Motivation to Learning Computer Programing Using a Game Application

Nantapong Keandoungchun, Jitimon Angskun, and Thara Angskun*

***Abstract*—Computer programming is a course studied in almost all fields; nevertheless, the survey found that many students obtain low grades or withdraw from the computer programming course because the students lack the motivation to learn. This article proposes the development of a game application for motivating computer programming learning. The contents of computer programming lessons are designed in the game style. In addition, gamification concepts encourage the students to learn the lessons. This research assesses the student's motivation to study the C language program. The sample consisted of 245 students studying C language. The motivation assessment questionnaire was divided into seven aspects, namely 1) a Future-oriented person, 2) an Ambitious person, 3) a Diligent person, 4) a Success-oriented person, 5) a Responsible person, 6) a Hardworking person, and 7) a Venturesome person. The evaluation results indicated that the game application encourages students to learn computer programming. When considering students' motivation before and after learning using the game application, the results revealed that the average motivation in all seven aspects increased significantly. The aspect of ambitious person differed significantly at the 0.01 level, while the aspects of future-oriented, diligent, responsible, hardworking, and venturesome persons differed significantly at the 0.05 level.**

***Index Terms*—Game application, computer programming, motivation**

I. Introduction

Many universities have included Computer Programming as one of the primary or core subjects that all students in the curriculum must study. Most of them have also included Computer Programming as the core subject of all disciplines in the Faculty of Engineering and Faculty of Digital Technology. However, each field may study a different programming language, such as Python, C, and PHP. Most computer disciplines teach C language as the core subject because it is a flexible language, i.e., it can combine multiple instructions into a single instruction, making the code more compact. It is also a structured language, so it is suitable for beginners to practice programming step by step [1]. The C language is high-level, but its performance is close to that of a low-level language; therefore, it is widely used among programmers today [2].

According to the study and literature review, it was found that there are many factors related to academic achievement [3]. One crucial factor is that students need more motivation to study. A survey of the achievement motivation of the 168 first-year students in the Information Technology, Suranaree University of Technology revealed that the students were motivated to succeed in learning Computer Programming. Two students had the highest level of motivation, with average scores of 3.77. 87 students had a high level of motivation, with average scores of 2.89. 76 students had a low level of motivation, with an average score of 2.15, and three students had the lowest level of motivation, with an average score of 1.17. In addition, the data of students who answered questions based on cumulative grade point average (GPA) was analyzed, and it found that for students with grades higher than the mean (i.e., grades C+, B, B+, and A), the average motivation was at a high level. They represent 42.2% of students.

On the other hand, 57.8% of students with grades lower than or equal to the mean (i.e., grades C, D+, D, F, and W) had average motivation at the low level. Lack of motivation to study is a severe problem because it is the heart of successful learning. If the learners feel bored, uninterested, do not want to learn, or lack the motivation to study. It inevitably affects teaching and learning. Students may turn their attention to other activities instead of studying. At present, it is found that computer games are considered a type of entertainment media that can create motivation, encourages students to have fun and enjoy, have a positive attitude towards the subjects, and be able to solve problems on their own [4]. In addition, the game can also improve the learners' learning skills, increasing the learners' self-learning skills and enhancing the teaching to be more attractive [5, 6]. There is also a concept of gamification [7], which is applying non-games to design a game to make people interested and participate in the activities. It is a concept that adopts the theory of game and game design techniques such as point accumulation, level promotion, trophies, and leaderboards that are applied in instructional design to motivate interest in learning.

There are related research studies on game application development for motivation in learning C language that applies gamification principles. Some research is associated with C language learning. Kyaw *et al*. [8] studied Element Fill-in-Blank Problems (EFP) for the C programming learning assistant system. The results revealed that EFP could detect students with difficulty studying C programming. Sun and Hsu [9] applied eye-tracking devices to improve students' learning self-efficacy and performance in a C programming course. The findings suggest that eye-tracking and peer scaffolding methods can be used to learn the C programming language, as they significantly enhance learners' self-efficacy. Demaidi *et al*. [10] applied blended learning in a C

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programming course. The results revealed that blended learning improved student performance compared to traditional learning.

