ROOM ESCAPE AT CLASS: ESCAPE GAMES ACTIVITIES TO FACILITATE THE MOTIVATION AND LEARNING IN COMPUTER SCIENCE

Carlos Borrego, Cristina Fernández, Ian Blanes, Sergi Robles

Department of Information and Communications Engineering, Universitat Autònoma de Barcelona (Spain)

Received November 2016

Accepted March 2017

Abstract

Real-life room-escape games are ludic activities in which participants enter a room in order to get out of it only after solving some riddles. In this paper, we explain a Room Escape teaching experience developed in the Engineering School at Universitat Autònoma de Barcelona. The goal of this activity is to increase student's motivation and to improve their learning on two courses of the second year in the *Computer Engineering degree: Computer Networks and Information and Security*.

Keywords – Room escape, Riddles, Gamification, Computer science.

---

1. Introduction

One of the problems identified in the Degree of Computer Engineering of the Universitat Autònoma de Barcelona that also affects other studies is the lack of student motivation. This lack of motivation directly influences their study performance and their average mark. In this paper, we intend to amend this situation by designing and conducting a special Room Escape recreational activity. In this type of activities, participants are confined together in a locked room and can only escape after solving a number of brain teasers (Renaud & Wagoner, 2011; Zipke, 2008; Brent, 1999). In our Room Escape, these riddles are directly connected to the studying subjects. We have selected two undergraduate courses of the Degree in Computer Engineering of the Universitat Autònoma de Barcelona to perform a first practical deployment: Computer Networks and Information and Security.

Room escapes (or Real Escape Games) were firstly used in Japan in 2007 (Corkill, 2009), and grew rapidly in 2012-13; expanding first in Asia (starting in Singapur), afterwards in Europe (starting in Hungary), and then in Australia and North-America. It is not clear what the precursor of these activities was, but probably it was a combination of different activities with common elements, such as treasure hunts, point-and-click adventure games, or even adventure movies (Nicholson, 2015).

We have divided the Room Escape teaching experience into two phases. Firstly, students must earn access to the Room Escape activity by solving several challenges proposed during the regular classes of the involved courses. The first students solving each challenge get admitted to the main activity. Secondly, the designed Room Escape is conducted. In this activity, students in a locked room must solve a series of riddles using their knowledge on the two courses. If they solve these puzzles in less than one hour, they can successfully get out of the room, winning the activity. During these two phases, students get motivated to learn and they validate the knowledge acquired during the classes. In the rest of the paper, we describe the Room Escape design and the experience that we have carried out.

Our specific objectives are:

- To design the challenges to be proposed in the classes of Computer Networks and Information and Security.
- To design a Room Escape in the context of the aforementioned courses.
- To describe the practical activity of two student groups.
- To present the results and discuss their application and implementation in the rest of the courses of the Engineering School.

2. State of the art

During the last years, there has been an incredible effort from the teaching community to propose new ideas to improve engineering students' motivation. Some very interesting proposals (Bravo & Edna, 2011; Oliveira & Oliveira, 2013; Fernandes, 2014; Tlhoaele, Suhre & Hofman, 2016), develop new methodologies capable of improving student's performance by using new teaching tools such as technology-enhanced, cooperative, group-projects, conceptual questions and new uses of traditional tools such as video resources.

One of the teaching tools that has interested most of the teacher community is the use games as teaching resources for undergraduate engineering students, as explained in Bodnar (2016) and Cortizo Pérez, Carrero García, Monsalve Piqueras, Velasco Collado, Díaz del Dedo and Pérez Martín (2011). The result of this research is that there are many very solid and interesting proposals to improve teaching in engineering schools. In Kari (2016), a comprehensive survey can be found where the state of the art of game-based learning in building services engineering education at university level is reviewed and discussed in detail. As explained in Wang (2004), these teaching methods have proved to be effective in teaching abstract concepts and in giving students a certain level of real-world experience. These game-based teaching methods have been applied in different engineering subjects such as programming, as introduced in Mladenović, Krpan and Mladenović (2016), where the authors of this teaching method provide a way to make the students learn something serious and difficult like programming while doing something fun like creating and playing games. In a very similar way, in Crown (2001), JavaScript web-based games are proposed to improve visualization skills of engineering graphic students.

