Adapting Educational Content to Maximise Reuse Across Knowledge Groups via Interactive Experiences

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1 Introduction

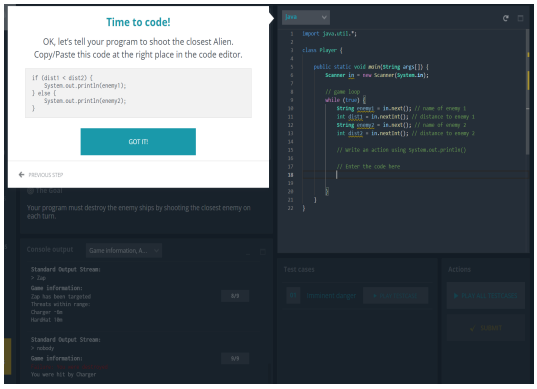
In recent years, the use of technology in education has gained popularity, providing teachers and students with a new means of presenting and absorbing content. One of these resources are educational games, which, through the entertaining and competitive aspects of computer gaming, provide an interactive learning space that promotes analytical thinking.

2 Problem

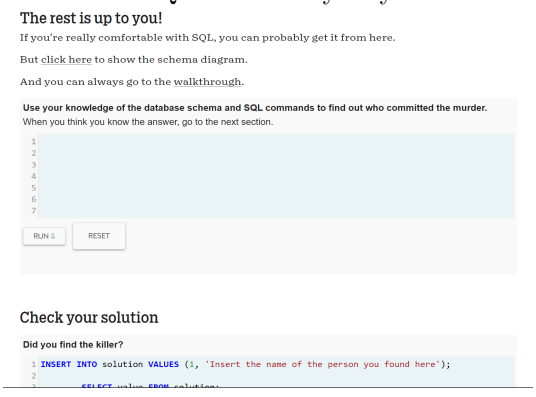
The main issue with many educational games is that they cater to only one knowledge group, usually beginners. One could argue that players who are already familiar with the content cannot benefit from educational games since there is no more knowledge to be gained. However, these types of games offer an interactive space to not only learn, but practice a certain set of skills in a way which is challenging and entertaining. Therefore, it is important that these types of resources are also available and suitable for more experienced users.

On the other hand, authoring content to be suitable for other categories is difficult, expensive and time consuming, especially in the educational games field. As a result, while games in general might have different difficulty settings, educational games are either made for complete beginners or people who are already confident in their knowledge. For example, the screenshots bellow are taken from two different games (Codin Game [1] and SQL Murder Mystery [2]), each of them targetted to a different knowledge group.

Codin Game



SQL Murder Mystery



Another common issue with these types of games is that they tend to be targetted at children or younger students, making them unappealing for older students who could also benefit from such content. This is the most prevalent in educational games which tackle scientific content as this type of information is usually expected to be presented in an academic setting to older students.
In addition, most of these educational games rely on a competition based approach and not many options are available for people who do not enjoy this competitive side and prefer to learn at their own pace.

3 Proposed Solution

The game this project is aimng to create will be single player to avoid the overused competitive format, but will contain a few achivements in order to motivate users to complete it. Since the targetted group are older students, the storyline will be engaging, and more parts of the story will

be revealed the more they play. The concept is very similar to that of the game Hades [3], which, even though is not an educational game, applies some techniques that promote reusability of content. An example of this would be that as the players are more advanced, they are required to chose some obstacles to make the game more challenging, even though the content itself stays the same.

4 Objectives

The aim of this project is to investigate methods of adapting educational content to maximise reuse across knowledge groups. The result will be an escape-room style game which will make use of the methods found and will focus on four topics in computer science: object oriented programming, logic and verification, database systems and web development. I chose these particular topics as they are suitable for beginners and allow for a variety of puzzles to be implemented. Some examples of these will be given in the methodology section.