Some research is focused on using games or gamification in education. Daungcharone *et al*. [3] developed a mobile game for C programming language learning. This study examined the motivation and learning achievement differences between students with experience and inexperience with educational computer games. Talingdan and Llanda [11] developed an Android-based application that applied gamification concepts to facilitate the learning of C programming. The results revealed that the application is an effective Gamified tool in learning C programming as students can learn more significantly. Zainol and Aziz [12] developed a game called C-hunter for learning C++ language. The result indicated that this game made learning more fun and enjoyable. Gulec *et al*. [13] developed a responsive web platform to teach the syntax and logic of the C programming language by using game elements. The results indicated that this game could be used as an educational tool. Montes *et al*. [14] created an online game called DFD-C to teach basic C programming concepts. The results revealed that the game could significantly improve the test score of students. Vegh and Takac [15] applied a few online games (e.g., LightBot, RoboZZle) to teach C programming language to children. The results revealed the possibility of using this online game in education. Jusas *et al*. [16] applied gamification concepts to an object-oriented programming course. The results demonstrated that the gamification of the OOP course resulted in more sustainable behavior of the students.

Most existing research focused on improving learning achievement with educational games, while the effect of educational games on learning motivation still needs to investigate. Thus, this article proposes the development of a game application to help build motivation for studying computer programming. In this research, the C programming language's content was designed as a game and applied gamification principles to create learning motivation.

II. Game Application Framework

This research focuses on applying the content of C language and gamification principles to develop game applications to generate inspiration for computer programming learning. The game application development aims to create motivation for learning the C programming language. It was designed according to the concept of learning game theory. This application was applied to a sample group of students to study whether the game application could motivate the students to learn C language. The conceptual framework of a game application is divided into three parts: input, process, and output, with details as follows.

A. Input

The input data consists of two parts: data from developers and data from players. The input data from the developer will be part of the C language content designed as a game application. Experts evaluate this knowledge of the C language before applying for a game application design. The input data from the player comprises the name of the player's personal information, the answer that the player selects from the game application screen, and logging in to the system each time.

B. Process

The game application stores the player's information when a player logs into the application. Then the player can play the game according to the steps of the game application placed, and the application can save the playback history data, which players can log in to play whenever it is convenient for them. The player must start playing from the first level of the game. The process that occurs during play is on the first-time login. The game application then leads the player to the game's first stage. Suppose the player has passed the first level or has played at any level. In that case, the application will retrieve the player's play data when logging into the application again so that the player can continue to play at the next level. Players can choose the next level from the current level they just passed. At each level of the game application, the player has to select or play according to the problem specified to test that the player understands the content of the C language subject. Players can also go back and play at the same level they have already been passed.

C. Output

The output is the result of the running process of the game application, which occurs after the player submits a value (i.e., playing the game) through the screen. For example, clicking to select the answer, calculating the displayed value to the player, showing the score after the player completes each level, showing the scoreboard to players, changing stages played, and receiving a special award.

III. Functional Structure of the Game Application

The functional structure of the game application is divided into three parts: Story, Principle, Score, and Coin Calculation. The details are as follows.

A. Story

The story in the game application is based on the content of the C programming course. Each content will be created in the form of a game stage. Players must play and score points to pass each step. The game application consists of 9 stages which are grouped into three groups based on similar game styles as follows:

Stage 1–**3** How to play: Match the correct information.
Content: Variables, Variable Types, Signs, and Operations in C Language
Objective: To correctly let players know variables, variable types, and the use of signs and operators in C language.

Stage 4–**5** How to play: Open the hint and match the meaningful sentence.
Contents: Display and get data commands such as printf(), puts(), getch(), and getchar(); Control commands such as if, else if, for, switch, do while, and while; The definition of each display, get and control command.
Objective: To let players know how to use display and control commands and receive information

correctly.

Stage 6–9 How to play: Drag the answers to fill in the missing parts to complete the code.
Content: It is a programming part. It begins with the primary level (e.g., assign or print variables) and to the intermediate level (e.g., using alternative and control commands).
Purpose: To let players know how to write programs correctly and check for missing grammar to ensure completeness.

B. Principle

- Whenever players complete all stages, the application will notify them. If the players win, they can select the next checkpoint. Otherwise, they can choose the same level again or return to their main screen.
- Stages 1–3, 4–6, and 7–9 are called Hell, Human, and Heaven groups.
- Whenever the player completes a level, it will always be leveled by one level.
- To play the next level, the player must pass the current one.
- The player must collect five or more stars to move to the higher group.
- The player can go back to play in previous stages.
- It displays the name and score by ranking in the leaderboard. Leaderboard scoring will be calculated from the total score received. The leaderboard is divided into two parts: the overall and each stage leaderboard.
- Purchasing items in the game are used for coins only.