Some other proposals have introduced escape rooms in universities for socialisation purposes, such as in Salisbury and Ung (2016) or for library instruction, Hsu, Cheng and Huang (2009). In this article, we want to describe a real escape room teaching experience designed to improve engineering students' motivation.

3. Design

3.1. Description of the Room Escape access challenges

In this section, we describe the individual challenges that give access to the Room Escape activity. These skill challenges are developed in parallel with the agenda of the two selected courses. They aim to increase the involvement of students with the subject as well as the perceived value of the knowledge imparted. Students can obtain a cryptographically signed ticket that gives access to the Room Escape activity by completing one of the four proposed challenges. Two of these challenges are proposed for the subject of Computer Networks and the other two challenges for the Information and Security subject. In the Computer Network course, students learn the basic concepts of networks using the TCP/IP Internet protocols as a reference. This subject is focused from the point of view of both the network interconnection, and the relationship between computers and applications. In the Information and Security course, concepts such as information measurement, data compression techniques, cryptography, privacy, authenticity, accessibility and public key and private key infrastructure are studied.

In the first Computer Networks challenge, students are asked to create an IP packet with a number of specific requirements (for example, they have to activate the “evil bit", as proposed in RFC 3514 for the April Fools' day, 2003, whose title is "The Security Flag in the IPv4 Header"). This packet must be delivered using the Internet to a particular monitored host. By using a sniffer, the teachers are able to know who has solved this riddle. No further instructions are given, nor is any hardware provided to the students.

In the second challenge for the Computer Networks course, students have to investigate a provided IP address. In the metadata associated with this address, students have to find some hidden GPS coordinates. If they succeed, students use them to physically find a wifi hotspot from which they can extract, if they know how to interact with it appropriately, a ticket for the Room Escape activity.

In the first challenge for the Information Security subject, students are asked to send an email with certain characteristics. The body of the message must contain the decompression of a compressed LZ77 message given (Ziv & Lempel, 1977). Additionally, the message must be sent to an email address that is presented to the students as a QR code (Eisaku, Hanaizumi & Hock, 2004) compressed using a run-length encoding (Robinson & Cherry, 1967).

In the second challenge for the Information and Security subject, students receive a video in which they can see a professor that enters into his office and examines some documents in a file cabinet. Among the documents shown in the video, there is the public key and part of the corresponding private key used to sign the tickets to the Room Escape activity. In practice, knowing part of a private key lowers the difficulty of the cryptoanalytical problem of finding out the complete key, and allows the students to break it in order to create their ticket for the Room Escape activity.

3.2. Description of the Room Escape activity

For the Room Escape activity, we turn a department meeting room into a playing stage. To this purpose, we use the following material:

- a computer projector,
- a laptop computer with Internet connection,
- microphones and surveillance cameras,
- a visual hour countdown timer, and
- a walkie-talkie.

In a contiguous office, we set up a control room from where the teachers monitor the progress of the students during the activity. In this room, the following material is used:

- a computer with Internet connection that receives the images and the sound from the playing stage, and
- a walkie-talkie.

Next, we show an outline of the design of the riddle sequence that the participants have to overcome as well as the objects that will help them in this task. Students have to solve this series of riddles within one hour. In the following figure, the riddle flow and dependencies are depicted. Each numbered box corresponds to a riddle or an object involved in the Room Escape activity. These boxes are divided into three fields. In the first field, the requirements for the challenges are shown. In the second field, the goal of the challenge is described. Finally, the third field presents the information that is obtained once the challenge is solved.

