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GAME THEME BASED INSTRUCTIONAL MODULE TO TEACH LOOPS AND CHOICE STATEMENTS IN COMPUTER SCIENCE COURSES

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With the fast development of computer science and technology, computer games have become one of the integral parts of modern way of living. Research studies have conveyed that educational games are motivating, engaging and provide a reliable learning context. Due to the expansion of the educational transform, game theme-based learning methodology has become one of the current research focuses. There is a need to change the traditional passive method of teaching to an active method of teaching such as game and simulation-based learning. So, we need to provide a better learning environment by increasing the student's motivation towards learning. The game theme-based instructional (GTI) modules prepare the learners to think critically, and the students can adopt new challenges of the relevant knowledge. This paper presents a novel and exciting methodology of teaching algorithms by motivating the students towards learning. We designed and developed The Ball Targeting Game consisting of two GTI modules to teach loops and choice statements. The gaming modules demonstrated in this paper were developed using Vizard, which is a virtual reality toolkit used for developing virtual worlds and immersive applications for visualization and simulation using Python as its scripting language.

Keywords: Game Theme Based Instructional Module, computer science, algorithms

CCS Concepts:

• Software and its engineering∼Software creation and management∼Software development techniques

1. Introduction

Teaching computer science and coding to students can often be a difficult task and many of the concepts and skills involved can seem complex. This is usually

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the case for algorithms, which are an essential part of computer science, but many students can find them confusing if they are not taught effectively. The traditional way of teaching is text-based programming, which is not so inspiring to most of the students. Teaching algorithms using Game theme-based instructional (GTI) module can provide a better understanding of the concept than with a traditional instruction approach and engage students to learn by hands-on experience. Due to the change in the education system, five of the most frequently studied nontraditional methods are:

- Flipped classroom
- Problem-based learning
- Gamification
- Case studies and
- Social media-centered learning.

The authors of [9, 10, 12] defined the flipped classroom as a "pedagogical model in which the typical lecture and homework elements of a course are inverted". The definition of problem-based learning according to [7, 20] is "an instructional method in which students learn through facilitated problem-solving." Gamification is described as "the use of game design elements in non-game contexts" [3, 14]. The case study method refers to "an approach that allows researchers to develop and present an in-depth view of a particular situation, event or entity" [19]. The researchers of [5, 8] defined social media-centered as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content.

Game theme-based learning helps to improve the problem-solving skills of students and produce better learning outcomes [21, 23]. GTI modules help the students to have a better understanding of concepts by engaging them more towards learning according to [16, 18, 23]. Studies have shown that the simulation element of games has educational potential regarding both subjective and social perspectives [22, 24].

This paper discusses the design and implementation of the two Game theme-based instructional (GTI) modules named Shipment and Factory for teaching loops and choice statements to computer science students in an introductory programming course. The Ball Targeting Game was developed to teach loops and choice statements. The GTI modules are developed using virtual reality software and provide better understanding of the concept of loops and choice statements. The gaming modules demonstrated in this paper were developed using Vizard, which is a virtual reality toolkit used for developing virtual worlds and immersive applications for visualization and simulation using Python as its scripting language. Vizard supports high-quality 3D sound and multi-user networking and can import other gaming environments by adding them in the script. The main objective of the GTI module is to provide better understanding of the concept of loops and choice statements by using a constructivist approach of learning by doing.

The paper is structured as follows. The next section briefly describes the work done previously. Section 3 discusses the modeling of GTI modules, while in Section 4 the implementation of GTI modules is presented. Finally, we conclude and provide insights for future work in Section 5.