C. Score and Coin Calculation

The total score of each stage is 2,000 points, which are acquired from:

- 1,000 points for every completed stage.
- The remaining 1,000 points are calculated from the:
  - ✓ Remaining hearts (200 points each, hence 3 hearts equal to 600 points)
  - ✓ Time (4 points per second, maximum is 400 points)
- Coins of each stage are a total of 320 coins from:
  - ✓ 160 coins for every completed stage.
  - ✓ 160 coins for a total score (20/125 × (total score – 100)).

IV. Game Application Testing and Discussion

There are two testing results: game application design and development and game application evaluation.

A. Result of Game Application Design and Development

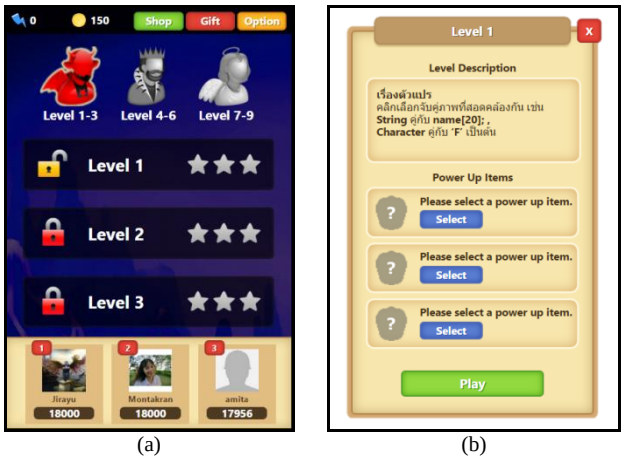
1) Game access

For accessing the game application, it receives information from the player and saves the player's report into the database consisting of:

- The register page is a user interface for players to fill in their information, such as student I.D., name, gender, photo, and password.
- A login page is a user interface for players to sign in.
- The stage of page selection contains a list of the stage for players to select.

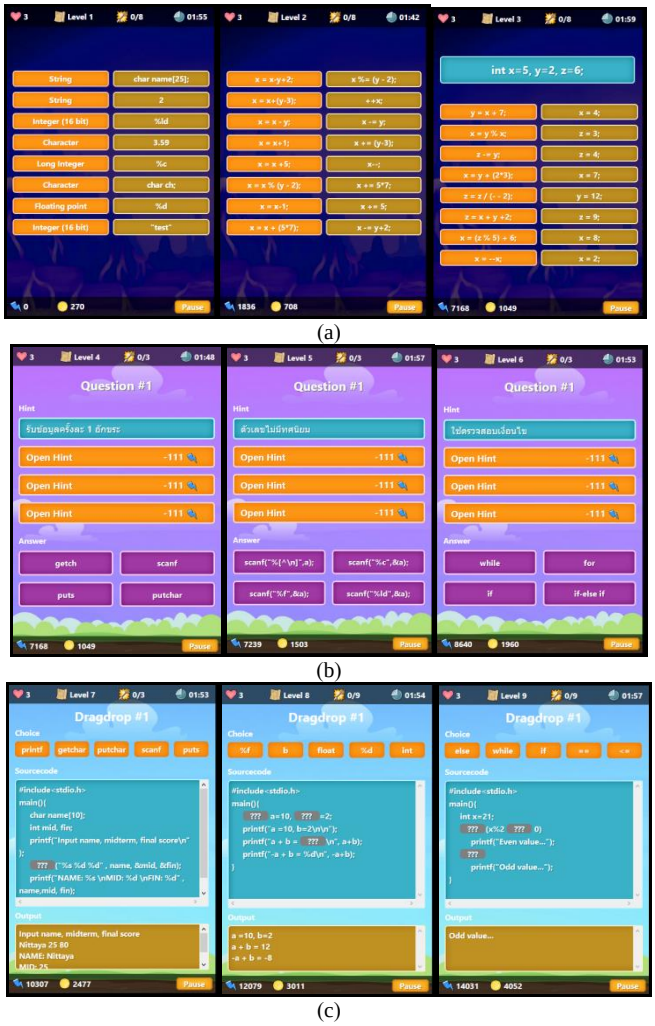
2) Game playing

This game consists of three groups, namely Hell (Stages 1–3), Human (Stages 4–6), and Heaven (Stage 7–9) group as shown in Fig. 1a. When players select each stage; the application will display how to play information as shown in Fig. 1b to inform players before playing the game. On entering each stage, players can choose special power-up items, making the stage easier. However, players may challenge themselves by selecting no items. Finally, when players click the "Play" button, the application will display the stage, as shown in Fig. 2.



