Codigo: A Game Application for Learning Basic Python Coding

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Abstract

The study introduces "Codigo: A Game Application for Learning Basic Python Coding," designed to enhance the traditional approach to teaching Python programming for beginners. The research aims to overcome challenges in conventional teaching methods, such as low engagement and difficulty retaining programming concepts. The game offers an interactive and enjoyable learning experience with challenges and rewards by incorporating gamification principles. The researchers employed a purposive research design with 159 first-year Computer Science students at City College of Angeles as participants. To assess the system, the researchers used the ISO-25010 standard. Evaluation results from IT and non-IT experts indicate a positive response, with strong agreement on functional suitability, performance efficiency, usability, and reliability. Notably, non-IT experts express significantly higher overall satisfaction.

Keywords: gamification, GameMaker Language (GML), gameplay, traditional learning, Raosoft, Linear Search Algorithm

INTRODUCTION

In today's society, computer programming has become an essential skill as the world move towards automation (Garcia & Revano, 2021). Universities offer courses and programs to produce skilled programmers and meet the growing IT/CS industry demand. Python is a programming language included in the curriculum due to its high demand (Sava, 2023) and popularity among developers (Vailshery, 2022a). It is a go-to language for various applications, mainly in data analysis, web development, machine learning, and system administration (Vailshery, 2022b; Nagpal & Gabrani, 2019). Therefore, starting with this language is a good choice for those who want to pursue a career as a programmer since it is simple, easy to use, flexible, and offers more opportunities for those skilled at it.

Also, learning how to code in general can be a daunting task for novice learners, especially those without pre-existing programming knowledge. Usually, novice learners need help with programming syntax, logic, and concepts (Prather et al., 2018). This is due to the nature of programming languages, wherein one can interpret the problem differently from the other, and the behavior of the source code is not reflected as it produces the actual result in the form of text (Kadar et al., 2021). It is also why program debugging is difficult for novice learners, as many possibilities and assumptions need to be considered (Fitzgerald et al., 2010). Moreover, several factors such as motivation, attitude, individual differences (e.g., capacity for learning and proficiency in mathematics), and teaching strategies also complicate the learning process (Björkholm & Engström, 2017; Garcia, 2021).

Statement of the Problem

Learning Python programming in the classroom through traditional teaching methods is less effective, especially for novice learners (Xihui Zhang et al., 2019). Challenges in teaching and learning include:

1. Conventional instructional materials do not foster motivation in students. As the results show in the study conducted by Zhang et al. (2019), active learning approach is more effective than the traditional teaching approach.
2. There are low student engagement levels due to the lack of immersive features in traditional learning. According to Cheah (2019), students' perceptions of computer programming as

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difficult and tedious deteriorate their interest in programming.
3. Students easily forget programming concepts. According to Brown & Wilson (2018), novice student programmers need to remember the syntax for the different parts to tackle one coding problem.

Objectives of the Study

The study analyzed the efficacy of a game-based approach to learning Python by developing a game entitled 'Codigo.' Specifically, the study objectives are:

1. To produce a system that has a motivational and recreational vibe and is capable of teaching Python programming;
2. To instill an immersive storyline in the game where users can envision themselves as part of the story; and
3. To provide a system capable of teaching Python programming fundamentals and making it memorable.

Significance of the Study

1. To the Instructors: The study will benefit instructors by providing their students with a new and entertaining way to teach Python programming subjects (Niklas Humble et al., 2021). The data from the study could also be used to improve teaching methods.
2. To the Students: The study will likely increase students' motivation and engagement towards learning Python programming since studying concepts gives off a game-like feel, making it more enjoyable (Theethum et al., 2021). Next, it can help students develop their problem-solving skills and improve their retention of programming concepts. Lastly, the study could spark interest in pursuing a career in computer science (Steinmaurer, Pirker, & Gütl, 2019).
3. To the Researchers: The study serves as a requirement for the students to graduate. The study will help enhance the skills they have acquired in their course.
4. To the Future Researchers: The data collected from this research can be used as a reference if researchers decide to study the same topic.