2. Related works

The design, implementation, and evaluation of a game theme-based instructional (GTI) module to teach linked list and binary tree is presented by [17]. GTI modules are designed to invigorate the instructors to teach and motivate the learners to learn the concepts of the linked list and binary trees using a gaming metaphor. The purpose of their paper is to explore the issues concerning the usability and likability of game theme-based instructional module to teach linked list and binary trees. The results of the evaluation of GTI modules show the effectiveness of GTI modules and demonstrates that the GTI module is more usable and likable. Game theme based instructional modules for computer science students that motivate and engage students while contributing to their learning outcomes are developed by [18]. They design game theme based instructional modules to encourage faculty to teach and motivate students to learn the concepts of object-oriented programming using interactive, graphical, game-like examples. Study of [1] focuses on designing and implementing a virtual reality (VR) game-based application (iThinkSmart) to support computational thinking (CT) knowledge. The study followed the design science research methodology to design, implement, and evaluate the first prototype of the VR application. An initial evaluation of the prototype was conducted with 47 computer science students from a Nigerian university who voluntarily participated in an experimental process. Authors of the paper [21] designed and implemented two modules teaching arrays and loops aiming to provide an alternative way of teaching the two data structures to students in introductory Computer Science courses. To accomplish this, they developed the two Virtual reality instructional (VRI) modules within the Vizard development platform using Python and included seven different types of loops for the Duck Game and two functions for the Array game. The purpose of the study presented in [2] is to investigate the use of an educational game to enhance student learning effectiveness. The results show that the combination of gamification and traditional learning methods can enhance students' learning motivation and learning effects. According to their conclusion, with the development of educational technology, educational games are becoming more and more popular, and further research is therefore recommended. The paper [4] surveys gamification tools used to teach computer programming. According to them, many researchers use game mechanics in a story to teach, encourage, and engage students in learning programming concepts. Also, this technique is a useful support for instructors because it helps them to realize more engagement, motivation, collaboration, fun, and effectiveness. Six serious games with various genres for teaching information security courses and evaluate their effectiveness as an efficient teaching tool are presented by [13]. The study also determines which game genre is the most suitable

for delivering educational contents. The obtained results proved and confirmed the hypothesis that educational games have a positive impact as a pedagogic tool on the educational process. In their work, [6] present a collaborative game that was developed to assist students in learning algorithms and they explore its learning capabilities. The game aims to assist students in learning constraint satisfaction algorithms and it is based on the map coloring game. They conducted an evaluation study in real classroom conditions and revealed quite promising results which indicate that the game is an effective way to enhance students' motivation, engagement and interest and it also helps students to deeper understand the functionality of constraint satisfaction algorithms.

3. Modeling the Game Theme-based Instructional (GTI)

This section discusses the modeling of the two GTI modules: Shipment and Factory. It gives a brief overview of the Vizard platform used to develop the games as well as the concepts covered in the Ball Targeting Game.

3.1. Design considerations

The modules were built with the constructivist theory in mind, which states that the students build knowledge by experiencing it for themselves in the real world. Constructivism refers to the belief that the learners construct knowledge for themselves via interaction. Constructivists focus more on an understanding of knowledge through experience and less on verifying the concept [15]. The modules were also built using functional and nonfunctional requirements. The functional requirements were taken from the student's perspective while the nonfunctional requirements were taken from the instructor's perspective. The functional requirements include the following:

- User interface must be intuitive,
- The student should be able to understand the instructions,
- Displayed pseudocode and flowchart algorithm should be comprehensible.

The nonfunctional requirements include the following:

- Each module should motivate the student to learn,
- Each module should teach the student about the loops and choice statements,
- Reaction to user input should be immediately rendered,
- Graphics should be appealing to the students,
- The modules should be portable, i.e. the student should be able to play each module on any platform,
- An award system should be featured.

3.2. Vizard framework

Vizard as a virtual reality toolkit is a Python-based integrated development environment (IDE) used to develop virtual reality applications. Three-dimensional models can be built in 3D MAX and then imported into the Vizard environment using its built-in exporter. Models and images imported into Vizard can be positioned into the environment and scaled to fit. Through its libraries, Vizard provides built-in functions that govern interactions between objects and their environments. One can also add shapes, text, buttons, and sliders through those functions. Vizard consists of a Python script editor and a debugger. After a script has been created, it can be run with or without debugging. It can also be published as an executable (.exe) file for use by the general public.

3.3. Loop and choice statement GTI module concept

The Ball Targeting Game covers different types of loops and choice statements. They are listed as follows:

1. **If/Else.** In this type of choice statement, an action is carried out if a condition is met. If the condition is not satisfied, a different action is carried out.
2. **Nested If/Else.** This type of choice statement is executed the same way as an **If/Else** choice statement; the only difference is that this choice statement is an **If/Else** choice statement located within another type of choice statement or loop.
3. **Switch statements.** In this type of statement, if a variable being evaluated meets a certain condition, then an action is executed for that condition. Otherwise, a default action is executed.
4. **While loop.** The actions specified in the body of this loop are repeated as long as a certain condition (loop guard) is satisfied. The loop breaks when the condition is no longer met.

