The snakes and crocodiles in the game added a challenge that made me more careful.	4.40	0.73
7	Auxiliary elements such as 'stick' and 'axe' cards make the game more interesting.	4.43	0.69
8	This game has a balance between challenge and learning.	4.51	0.64
9	The layout of the game board is flexible and easy to understand.	4.41	0.66
10	I think the elements in this board game are suitable for basic programming topics.	4.51	0.62

Total mean	4.45	0.56
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4.3 Impact of learning

The findings from Table 6 show that students gave the C++ Maze Board Game high ratings for its impact on their learning, with average scores ranging from 4.24 to 4.52. This indicates that most students strongly agreed that the game improved their understanding of C++. The highest-rated statement highlighted learning from their own and others' mistakes, which shows that the game encouraged reflection and peer learning. Students also felt that the game made reviewing more enjoyable and helped them understand programming logic and syntax better. They viewed the one-minute limit per question as helpful for improving focus and quick thinking.

Even the lowest-rated statement, which mentioned greater focus during the game compared to regular lessons, still considered a high score. This indicates that students found the game more engaging than traditional teaching methods. Zhao et al. (2022) stated that students gained from using serious game-based learning in programming courses. This approach led to more engagement than traditional teaching methods. The small differences in responses, shown by low standard deviations, suggest that most students had similar positive views. Overall, the data suggest that the C++ Maze Board Game is an effective and enjoyable way to learn programming. It encourages active learning, helps students apply their knowledge, and builds confidence through practice and interaction.

Table 6. Impact of learning

No	Item	Mean	Standard Deviation
1	I am more focused when playing than during regular Teaching and Learning.	4.24	0.76
2	I understand the basic concepts of C++ programming better after playing.	4.44	0.59
3	I was able to learn through my own mistakes and those of my friends in the game.	4.52	0.62
4	I feel more confident answering quizzes, tests and final exams after this game.	4.30	0.71
5	This game helps me review in a fun way.	4.48	0.64
6	I am more interested in learning C++ after this experience playing this board game.	4.32	0.69
7	This game helps me remember important terms in C++.	4.37	0.73
8	I understand the function and logic of a syntax better after playing.	4.46	0.64
9	This activity helped me make a better connection between C++ theory and practice.	4.46	0.69
10	I think it's easier to relate the problems given in the game to examples in real code.	4.43	0.64
Total mean		4.40	0.57

Furthermore, this study also indicates that students who had no prior experience playing board games resulted in a maximum score of 4.22 for item 5 and the mean score for impact of learning is 4.06. This analysis is to study the mean scores for both with or without experience playing other board games towards the impact of learning in using C++ Maze Board game. In a recent study of Lindner & Lindner (2024) supported that the high mean score helped them revise the C++ topics in an enjoyable way. However, the students who had experienced playing board games scored a maximum score of 4.69 for item 3 while the mean score scored a higher mean value of 4.54. The research of Nakao (2019) suggests that engaging in board game activities may improve cognitive functioning in individuals for both categories, thereby potentially mitigating cognitive deterioration.

5. CONCLUSION

In conclusion, the findings show that students positively received the C++ Maze Board Game. They scored high on both the game elements and its impact on learning. Students particularly liked the reward system, the balance of challenge and content, and how the game made learning more enjoyable. They felt the game helped them understand programming concepts better, improved their focus, and encouraged active and reflective learning. Even students without prior board game experience responded positively, though those with such experience reported higher scores. While educational games seem effective in teaching programming, some people believe that traditional methods may still be useful, especially for students who do well in organized, non-gaming settings. Balancing these approaches could lead to the best educational results. Overall, the C++ Maze Board proved to be an effective and engaging tool for supporting programming education. This aligns with earlier studies that emphasize the cognitive benefits of learning C++ programming through games.

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