An Escape Room For Learning Computer Programming

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Abstract

Game-based learning is a strategy where games are used as a challenge for students to learn and apply the contents of a subject matter. In this sense, game-based learning is an instance of problem-based learning.

In this paper we discuss how game based strategies can be used to motivate students to perform the actions required for each of the learning phases. Namely: motivation, information, understanding, application and validation (feed-back).

Then we present the application of those strategies to the design of an escape room where computer programs are required to solve the puzzles of the game.

The designed escape room is then used as a game-base strategy in an introductory seminar on the Python programming language.

Keywords: Game-based Learning; Escape Room; Learning Phases; Learning Computer Programming.

1 Introduction

An escape room is a game activity where a team of players is confined in an enclosed room and needs to find hints and clues to solve a series of puzzles required to open the locks that open the room. Escape rooms have become very popular in the last decade. In addition to their original purpose as a game, escape rooms have been extensively used in areas such as the enterprise (as team-building routines) and education (as learning environments where puzzles are related to the subject matter) (Call et al, 2021; Lopez-Fernandez et al., 2021).

In the educational field, escape rooms can be used as problem based strategies to guide student teams towards the completion of a set of goals. In a sense, escape rooms can be viewed as a situation from which "students cannot escape without learning" (Cowan 1998; Bofill 2006).

In this paper we focus on the different phases of learning (namely: motivation, information, understanding, application and validation or feed-back) (Bofill & Miró, 2007), and how the use of escape rooms can be used to induce student activities that enhance each of these phases. We then describe our escape room, and its application to a game-based learning introductory seminar for learning computer programming in Python. In this escape room, the puzzles require solving computer programming problems, with hints hidden in the course notes and syllabus.

2 The phases of learning

In (Bofill & Miró, 2007) we decompose the process of learning in a sequence of phases, in order to be able to design student activities for each phase. The phases we proposed are the following:

1. **Motivation**, in two senses:
    a. **Subjective motivation** reflects the attitude of the student towards the subject matter and towards the activity of learning. A student is motivated when she *wants* to learn the contents and, as a consequence, when she is ready to invest some time and effort to this purpose. Subjective motivation can be *intrinsic*, when the student wants to learn because she *likes* it (the reward for the effort is successful learning), or *extrinsic*, when studying is felt as an obligation, and the effort is based on an external reward (or to avoid a punishment). Without some intrinsic motivation, though, learning is bound to failure.
    b. **Motivation of the subject contents**. The subject is well motivated if the student understands the *finality* of what she is about to learn, and its relationship with what she already knows. Subject contents must be contextualised and related to the previous experience of the learner.

Motivation of the contents must be accompanied with a clear formulation of the learning objectives (what will the student get to know and be able to do after the learning process).

2. **Information** or acquisition of factual knowledge. The student must be somehow exposed to some sort of explanation of the contents of what she is going to learn. In that phase, the student must gather the information and process it. Information can be transmitted by *frontal teaching*, or from different kinds of *learning materials* such as course notes, problem collections, books, tutorials, presentations, videos and so on.
3. **Understanding** of the matter. After this phase, the student must be able to explain the subject matter, and to find the relationships between the concepts introduced, and the relationship between new concepts and what she already knows. Understanding requires *significant* learning. Sometimes understanding is confused with learning as a whole: I understand it, therefore I know it. But often this is not the case. The following phases are also necessary,
4. **Application** is the ability to transfer knowledge onto a different context, and it corresponds to *deep learning*. Knowledge transference involves activities such as the evaluation of the new situation, the identification of the required knowledge for the new context, and the translation of this knowledge to the new requirements. For deep learning to take place, application should go beyond the solution of prototype problems (procedural knowledge) based on a theory (conceptual knowledge).
5. **Validation** is the required feed-back to assess that we are following the right learning path. Validation is required in all the previous phases: validation of the learning objectives, validation of the factual knowledge, validation of understanding and validation of knowledge transference. Validation requires assessment and feed-back in order to enhance what we did well, and in order to be able to learn from mistakes. In an academic context, validation requires *reflection* and *formative assessment*, as opposed to mere selective assessment and grading.

Quoting John Cowan (Cowan 1998):

> "I take teaching to be: The purposeful creation of situations from which motivated learners should not be able to escape without learning or developing".

The purpose of the above scheme is to design student activities for each of the learning phases.

3 Learning Python with a game-based learning approach

The course we want to design is a 20h introductory course to the Python programming language, for students with some programming experience with other languages (C and Java). A "frontal" approach, like explaining the structures and syntax of the language, one after another, would be boring, both for the students and the teacher. On the other hand, computer programming is a skill which, like bike riding, should be learned by practice.

Problem based learning is a resourceful alternative approach, well suited for the situation. In problem based learning, the learner is confronted with a problem that needs to be solved, which requires the study of the subject matter. In this way, the problem is the conducting thread that motivates the need for the subject matter (learning phase 1.b).

Game-based learning can be organised in such a way that one or several problems are embedded in the game. In our case, the student is confronted with an escape room situation where she needs to find clues and solve programming problems to find the passwords that open the locks and produce the passwords of the game. In this way, the student gets involved with the challenges and puzzles of the game, which enhances subjective motivation (learning phase 1.a).