4. Game theme-based instructional (GTI) module implementation

This section details the implementation of the two modules and the user interaction featured within them.

4.1. Game engines

The Ball Targeting Game was implemented using the Python programming language within the Vizard Virtual Reality Toolkit, a Python-based integrated development environment used to develop virtual reality applications. On the developer's side, the Vizard IDE provided the libraries needed for the source code of the two modules, represented as ballTargetingGame.py. After development, an executable

file ballTargetingGame.exe was created from the Python file. Once the executable file has been created, it could be used on a standalone computer, without having Vizard installed on it beforehand.

4.2. The Ball Targeting Game

In this section, the entire process of creating a foundational application will be explained in which through a game student will understand virtual reality coding as the basis of a game. The main idea is to create two modules of the game called Shipment and Factory. In both modules, multiple targets are set and essentially multiple functions are repeated. The essence is to have some kind of weapon with which we will need to hit all of the given targets that make some kind of movements without touching them. We need to find the targets which are mapped and placed in certain positions on the scene itself. In order to make it easier to understand and display the functions, the application is divided into several classes. Ready-made models are also used, which are imported into Vizard and thus used during implementation to realize our goal. Following libraries are needed to provide access to the basic Vizard functions:

- import viz – library which is necessary because it provides access to the Vizard library,
- import vizcam – library with which we call the camera that will follow the model,
- import vizact – library that included commonly used applications,
- import vizshape – library with which we will be able to position the models,
- import math – library with which we will be able to provide different values of different constants.

In order to achieve the goal of enhancing students' learning about algorithms and in particular loops and choice statements, a flowchart diagram corresponding to the interaction flow in the game has been created and given in Figure 1. Students need to study the flowchart to obtain an initial understanding on how they can play the game and win. By comprehending the flow of the game based on the algorithm, students can learn how the different types of choice statements and loops behave and how they can be integrated in a computer program. After students have understood the flow and the general idea of the concepts, the game code can be made available to them as a next step. This would provide them the possibility to apply the gained knowledge by modifying the existent loops and choice statements or by interchanging concepts by related ones (e.g., one type of loop with another type of loop) and observing if the flow of the game has changed. We strongly believe that this approach will be especially helpful for computer science students without previous knowledge or programming experience, as in this case they would be given an initial program, which they can modify and further enhance instead of having to

