Impact of the Virtual Reality- Thinkercise

Shweta Nigam [(1)], *Priya Jogi* [(2)]

[1]**Faculty, **[2]**Student**
[1]**Asst. Professor, Department of Information Technology, Shatayu College of Professional Studies,Nagpur**
[2]**Department of Information Technology, Shatayu College of Professional Studies,Nagpur**

ABSTRACT—

Thinkercise was developed to be an educational VR game for reviewing knowledge and skills in Python programming. The game not only encourages players to move their physical body during the game play but also prompts players to use their basic Python programming information and skill to complete a task in the game. In the game play, players are required to answer a series of programming related questions by moving their body in various ways in a limited time, such as punching a target, or avoiding an obstacle. To achieve the maximum score, players could do with to hit the correct answer targets at the right time as well as to avoid all obstacles in the game successfully. Experimental results demonstrate that our game helps increase the students' routine in computer programming by 40.8%. It outperformed self-learning by 30%.

Index Terms—Game based learning, Gasification, Virtual reality, Exercise, Oculus rift

1. INTRODUCTION

Game-based learning and its impact have been explore for many years [1]–[3]. Previous works [4]–[1] reveal that game-based knowledge has a positive effect on the student's learning process as it increases the student's motivation for learning and the student's learning achievement as well as provides them with good opportunity to acquire or review pieces of Python programming information and skill.

Although there have been several attempts to apply game-based learning to subjects such as mathematics [2], statistics [4], biology [7], and chemistry [8], most of those attempts did not involve Virtual Reality (VR) games. VR is a computer generated, interactive, simulated visual and audio environment that can bear a resemblance to a fantastic world or the real world. In the immersive and enjoyable surroundings of these worlds, players automatically acquire pieces of knowledge and skill while they are enjoy the game content. For this reason, we developed an educational VR game called Thinkercise to better motivate students to learn and enjoyably increase their computer programming skill.

The expected education outcomes of Thinkercise are the following: 1) students will successfully acquire programming skills in core Python programming and 2) students will be fluent in the use of conditional statements, loops, purpose calls, exception handling and data structures.

2. RELATED WORK

This section reviews relevant preceding works on virtual reality and game-based learning.

A. Virtual Reality

Virtual Reality (VR) is an advanced, human-computer boundary that simulates a realistic-looking environment. The user can move around in a virtual world and interact with the objects in it.

In the past decade, applications of VR technology have lengthened from the entertainment industry to various fields. For example, in clinical medicine, VR simulation has been used for physical rehabilitation, pain management, surgery training, anatomical education and the treatment of psychiatric disorders [9]–[11]. Flight replication is one of the earliest applications of VR, in which tasks performed in the virtual world provide the training. Trainee pilots can practice their flying skill safely with no danger of crashing a real plane [12]–[14].

Numerous studies of VR use in education yielded positive results such as increasing time-on-task [15], pleasure [16] and motivation [17].

B. Game-based learning

Game-based learning relies on games that not only enhance understanding and skill acquisition but also involve problem solving and provide a sense of achievement through the content and game play [18].Several works [4]–[6], [8] demonstrate that game-based learning is beneficial for students in many

ways including 1) increasing motivation for learning, 2) improving learning achievement, and 3) providing a good opportunity to acquire knowledge and skills.

Although there have been several attempts to apply game-based learning with programming subjects [19]– [21], most of them were NOT VR-based games.

3. DATASET

In this work, we created a dataset called Thinkercise quiz dataset, consisting of 300 questions and answers about Python programming under nine topics: 1) Variables, 2) Data types, 3) Built-in functions, 4) Conditionals, 5) Repetition, 6) Error and exception,7)Functions, 8) Data structures and 9) Integrated topics. The questions and answers were uniformly distributed among all topics and further classified into three complicatedness levels: easy, medium, and hard. Some example questions are shown in Table I.

TABLE I: Examples of questions from the dataset.

Level	Example questions
Easy	What is the difference between topple and set?
Medium	What is the output of the following code: print([x for x in range(3)])

Hard	What is the output of the following code:
	def main():
	name = 'adam'
	printName(name)
	print(name)
	
	def printName():
	print(name)
	name = 'jack'
	main()

4. SYSTEM SCENARIO

Thinkercise integrates an educational game with virtual reality technology. The game flowchart is shown in Fig.1. When players enter the game, the main menu will be displayed (Fig.2a). Players can choose among 3 different options:

1) Game play mode: players are required to hit the correct target at the specific time for each question as well as avoid the obstacles which will occasionally appear on the screen.

2) Tutorial mode: the instructions and rules will be shown and guide the players to complete one question of the game play mode.

3) Exit: the program will be terminated.

5. THINKERCISE

In this section, the details of game components:

- system requirements, 2) questions and answers, 3) tutorial mode and 4) game play will be described.

TABLE II: Game play setting in each difficulty level.

Level	Topics included	Music speed	Target freq.
Easy	Variable, data type, build-in function	Low	10
Medium	Condition, repetition, error and exception	Medium	18
	Functions,		

| Hard | data structure, integrated topic | High | 24 |

A. System requirements

To play Thinkercise, students must have the Oculus Rift headset and a PC with the minimum specification of Intel i3-6100 with NVIDIA GTX 960 4 GB, 8 GB of RAM and Windows 10.