The game will consist of a couple of runs, their number being dependent of the difficulty, in which the player will have to escape from a few rooms, each room requiring the completion of a variety of puzzles. There will be three difficulty levels: beginner, intermediate and advanced and the player will be able to switch to any of them during the game. In order to help beginner and intermediate players solve the puzzles, hints will be placed around the room. Such hints could include posters on the walls, books, computers displaying already written code and any object that could contain some text refering to computer science knowledge.
Main objectives:

- Functional:

    1. The player will be able to select a difficulty level from the provided list: beginner, intermediate and advanced
    2. The player will be able to move around the world from the perspective of a controllable character
    3. It will be possible to change the difficulty at any time
    4. After playing for some time, the player will be prompted to switch to a more advanced difficulty
    5. Beginner and intermediate level players will be able to find hint around the rooms to aid them in solving the puzzles
    6. Intermediate and advanced level players will have a time limit to solve some of the rooms and puzzles
    7. The players will be able to see a countdown of how much time they have left
    8. Minimalistic sound effects will be used to make the experience more immersive
    9. The player will be able to complete a run of the game by escaping from 3 to 6 rooms
    10. After the player completes a run of the game, the story will advance
    11. Each room will contain 3 to 5 puzzles that require computer science knowledge
    12. Each of the puzzles will have elements that can be randomly generated to ensure the chances of encountering the same puzzle twice are as low as possible.
    13. The rooms will also contain a few basic escape-room style puzzles
    14. After a player encounters a certain room, the chance of it reapearring will be lowered

- Non-functional:
    1. The game will be entertaining
    2. People with no previous computer science knowledge will be able to play the game
    3. The game will be challenging for players with previous computer science knowledge
    4. The storyline will be engaging

Extensions:
These are objectives which may not be necessary for the goal of the project to be achieved, but which could further improve the quality of the game. Since they are not essential, they will only be implemented at the very end of the development process, if time allows.

1. More intricate sound effects could be used to improve the atmosphere of the game
2. New computer science topics could be added
3. The 3D assets could be improved to make the experience more emerssive

5 Methodology

An agile approach will be the most suitable for this project as I may need to quickly make changes to the initial plan, based on the feedback received during the testing phase or the information acquired during the research step. This agile approach will be combined with plan-based elements to ensure the progress and changes made to the initial objectives are well documented.
Since this is a large project that involves more aspects than just creating a game, its development could be divided in four main steps:

5.1 Research

This step will constitute the foundation of the project as it will define some of the objectives of the implementation stage. With the research done up to this point some of the methods of adapting content that were found are:

- using probabilities to ensure beginners have a lower chance of encountering more difficult puzzles;
- providing hints for the less advanced categories of players to aid them in solving the puzzles;
- using a time limit to make the game more challenging for the more advanced players.

Further research will be done by reading related literature and exploring existing games that implement some of the principles targetted by this project. Depending on the results of the research step, the list of objectives presented in this document might expand.

5.2 Resources Creation

This step involves creating or acquiring 3D assets and sound effects, designing the rooms and puzzles involved in the game and creating the storyline.
The initial 3D models will not be complex to allow more time to be spent for research and implementation since that is the main focus of the project. As development progresses, if time allows, more complex assets might be created in order to make the game more appealing to the players.
There will be two types of puzzles involved in the game, puzzles requiring computer science knowledge and normal puzzles usually found in escape-room style games. The latter will involve finding

various objects and combining them to achieve tasks, solving riddles and decrypting codes. The computer science puzzles will require players to investigate already written code, then apply the knowledge to write their own, using SQL commands to obtain information, modifying already existing code to affect the environment and solving a variety of problems in order to gain access to certain items.
Even though creating an interesting storyline to be used in the game is not the main objective of this project, it is an essential element in assuring that the content is interesting for the target players, which are people who are interested in computer science.

5.3 Game Implementation

This stage will be intercalated with the testing phase because the game may need further improvement upon receiving feedback. Therefore, after a version of the game is completed, it will be playtested by a variety of players, each of them providing feedback which will be taken into account for the next version. Ideally major changes will only occur from the first to the second version, yet the schedule will include time for a major change between the second and third version to account for the worst case scenario. If the second version does not need major improvements, the remaining time will be used to implement some of the extensions mentioned in objectives, in order to make the game more polished.