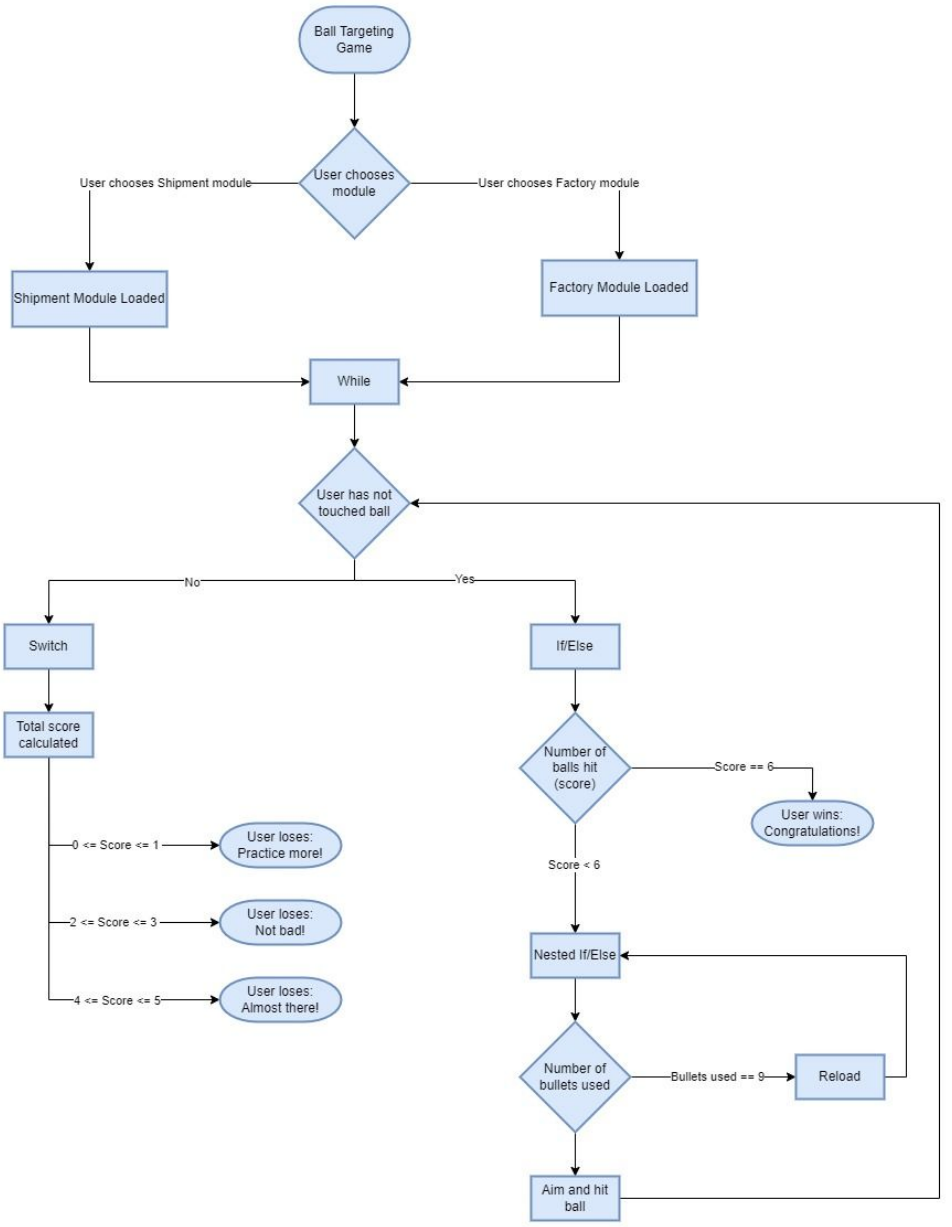

Figure 1. Flowchart representing the different loops and choices offered in the Ball Targeting Game

develop everything by themselves from the very beginning. The students' motivation and the effectiveness of the approach are planned to be evaluated in the future using a questionnaire.