Conceptual Framework

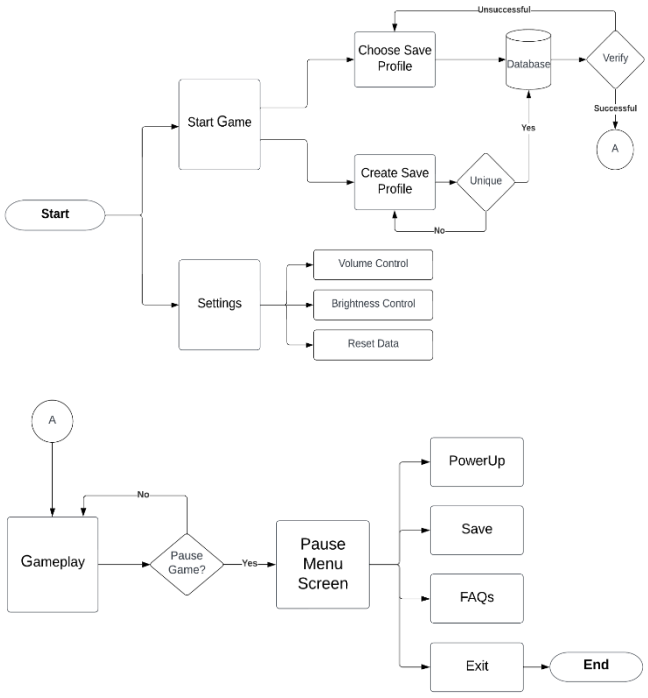

Figure 1. Conceptual Framework (User)

The conceptual framework shows the different possible options for the user to choose from. Once the game has been initialized, the user will be brought to the Main Menu Screen, where they will have three options: Start, Settings, and Exit.

If the user chooses to Start, they will be transferred to the Save Room option, where they will choose among five slots to store their saved data for the game. The saved data will then be transferred to the game's database. The game will ask the user for a name for his saved file; the name must be unique to avoid confusion. If the save name is unique, it will be stored in the database; otherwise, the game will ask for another user name. If the user has an existing saved file, they will have to choose, and the system will verify which saved file to load, and the main game will start.

During gameplay, if the user taps on the pause button, the pause menu screen will pop out, and the user will have five options: Resume, Powerup, Save, FAQs, and Exit. If the user chooses Resume, the pause menu screen will be minimized, and the game will continue. The Powerup option will take

the user to the Powerup room, showing how many powerups the user has collected. Powerups can only be obtained by defeating the boss of each level. Moreover, if the user chooses Save, the user's current progress in the game will be saved in the database. Further, if the user chooses the FAQs option, a new window will pop out containing the necessary information to help the user fully maximize one's gaming experience. Lastly, if the user chooses Exit, the user will be redirected to the main menu, where the user can exit the game.

In the settings feature, the user can adjust the volume and brightness and reset data to delete allof the user's saved files. The exit game causes the game to end. Figure 1 displays the visual representation of the conceptual framework for the user.

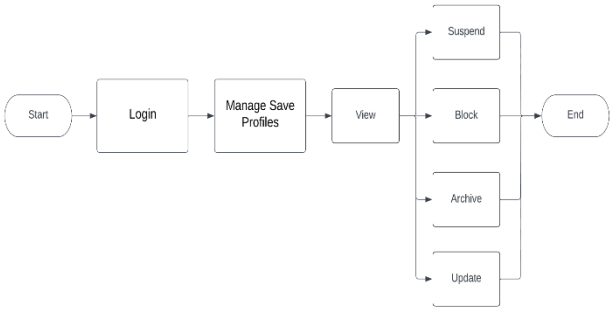

Figure 2. Conceptual Framework (Admin)

The admins can access the players' saved files at the administrative site. The admin has full view of saved profiles and the power to manage them inside the admin site. In managing the saved profiles, the admin can suspend, block, update, and archive. The admin can suspend a saved profile if it has been offline for over 30 days. Next, the admin can block a saved profile if it has been offline for over 60 days. Moreover, the admin can archive a saved profile if the status is "Blocked." Lastly, the admin can update an existing saved profile. For example, the admin can change the saved profile's current level, Mc's health, and associated data, such as the saved profile's unique ID. Figure 2 shows the conceptual framework for the admin.