To avoid trivialization, care must be taken not to place too much emphasis on the game: the student must be aware at all times that this is a "serious" game, and that the actual purpose of the game is learning. To this effect, the programming problems embedded in the game should be sufficiently challenging and attractive by themselves. In our course, the problems include a Morse decoder, a drawing with turtle graphics, an hexadecimal to decimal converter and a fractional number calculator.

Information on the Python language (learning phase 2) is provided with a syllabus and a series of course notes and examples that accompany each of the programming challenges. Besides, in order to motivate students to study these notes, game-related hints are hidden within the notes. Therefore, students need to read the notes in order to be able to proceed with the game.

Understanding of the language syntax and structures (learning phase 3) should be straightforward for students who already know other languages, so the challenge lies in the application of these language structures to the problems that need to be solved (learning phase 4).

Computer programming is a subject that is easy to validate (learning phase 5). A computer program either solves the proposed problem or it does not. In this sense, feed-back is self provided and immediate (if the problem is not too large). Yet, the game takes place in the classroom and the role of the teacher is to provide help in developing the computer problems (and, eventually, to provide hints for the game when students get stuck).

The escape room is designed for 10h of work, altogether. In the remaining 10h the students must invent, design and implement a small programming project with the help of the teacher (Lima et al, 2017).

Finally, playing games in teams is both more fun and more productive. In our course students are organised in teams of two or three people, but care is taken that each student is involved with the computer programs.

4 The bridge over the river Splash, an escape-room

Paris 1901, The game starts at the telegraph office of the railway station. Suddenly an alarm goes off and the telegraph machine spits this text:

```
... --- ...
-... .-. .. -.. --. .   -... .-. --- -.- . -.
... - --- .--.    - .-. .- .. -.
... --- ...
```

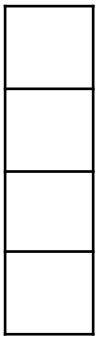
The players must understand that this is a Morse encoded message, and they must build a computer program to decode it. Course notes are provided with all the Python structures required to write the program, and hidden within the notes, there is a table with the Morse code.

Once they finish the program, the decoded text is the following:

```
SOS
BRIDGE BROKEN
STOP TRAIN
SOS
```

The password to the next screen is the christian name of the inventor of the code.

They run off towards the train, which is already leaving the station, but the train platform is too high to jump on it. They manage to figure out that they need a ladder, and they have to write a computer program that uses turtle graphics to draw the picture of a ladder (which they show to the game assistants). The following is the drawing of a ladder:



They climb to the train platform but the door is locked. There is a sign that reads:

0x2F3A

The players have to understand that this is a number in hexadecimal format, and they must translate it into decimal notation. To do so, of course, they have to build a computer program that translates any hexadecimal number into a decimal base (the course note includes enough hints to solve the problem). Once they find the answer they introduce it into the lock and they are able to enter the train.

But, elas! The brake is quite complicated. There is an instruction panel that says:

Good job! But there is one last problem to solve. The brake works with a gear shift that requires a precise combination of wheels. The right combination is the simplified fraction resulting from the following expression:

(8/21 + 3/14) * 3/5

Therefore, again, they need to build a computer program that can operate with fractional numbers.

Once they find the solution, they enter it and the train stops. In the last window of the game, a reference solution of the programs is provided, so that they can compare it with their own.

Figure 1. The escape room has been solved with success!!!

5 The Python seminar. Running and assessment of the escape room

The Python seminar will take place by the end of June (just before the PAEE/ALE conference). Without much explanation, the students will be required to solve the escape-room, and the teacher will accompany them and help them understand the course notes and develop their programs.

At the end of the seminar they will be asked to answer the following assessment quiz:

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The game has been a motivation to start working on the subject	1	2	3	4	5
The game has engaged me to practice more	1	2	3	4	5
I have enjoyed learning through play	1	2	3	4	5
The game has helped me to acquire a deeper level of understanding	1	2	3	4	5
I like the fact that I could solve the problems at my own pace	1	2	3	4	5
Mention three positive aspects that you have enjoyed					
Mention three shortcomings or things that you would improve					

Table 1. Summary of the questionnaire based on SEEQ regarding GBL and evaluation methodology.

The processed results will be presented at the conference.

6 Conclusion

This paper presented the realisation of an escape room as a means of designing student activities to enhance student involvement in each of the learning phases (motivation, information, understanding, application and validation). The course will take place just before the conference and results will be presented there.

In the meantime, a short version of the escape room has been tested on a different course with good results: students reported interest in moving along the windows of the game, and wanted to solve the escape room. This provided extra motivation for solving the programming problems involved.

7 Final remark

I asked my friend, Miguel Valero, who has become a reference in cooperative learning and project based learning (Valero, 2022), how does he organise his learning activities so that the students get the most out of them. He answered that, most of the time, he had enough if students were active in and out of class, because learning would be more likely to happen than what they would get by sitting and listening to the teacher's explanations.

8 References

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Acknowledgement

This work has been supported by the Institut de Ciències de l'Educació (ICE-UPC-Tech) Convocatòria de projectes d'innovació docent 2021 (Acord CG/2021/02/34, de 9 d'abril de 2021), and by the Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona (upc telecos-UPC-Tech).