B. Questions and answers

The total 300 questions and answers are hand-crafted from several sources and have been divided into 9 Python programming language related topics.

These questions and answers will further be equally classified to 3 difficulty levels: easy, medium and hard. During the game play, the system will randomly sample 10 questions and display them to the players.

C. Tutorial mode

In the tutorial mode, players will learn how to play the game. When players enter the tutorial, the game instruction and rules will be shown to the user as well as the instructions on how to control the Oculus Rift as shown in Fig.2b. Then, the players will be guided, step-by-step, to complete one question in an easy level of the game play mode and fever time.

D. Game play

In the game play mode, players will first enter their weight in kilograms (Fig.2c) such that the game will be able to calculate their calories burned during gameplay.

1) Calories calculator: Calories burned per minute (CBpM) is: (M ET BodyW eight (KG) 3:5)=200 where M ET is a ratio of human working metabolic rate relative to resting metabolic rate. Metabolic rate is the rate of energy expended per unit of time which describes the intensity of an exercise or activity [22]. In Thinkercise, we refer the M ET = 12 which is equal to boxing and we use this number to calculate the calories burned in a game.

2) Game play difficulty: After entering their weight in kilograms, players select question topics and difficulty level from the menu as shown in Fig.2d.

(a) Main menu	(b) Tutorial	(c) Insert weight

(d) Difficulty menu	(e) Gameplay: hitting targets	(f) Gameplay: avoid obstacle

Fig. 2: Thinkercise pipeline

- Game play setting: During game play, the system starts by displaying the question to the players. Players will have 20 sacs to find the answer. However, during that time, there will be disturbances. Two colored cubes, one blue and one yellow, will be randomly generated as well as obstacles. Players have to hit the blue cubes or targets with their left hand and the yellow ones with their right hand to obtain the score (Fig.2e). Mismatch hits mean no score. To further encourage the body movement during the gameplay, the players are required to avoid the obstacles or the pink bar in Fig.2f, otherwise they will lose their score.

- Fever time: After 10 questions, there will be a fever time where players can collect extra scores from hitting non-stop targets. The duration of the fever time is based on the product of their combos and their scores. This encourages players to answer the question correctly and hit the right targets or avoid the obstacles as much as possible.

6. EXPERIMENTAL RESULTS

To evaluate Thinkercise, 20 students (12 males and 8 females) whose average age is 21 were asked to participate in the experiments. These students were the senior students at the Faculty of Information Technology, who were familiar with Python.

A. Quantitative results

We split the participants into two groups: 1) group-A which consists of 8 students who only reviewed the topics via reading books or doing exercises, also called the traditional way, and 2) group-B which consists of

TABLE III: The average scores of the pre-test and post-test exam of two groups separated by gender.

		Pre-test(%)	Post-test(%)
	Male		
Group-A		51.6 2.3	78.3 2.1
	Female	85.0 0.5	80.0 2
	Male		
Group-B		53.3 3.0	86.7 1.1
	Female	38.3 1.3	86.7 1.7

7. CONCLUSIONS

In this work, we propose Thinkercise as an alternative tool for reviewing Python programming. Thinker-cise is a VR computer-based game which aims to increase students' motivation for learning as well as their computer programming skill. There are at least 300 question-and-answer pairs across 9 topics about Python. The quantitative results demonstrate that the average scores of the students who review topics via both reading books and playing Thinkercise increased about 40:83%, while the scores of students who only read a book increased only about 10:83% over a week of experiment. Moreover, we found that students prefer to play Thinkercise 4 times more often than reading books. Finally, 83:33% of the participants left positive comments about the game with the average score of 4.46 out of 5 for the degree of satisfaction.

REFERENCES

[1] F. Ke, "A qualitative meta-analysis of computer games as learning tools," in Gaming and Simulations: Concepts, Methodologies, Tools and Applications, 2011.

[2] M. Kebritchi, A. Hirumi, and H. Bai, "The effects of modern math computer games on learners' math achievement and math course motivation in a public high school setting," British Journal of Educational Technology, 2008.

[3] G.-J. Hwang, L.-Y. Chiu, and C.-H. Chen, "A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses," Computers & Education, 2015.

[4] P. Boonpotjanawetchakit, K. Kaweerat, and S. Vittayakorn, "Elemem: Interactive digital card game for chemistry," in EDUCON, 2020.

[5] M. Alaker, G. R. Wynn, and T. Arulampalam, "Virtual reality training in laparoscopic surgery: a systematic review & meta-analysis," International Journal of Surgery, 2016.

[6] E. Yiannakopoulou, N. Nikiteas, D. Perrea, and C. Tsi-gris, "Virtual reality simulators and training in laparoscopic surgery," International Journal of Surgery, 2015.

[7] R. L. Page, "Brief history of flight simulation," 2004.

[8] W. Wei, L. Dongsheng, and L. Chun, "Fixed-wing aircraft interactive flight simulation and training system based on xna," 2013.