5.4 Testing phase

Since the aim of the project is to maximise reuse of content across knowledge groups, people with various computer science knowledge will be needed for the testing phase. The targetted groups that I will reach out to are the Game Design Society, collegues from the computer science course and friends with no computer science experience. Along with playtesting the game, they will be asked to provide feedback, evaluating their experience with it and suggesting some improvements. Depending on the results, some of the suggestions may become main objectives or extensions. In order to check that the non-functional objectives have been met, the evaluation will be done from a scale of 1 to 10, aiming for an average of at least 7.

6 Timetable

Week	Activity/Deadline
T1 W1	Write project specification
T1 W2	**Project specification deadline**
T1 W2-W3	Read relevant literature
T1 W4	Create 3D assets and soundtrack
T1 W5-W6	Create puzzles + storyline
T1 W5-W7	Implement simple aspects of the game such as a title screen, player controls, options menu
T1 W8-W9	Introduce the rooms and puzzles in the game, giving them a chance to appear based on the difficulty chosen by the player and other factors
T1 W9	**Progress report deadline**
T1 W10	Implement any missing features and write a questionnaire for the testing phase
Christmas Holiday	Begin the testing phase
T2 W1	Analyse results from the testing phase and write up new objectives
T2 W1-W3	Implement the new objectives
T2 W4	Start new testing phase and interpret results
T2 W3-W4	Write first half of final report
T2 W4-W5	Implement any new objectives or extensions
T2 W6	Final testing phase
T2 W7	Game is complete
T2 W8-W9	**Project presentation**
T2 W8-W9	Finish writing final report
T3 W1	**Final report**

Aside from the tasks pictured above, meetings with the project supervisor will also occur every two weeks to discuss progress and request advice if needed.

7 Resources

The game engine I will use in the development of this project is Unity, which uses C# as the programming language. Unity is the most advantageous game engine as it has a large community, therefore there are many guides and articles I could use in case I encounter any difficulties during the development of the game. Some other resources I will be using include Blender (for 3D assets) and Bfxr (for sound effects). All of these resources are free to use and easily accessible online, with official tutorials available, therefore, acquiring and learning how to use them should not take time away from the actual project.
All the work will be done on my personal computer as I already installed some of these resources and using DCS computers while they are not essential for the development of my project might entail the unnecessary risk of them being unavailable at certain times.

8 Risks

While considering the risks that could affect the proposed timetable, I identified the following list, along with some possible solutions:

- The computer I am working on malfunctions. A backup of the project will be kept on GitHub so I can continue working on it from a different device.

- I am unable to work due to unforseen circumstances. The timetable accounts for a few holidays and some free time which can be used to recover the days I am unable to work.
- I might run into some Unity related issues since I do not have that much experience with it. As mentioned previously, there are various online resources to help with solving that.
- I have no experience in creating 3D assets, so I migth not be able to create quality ones. If I don't manage to create my own, I can always look online for already existing ones and their quality is not one of the main objectives of this project.
- People might not be available to test the game during term time. Since testing is the most important aspect of the game, the first version of the game will be completed before Christmas holiday so that people can have time to test it then.

9 Legal, Social, Ethical and Professional Issues

Since all the data that will be collected from human participants is limited to questionnaires related strictly to the contents of the project, no ethical issues need to be considered.

References

[1] *Coding Games and Programming Challenges to Code Better*. URL: `https://www.codingame.com/start` (visited on 10/12/2022).

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[3] *Hades (video game)*. 2022. URL: `https://en.wikipedia.org/w/index.php?title=Hades_(video_game)&oldid=1115058824` (visited on 10/12/2022).

[4] George Kalmpourtzis. *Educational Game Design Fundamentals: A journey to creating intrinsically motivating learning experiences*. 2019.

[5] Nicolas Dietrich. "Escape Classroom: The Leblanc Process—An Educational "Escape Game"". In: *Journal of Chemical Education* 95.6 (2018), pp. 996–999. DOI: `10.1021/acs.jchemed.7b00690`. eprint: `https://doi.org/10.1021/acs.jchemed.7b00690`. URL: `https://doi.org/10.1021/acs.jchemed.7b00690`.

[6] Anonymous. *Game-based learning across the disciplines*. Ed. by Carmela Aprea and Dirk Ifenthaler. 2021.

[7] *20 Programming Games to Level Up Your Programming Skills*. 2021. URL: `https://x-team.com/blog/coding-games/` (visited on 10/12/2022).