METHODS

This chapter contains the methods utilized to achieve this study's goal. The research design is the main foundation of this study, while system development methodology is the process of creating the game itself. Participants include the people affected by the research and the sampling technique used. The procedures discuss the different methods used to gather data for data analysis and the methods used to process the collected data. Design and Implementation shows the different specifications of the study, along with the other diagrams that portray the system's flow.

Algorithms

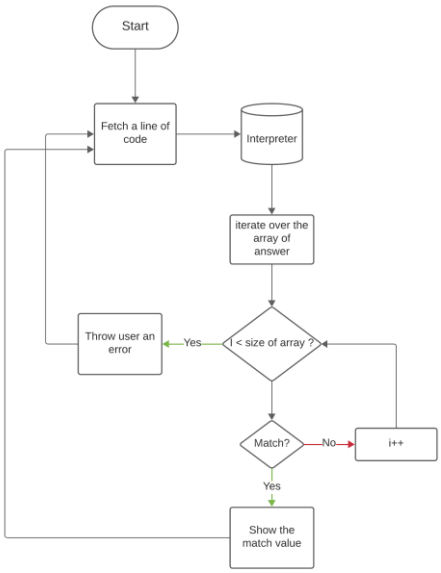

Figure 3. Linear Search Algorithm

This algorithm will be used in the game's compiler, to check if the given input of the user is suitable and corresponds to the given objective of the game. The game has a pre-made array of answers where the system will search through.

Research Design

A descriptive research design is considered the simplest type of research study. This research design allows the researchers to "study and describe the distribution of one or more variables, without regard to any casual or other hypotheses" (Aggarwal & Ranganathan, 2019). According to Cox (2019), quantitative research is where the

researchers utilize statistical analysis and numerical data to find specific answers to some questions that will lead to understanding certain behaviors and phenomena.

Participants

The researchers used Raosoft to compute the sample size for first-year respondents. Raosoft determines the minimum sample size required to estimate a statistic with a reasonable margin of error (Sample Size Calculator by Raosoft, Inc., 2024).

A 5% margin of error and additional variables were considered, with 264 firstyear CCA computer science students. The researchers' usage of Raosoft to calculate sample size led to a total of 159 participants for first-year computer science students

With 264 first-year CS students at CCA, a 5% margin of error and other factors were considered. The sample size calculation used by the researchers to arrive at the 159 total respondents for first-year CS students is shown below.

Given: $n = ?$
$N = 264,$
$e = 0.5$

$$n = \frac{264}{(1+264(0.05)^2)}$$
$$n = \frac{264}{(1+264(0.0025))}$$
$$n = \frac{264}{(1+264(0.0025))}$$
$$n = \frac{264}{(1+0.66)}$$
$$n = \frac{264}{1.66}$$
$$n = \mathbf{159.036145 / 159}$$

Procedure

The data was gathered through the following procedures:

a. **Web Research**: The researchers used web research to find reviews of relevant literature and studies to support their study. According to Affum (2022), the internet significantly influences students' academic outcomes due to its ability to provide access to journals and papers that are otherwise not all available in the traditional library that leads to several conclusions and objectives stated in the study.

b. **Questionnaire Evaluation**: The researchers used questionnaires to collect data from the respondents, including four IT specialists and 159 first-year CS students, once the game application is completed and ready to deploy. According to Picincu (2018), through questionnaires, researchers can contact many individuals and get the data they need to make better judgment. The questionnaire used was based on the criteria of ISO 25010.