(a) (b)

Fig. 1. The screen: (a) Stage selection and (b) How to play.



(a)

(b)

(c)

Fig. 2. The screen: (a) Stage 1–3 (b) Stage 4–6 (c) Stage 7–9.

Initially, the application will give three hearts and two minutes to play. Players must win before the hearts reach 0, or time runs out. The top bar will show the picture that represents the remaining hearts ( ), the current stage ( ), the correct answers ( ), and the remaining time ( ). In addition, the bottom bar shows the current score ( ) and total coins ( ). Finally, the "Pause" button is in the bottom right corner to let the players pause their game.

Fig. 2(a) shows an example of stages 1–3, where players must click each photo with the same meaning from both sides. If matching correctly, both photos will be disappeared, and players will get 20 coins, as shown in Fig. 3(a). On the other hand, their hearts will be reduced by one, as shown in Fig. 3(b). Players must play until all photos match correctly or the hearts reach 0.

Fig. 2(b) illustrates an example of stages 4–6 that provide four hints and answers. The first hint will be opened automatically by default. Based on hints, players must guess the answer. If they guess correctly, they will get 53 coins per question. Otherwise, the heart will drop by 1. Players can open more hints, but they cost 111 points per hint.

(a) (b)

Fig. 3. The screen: (a) Correct and (b) Wrong.

Finally, stages 7–9 will display source code in C language with missing parts and its output. Each question has five choices and only one correct answer. Players must drag the choice to that missing location. If dragging correctly, players will get 53 coins. On the other hand, if players drop the wrong answer into that place, the heart decreases by 1.

If players win the game within the time limit, the application will display stage information such as the number of stars, playtime, level score, best score, total score, and bonus coins. Moreover, three buttons provide players to replay, show the leaderboard, and go to the next level by clicking the "Replay," the "Leaderboard," or "Next" buttons, respectively, as shown in Fig. 4a.

Players will lose the game automatically if their hearts or time decreases to 0. Then, the application will display, as shown in Fig. 4b.

3) Other components

- Shop for purchasing or selling the items.
- Gift for sending or receiving the gift.
- Setting for adjusting the information via buttons such as on/off sound and effect button, personal information edit button, leader board button, Game details button, FAQ button, and Exit button.
- Personal information for editing student ID, password, name, gender, and photo.
- Leader board for displaying total score ranking or each stage ranking.
- Game details for showing the details.
- FAQ for showing the game instruction.

(a) (b)

Fig. 4 The screen: (a) Win and (b) Lose.

B. Result of Game Application Evaluation

1) Evaluation result of game application usability

The research uses a questionnaire to measure the game application's usability. It was evaluated with three groups of experts: three teachers with C language expertise, three C language programmers, and three former C language learners. The analysis results are shown in Table I.

TABLE I: OVERALL USABILITY TESTING RESULTS OF THE GAME APPLICATION

Seq.	Usability Aspect	$\bar{X}$	*S.D.*	Level
1	Efficiency	4.68	0.57	Highest
2	Effectiveness	4.79	0.52	Highest
3	Flexibility	4.60	0.71	Highest
4	Learnability	4.42	0.53	Highest
5	User Satisfaction	4.67	0.46	Highest
	Average	**4.67**	**0.58**	Highest

The usability evaluation of the game application found that players were satisfied with the application's capabilities in all aspects at the highest level. Players were most satisfied with effectiveness ($\bar{X}$ = 4.79), followed by efficiency ($\bar{X}$ = 4.68). The other aspects had averaged scores as follows: User Satisfaction ($\bar{X}$ = 4.67, Flexibility ($\bar{X}$ = 4.60, and Learnability ($\bar{X}$ = 4.42).

When considering the standard deviation (*S.D.*) in the data distribution in assessing the application's overall usability, it was found that the coefficient of variation (*C.V.*) = 0.12 when the value $\bar{X}$ = 4.67 and *S.D.* = 0.58. Therefore, the *C.V.*, which is less than 1, indicated a marginal difference among users. That means most subjects were similarly satisfied with all aspects of the game application's usability.