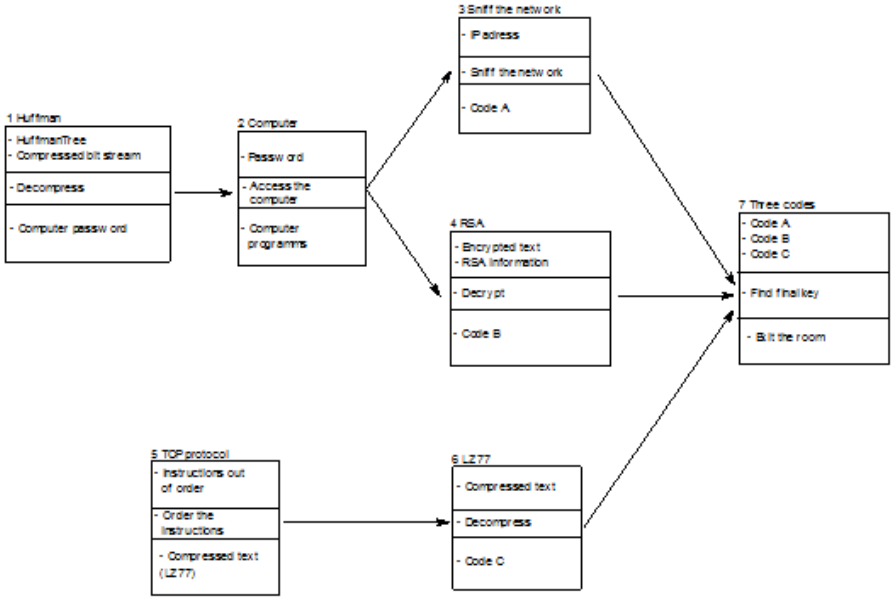

Figure 1. Riddle flow and dependencies

All these riddles are connected to the subjects of either Computer Networks or Information and Security. We now describe each of these riddles. The numbers next to riddles and objects correspond to the numbers in the boxes of the figure.

3.3. Riddles for computer networks

Students are presented with the following two riddles related to computer networks:

- Network sniffing (3): students find a text that contains an IP address to sniff. Then, they look for a special network field in all the sniffed packets to obtain the first code out of three final codes to exit the room.

- TCP conversation (5): students have to order some water bottles found in the room following the TCP protocol and using the text in the bottle labels. By ordering the labels, they also obtain ordered triples that correspond to a compressed text.

3.4. Riddles for information and security

For the subject of Information and security, students are challenged with the following riddles:

- Huffman coding (1): a part of a Huffman tree is found in the room as well as a binary string. This tree must be completed to obtain a code to decompress the binary string. The result of this decompression is the password to unblock the computer in the room.

- Public/private RSA scheme (4): students find a message encrypted using the RSA cryptosystem. They also find two RSA keys in a dictionary that can be used to decrypt the previous message using the computer, thus obtaining the second code to exit the room.

- LZ77 compression algorithm (6): from the ordered bottles (5), a sequence of triplets corresponding to a compressed message using LZ77 is obtained. When decompressing this, the third and last exit code is obtained.

By solving riddles (3), (4) and (6), students learn the code that unlocks a safe box in which they find the key to leave the room.

4. Conclusions

In this paper, we have presented a teaching experience consisting of a Room Escape activity developed at the Engineering School at Universitat Autònoma de Barcelona. The aim of this activity was to increase the student motivation for two subjects of the second year of the Degree in Computer Engineering: Computer Networks and Information and Security.

The result has been extremely positive. Students have actively participated in the Room Escape access challenges proposed in both subjects, increasing their motivation and willingness to learn. During the Room Escape activity, two teams of students have tested their knowledge and have worked together to solve all the riddles successfully. Those who have performed the activity found it, in their own words, "challenging, demanding, interesting and, above all, very amusing". Additionally, teachers have gained experience in the design and organisation of escape games at the university level, so we are ready to undertake a broader experience. Student participation has been remarkable, especially considering that there has never been a similar activity before in the Engineering School. However, we believe that participation will increase in the next years.

As future lines of research, we intend to organize other Room Escape activities, extending them to other subjects in the third year as a preliminary stage to deploy them in all the subjects of the Degree in Computer Engineering.

Finally, we believe that this experience can be applied to other subjects in different fields, such as mathematics, arts, biology or philology, for example. We have already contacted other teachers in other grades to share our experience and the proposal has been received with enthusiasm. When reproducing the experiment in the third year, or in any other grades in general, we have to take into account some points. First, the number of difficult riddles, especially those related to the academic content, has to be limited to three or four at most and, if possible, students should be able to work with different riddles in parallel. By doing this, the pace of the activity is smoother and students can work in smaller groups trying to solve different riddles at the same time. Second, it is recommended to combine these difficult riddles with easier ones so that students can see some progress, which gives them hope that they will exit the room. Finally, some clues have to be available to help students in case they get stuck while solving some riddle by using, for example, walkie-talkies to communicate with them.