c. **ISO 25010** was used by the researchers as an evaluation standard for the system, which enables high quality of software (Britton, 2021). The eight product quality characteristics of ISO 25010 include functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, and portability.
   - **Functional Suitability** refers to how successfully a system or product can perform tasks satisfying explicit and implicit demands.
   - **Reliability** refers to how successfully a system, product, or component performs certain functions in specific situations.
   - **Performance Efficiency** refers to how well a system performs given its resources.
   - **Usability** refers to a system or product's ability to be utilized to achieve specific goals successfully, efficiently, and adequately.
   - **Security** refers to how successfully a system or product protects data and information against security flaws.
   - **Compatibility** refers to how well a system, product, or component can communicate data and carry out its necessary activities using the same hardware or software environment.
   - **Maintainability** refers to how easily a system or product may be changed to meet new needs or to fix, enhance, or adapt to environmental changes.

d. **Portability** refers to how easily a system, item, or component may move from one environment to another.

Data Analysis

The researchers used the questionnaire as the primary research tool for this study, which was developed specifically to accomplish the objectives of the study. It also utilized the five-point Likert scale to interpret the results, which is commonly used in questionnaire-based research (Jamieson, 2023). The researchers used the questionnaire to collect the data required and evaluate the game's suitability for teaching Python fundamentals to 1st-year computer science students.

Likert Scale is a scaling method that is widely applied in studies that rely on questionnaires (Jamieson, 2023). It is a five-point rating scale that allows individuals to indicate their agreement or disagreement with a question or statement (Saul Mcleod, 2023).

Table 1. Likert Scale

Description	Range of Value
Excellent	5
Very Good	4
Good	3
Fair	2
Poor	1

The range of scale values for questionnaires is shown in Table 2. The participants were asked to complete a questionnaire after playing the game to rate the usefulness of Codigo for teaching Python fundamentals on a scale of 1 to 5, with 5 for "excellent," 4 for "very good," 3 for "good," 2 for "fair," and 1 for "poor.".

Arithmetic Mean, frequently used in statistics, is the average of numerical figures. It can be calculated simply by adding all the numbers in the set and dividing the response by the total number in the set (Srivastav, 2019). This mean may be an arithmetic mean that is simple or weighted. It is helpful to simplify the population's observations. The researchers used this method to get the overall average of weighted means.

Weighted mean was used as a statistical tool by the researchers to analyze the data obtained in the questionnaires (Taylor, 2020). The mean was computed to assess the game's appropriateness for teaching Python fundamentals.

Weighted Mean Formula:

$$\overline{x} = \frac{w_1x_1 + w_2x_2 + \ldots + w_nx_n}{w_1 + w_2 + \ldots + w_n}$$

Where:

$\overline{x}$ = Weighted mean,

x = Repeating value,

w = The number of occurrences of the weight

Frequency Count Distribution is a visual representation that uses graphs and frequency tables. The frequency with which a dataset contains examples of a variable's range of potential values is known as its frequency distribution pattern (Turney, 2022).

Percentage Distribution generally refers to a data presentation that shows the percentage of observations for each data point or collection of data points. The relative frequency of survey replies and other statistics are frequently expressed using this technique (JoVE, 2022). It usually happens and is used when a percent-based data set is used to represent a set of data, with each percentage corresponding to a different subset of the overall data set (Starmer, 2023). The general formula of percentage distribution is as follows:

$$P = \frac{F}{N} \times 100$$

Where: P = Percentage

F = Frequency

N = Number of Respondents

Likert Scale Interpretation The results that the researchers gathered from the respondents during the deployment and assessment will be used to analyze and interpret the data during the evaluation period. Interpreting Likert scale data involves considering directionality, central tendency, variability, response patterns, and comparative analyses to infer respondents' attitudes or opinions (SurveyPlanet, 2022).