2) Evaluation results of achievement learning motivation in C language

This assessment measures the student's motivation to study the C language program. The sample consisted of 245 students studying C language. The student motivation was assessed using a questionnaire divided into seven aspects,

namely 1) Future-oriented person, 2) Ambitious person, 3) Diligent person, 4) Success-oriented person, 5) Responsible person, 6) Hardworking person, and 7) Venturesome person. The data were collected and analyzed by means and standard deviation before and after learning C language. The details are as follows.

The results of the motivation assessment showed that students' pre-learning achievement motivation in C language in terms of future-oriented person, diligent person, and the responsible person was at high levels ($\bar{X}$ = 2.92, $\bar{X}$ = 2.68, and $\bar{X}$ = 2.66, respectively). In contrast, the pre-learning achievement motivation for ambitious, success-oriented, hardworking, and venturesome people was at low levels ($\bar{X}$ = 2.48, $\bar{X}$ = 2.43, $\bar{X}$ = 2.40, and $\bar{X}$ = 2.32, respectively).

The students' post-learning achievement motivation in C language in all aspects was at high levels ($\bar{X}$ = 3.09, $\bar{X}$ = 3.03, $\bar{X}$ = 2.88, $\bar{X}$ = 2.88, $\bar{X}$ = 2.82, $\bar{X}$ = 2.80 and $\bar{X}$ = 2.71, respectively) as shown in Table II.

Although the mean results of the motivation assessment of the players before and after learning were different, these differences may not be statistically significant. Therefore, this research analyzed the mean difference of the pre-and post-learning to ensure that these differences are statistically significant by using paired-sample T-test statistics.

In the test, two assumptions were made:

H_0: The students had the same motivation before and after learning.

H_1: The students had different motivations before and after learning.

The comparison of pre-learning and post-learning motivation in C language is divided into seven aspects according to the components of achievement motivation. The results are shown in Table II.

TABLE II: OVERALL RESULTS OF THE TEST OF ACHIEVEMENT LEARNING MOTIVATION IN C LANGUAGE IN ALL ASPECTS OF PRE-LEARNING AND POST-LEARNING BY T-TEST STATISTIC

Seq.	Achievement Motivation	Pre-learning		Post-learning		Sig. (2-tailed)
		$\bar{X}$	level	$\bar{X}$	level	
1	Future-oriented person	2.92	High	3.09	High	0.036*
2	Ambitious person	2.43	Low	2.71	High	0.010**
3	Diligent person	2.66	High	2.88	High	0.016*
4	Success-oriented person	2.48	Low	2.88	High	0.056
5	Responsible person	2.68	High	3.03	High	0.037*
6	Hardworking person	2.32	Low	2.82	High	0.026*
7	Venturesome person	2.40	Low	2.80	High	0.042*

* *Statistical Significance (Sig) At the 0.05 level*
** *Statistical Significance (Sig) At the 0.01 level*

Table II illustrates that after using the t-test statistic, there was a statistically significant difference at 0.01 level for an ambitious person. There was a statistically significant difference at the 0.05 level for the rest of the aspects, except for the success-oriented person aspect, which was not significantly different.

V. CONCLUSIONS AND FUTURE WORK

This research has developed a game application for motivating students to learn computer programming. It applies gamification principles as a guideline for developing the application to motivate students. The application uses C language content to design and develop a game. In this research, the game application was created for students to play the game as supplementary teaching to C language subjects in typical classrooms.

The result of the C language problem assessment by experts in all nine levels found that there were 130 questions, 33 of which did not pass. Of which 33 items did not pass, 29 questions were revised to make it work, and 4 questions were eliminated. The evaluation of the game application's usability found that experts were satisfied with their ability to interact with all aspects of the application at the highest level. Players were satisfied at the highest level in terms of effectiveness.

The results of the motivation assessment showed that students' pre-learning achievement motivation in C language in terms of being a future-oriented, diligent, and responsible person was at high levels. In contrast, the pre-learning achievement motivation of ambitious, success-oriented, hardworking, and venturesome people was at low levels. In all aspects, the students' post-learning achievement motivation in C language was at high levels.

After using the t-test statistic, the experiment found a statistically significant difference at the 0.01 level for an ambitious person. There was a statistically significant difference at the 0.05 level for the rest of the aspects, except for the success-oriented person aspect, which was not significantly different.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

NK formulated research questions. JA involved intellectual contribution, model analysis, and model evaluation. TA and NK generated figures and tables. Writing and reviewing were done by all authors. TA read and approved the final manuscript.

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