References

Bodnar, C.A. (2016). Engineers at Play: Games as Teaching Tools for Undergraduate Engineering Students. *Journal of Engineering Education*, 105(1), 147-200. https://doi.org/10.1002/jee.20106

Bravo, E. (2011). *Video as a new teaching tool to increase student motivation*. Global Engineering Education Conference (EDUCON), IEEE. IEEE, 2011. https://doi.org/10.1109/EDUCON.2011.5773205

Brent, R. (1999). Simulations, games, and experience-based learning: The quest for a new paradigm for teaching and learning. *Simulation & Gaming*, 30(4), 498-505. https://doi.org/10.1177/104687819903000409

Corkill, E. (2009). Real Escape Game brings its creator's wonderment to life. *Japan times*.

Cortizo Pérez, J.C., Carrero García, F.M., Monsalve Piqueras, B., Velasco Collado, A., Díaz del Dedo, L.I., & Pérez Martín, J. (2011). *Gamificación y Docencia: Lo que la Universidad tiene que aprender de los Videojuegos*. VIII Jornadas Internacionales de Innovación Universitaria Retos y oportunidades del desarrollo de los nuevos títulos en educación superior, pp. 1-8.

Crown, S.W. (2001). Improving visualization skills of engineering graphics students using simple JavaScript web based games. *Journal of Engineering Education*, 90(3), 347. https://doi.org/10.1002/j.2168-9830.2001.tb00613.x

Fernandes, S. (2014). Engaging students in learning: findings from a study of project-led education. *European Journal of Engineering Education*, 39(1), 55-67. https://doi.org/10.1080/03043797.2013.833170

Hsu, S.-H., Cheng, S.-C., & Huang, Y.-M. (2009). *The experience of adopting game-based learning in library instruction. International Conference on Technologies for E-Learning and Digital Entertainment*. Springer Berlin Heidelberg, 2009. https://doi.org/10.1007/978-3-642-03364-3_71

Mladenović, S., Krpan, D., & Mladenović, M. (2016). Using Games to Help Novices Embrace Programming: From Elementary to Higher Education. *International journal of engineering education*, 32(1), 521-531.

Nicholson, S. (2015). Peeking Behind the Locked Door: A Survey of Escape Room Facilities. White Paper retrieved from: http://scottnicholson.com/

Oliveira, P.C., & G. Oliveira, C. (2013). Using conceptual questions to promote motivation and learning in physics lectures. *European Journal of Engineering Education*, 38(4), 417-424. https://doi.org/10.1080/03043797.2013.780013

Renaud, C., & Wagoner, B. (2011). The Gamification of Learning. *Principal Leadership*, 12(1), 56-59.

Robinson, A., & Cherry, C. (1967). Results of a prototype television bandwidth compression scheme. *Proceedings of the IEEE*. IEEE. 55(3), 356-364. https://doi.org/10.1109/PROC.1967.5493

Salisbury, F., & Ung, E. (2016). Can you escape the library escape room? *Incite*, 37(5/6), 24.

Tlhoaele, M., Suhre, C., & Hofman, A. (2016). Using technology-enhanced, cooperative, group-project learning for student comprehension and academic performance. *European Journal of Engineering Education*, 41(3), 263-278. https://doi.org/10.1080/03043797.2015.1056102

Wang, G.G. (2004). Bringing games into the classroom in teaching quality control. *International Journal of Engineering Education*, 20(5), 678-689.

Zipke, M. (2008). Teaching metalinguistic awareness and reading comprehension with riddles. *The Reading Teacher*, 62(2), 128-137. https://doi.org/10.1598/RT.62.2.4

Ziv, J., & Lempel, A. (1977). A universal algorithm for sequential data compression. *IEEE Transactions on information theory*, 23(3), 337-343. https://doi.org/10.1109/TIT.1977.1055714