Table 2. Likert Scale Equivalent

Description	Range of Value
Excellent	4.20 – 5.00
Very Good	3.40 – 4.19
Good	2.60 – 3.39
Fair	1.80– 2.59
Poor	1.00 – 1.79

Table 2 displays the descriptive rating (Pimentel, 2019) that corresponds to the performance of "Codigo" for teaching Python basics. The survey included three IT experts. The researchers utilized ISO 25010 as an assessment criterion for the study to examine their responses regarding the application.

RESULTS

Table 3. Evaluation Result of IT Experts

Criteria	Mean	Descriptive Rating
Functional Suitability	4.00	Very Good
Performance Efficiency	4.33	Excellent
Compatibility	4.50	Excellent
Usability	4.00	Very Good
Reliability	3.75	Very Good
Security	3.60	Very Good
Maintainability	4.15	Very Good
Portability	4.33	Excellent
Overall Mean	**4.08**	**Very Good**

Table 3 summarizes the findings of the four IT experts who evaluated the system. The mean for each criterion is included in the table, as are its descriptive meaning and ranking. The overall mean of the software performance assessment score was **4.08**, which corresponds to **Very Good**. This implies that the system meets the user's demands, making it suitable for teaching fundamental Python programming.

Table 4. Evaluation Result of Non-IT Experts

Criteria	Mean	Descriptive Rating
Functional Suitability	4.66	Excellent
Performance Efficiency	4.53	Excellent
Usability	4.62	Excellent
Reliability	4.50	Excellent
Overall Mean	4.58	Excellent
Criteria	Mean	Descriptive Rating
Functional Suitability	4.66	Excellent
Performance Efficiency	4.53	Excellent
Usability	4.62	Excellent

The evaluation result of the non-IT experts is shown in Table 6. The system was assessed by 159 first-year computer science students at CCA. The system earned an overall mean of 4.58 which translates to an excellent descriptive rating.

DISCUSSION

The findings acquired in this study came from the evaluation conducted by both non-IT and IT experts. The result of the non-IT experts provided an overall mean with an excellent descriptive rating. This means that first-year student-users who tried the system were satisfied with their experience. Meanwhile, the evaluation of the IT experts resulted in an overall mean of Very Good. This is a positive response from IT professionals with potential improvement for the system in mind.

Conclusions

The goal of this study is divided into three. The first goal was to create a recreational tool that boosts the learners' motivation. With gamification, this goal was achieved. Gamification helps the learning of Python programming become a recreational activity where users have to program to defeat the enemies they will encounter. The system also adds a health system that could go down to zero, making the game more challenging and motivating users to do their best to learn Python programming to defeat the enemy.

The second goal was establishing a storyline, allowing the user to visualize themselves as a character in the game. This was achieved by creating a storyline on how the user ended up in the world of Pythonia and what the goal of being there was. The storyline helps increase the user's engagement, making them think about what could happen next or the ending. The game also features a character selection, where the users can choose to use a male or female character, depending on how they visualize themselves in the game.

The third objective of this study was achieved with the main features of the game. The semi-interpreter will help the user practice their coding capabilities, which in this case means they have to create a proper and working snippet of code that will meet the objective that the game has given. The power up room also offers knowledge that will help the learners learn the fundamentals since it provides users access on how to use the different syntaxes in Python. They can also view examples of how to use them properly.

Recommendations

This part of the study presents the recommendations for future researchers who plan to continue or conduct a similar analysis. The recommendations are based on the stated delimitations in this study and the suggestions from the respondents.

1. Add a feature that tracks how long the user has been playing, counts how many times the user has died, and gives an error output.
2. Add character customization that will help the user create a more accurate character to their liking.
3. Add a second game mode known as Arena Mode, which will allow the user to battle enemies already defeated in the story mode.
4. Add a ranking feature that ranks the standings of the user depending on the number of points and time played.
5. Add a mobile port.
6. Improve art style, possibly transitioning from 2D-pixel art into 3D.

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