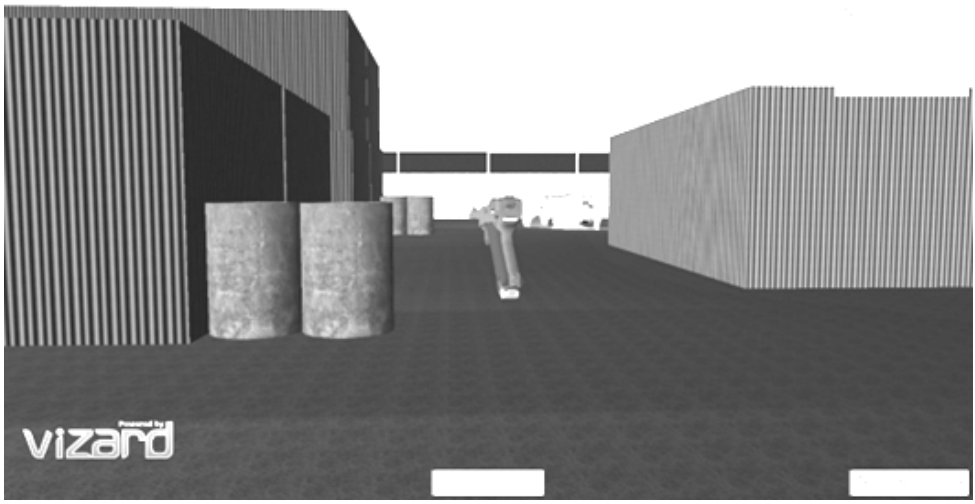

Figure 2. User screen after the Shipment module is loaded

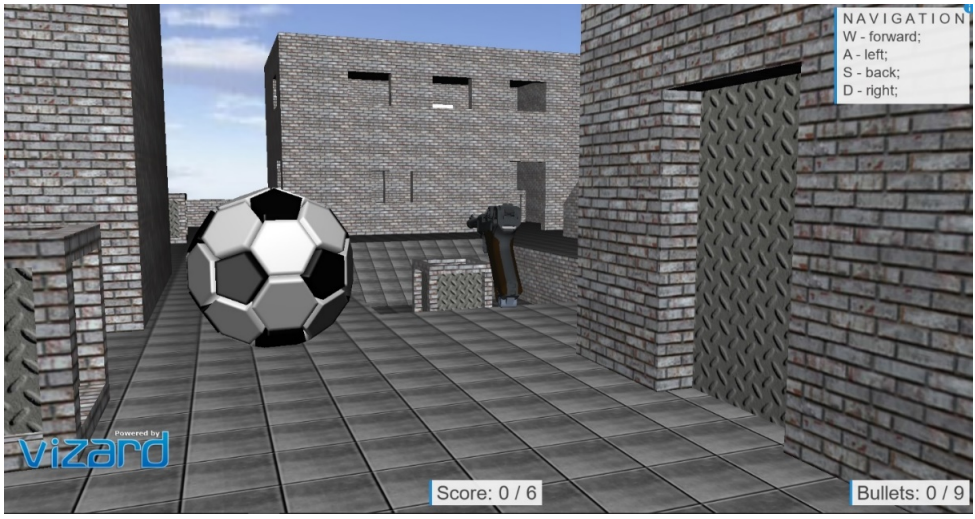

Figure 3. User screen after the Factory module is loaded

The interaction of the user with the game is as follows. At the beginning, a prompt asking the user to choose a module is shown. After the selection of a module, the respective module is loaded and an instruction about how the user can navigate is displayed, as shown in Figure 2 and Figure 3.

In each module there are six balls in total which need to be found and hit by the player. The player can move inside the map as described in the navigation shown in the corner of the screen and can try to hit a ball with a bullet by pressing the Space

Figure 4. Reloading bullets when no more are available

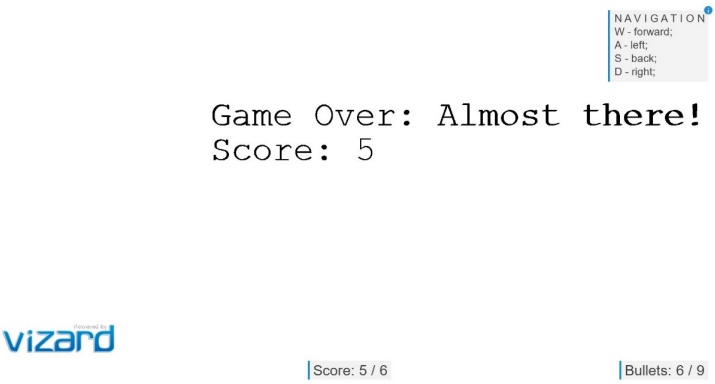

Figure 5. One of the screens shown when the user loses the game

button. The player has initially 9 bullets on disposal, but in case all of them has been used, the Button R can be pressed in order to reload new bullets, as shown in Figure 4.

The choice statements and loops are explained as follows:

- **While.** This loop contains the guard which determines when the game stops. As long as the user has not touched a ball, the game is running and the user can search for the balls, try to hit them and reload the gun if necessary. If a user touches a ball, the game stops and the user has lost the game.

- **Switch.** If the user loses the game, this option determines "how good" the user was in the game. Here, the number of balls hit before losing the game

is considered and a message such as "Practice more!", "Not bad!" or "Almost there!" is displayed (Figure 5).

- **If/Else.** Using this statement it is checked if the user has successfully found and hit all six balls. If the condition is fulfilled, the user wins and a respective message is shown. Otherwise, the game continues.

- **Nested If/Else.** While playing the game, the user occasionally has the option to reload new bullets if the condition that all nine available bullets have been used is met.

5. Conclusion

We designed and implemented two modules teaching loops and choice statements aiming to provide an alternative way of teaching algorithms in introductory Computer Science courses. To accomplish this, we developed the two VRI modules within the Vizard development platform using Python. In both modules, multiple targets are set and essentially multiple functions are repeated. The modules were built with the constructivist theory in mind, which states that the students build knowledge by experiencing it for themselves in the real world. The modules were also built considering functional and nonfunctional requirements. Students can study the provided flowchart algorithm prior to playing the game in order to understand the behaviour of different loops and choice statements and learn how they can be integrated in a computer program. As a further work, GTI modules evaluation using questionnaire to find the motivation of students and the effectiveness of the approach is planned. Modern technologies like automatized attendance tracking systems for tracking students' attendance and obtaining their feedback can be used [11]. We hope that the results of the evaluation of GTI modules will show that instructional modules can efficiently promote learning by encouraging the students' participation. Furthermore, we plan to develop more GTI modules to teach other concepts including, but not limited to concepts like linked lists, binary trees and arrays to introduce students to an alternate method of learning.

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