https://doi.org/10.36315/2025v2end005
Education and New Developments 2025

ENHANCING ACTIVE LEARNING IN ADVANCED DATABASE COURSES THROUGH AN EDUCATIONAL ESCAPE ROOM APPROACH

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Abstract

The increasing need for active methodologies in higher education has given rise to a set of innovative techniques such as flipped classroom and project-based learning, among others. This active approach facilitates and encourages the acquisition of specific competences and soft skills. In this paper, we present the work conducted as part of the educational innovation project "Fostering Active Learning through Computational Sustainability Projects in Advanced Database Courses". The project aims to develop active learning tools for the course Database Design and Implementation, part of the curricula of the Computer Science degree at Jaume I University. More concretely, in this work we describe how we designed and put into practice an escape room whose games were solved by applying the course contents. The escape room was structured as a sequence of puzzles based on core topics of the course, including logic and physical design, normalization, SQL optimization, and triggers. Students worked in teams to "escape" by solving a series of interconnected tasks that required a deep understanding of database practical skills. Each task was aligned with the course's learning objectives, ensuring that participants not only engaged with the content, but also applied critical thinking and analytical skills in real-time. To assess the effectiveness of the escape room activity as a learning strategy, feedback was collected from the students through a questionnaire. This survey explored their perceptions from two points of view: the escape room experience itself, and its usefulness as a learning tool for the subject. The results are very positive, showing that students experienced a substantial increase in motivation and engagement, as well as reinforced the course contents comprehension.

Keywords: *Active learning, escape room, advanced databases, higher education, collaborative learning.*

1. Introduction

The demand for professionals with technical expertise is undeniable, particularly in technology-driven fields such as Computer Science. However, possessing only technical and specialized skills is no longer sufficient. Nowadays, employers increasingly seek professionals with soft skills and teamwork abilities, considering them essential for performing any job.

In this new scenario, universities have a responsibility to incorporate these types of skills into their daily teaching. The Organization for Economic Cooperation and Development (OECD), in Learning Compass 2030 (OECD, 2019) defines core foundations as the fundamental conditions, essential skills, knowledge, attitudes, and values that serve as prerequisites for continuous learning across the entire curriculum. OECD divided skills into three groups: 1) cognitive and meta-cognitive skills (critical thinking, learning-to-learn…), 2) social and emotional skills (self-efficacy, responsibility, collaboration…), and 3) practical and physical skills (communication, technology…).

Higher education is evolving to transform traditional teaching methods by incorporating active learning strategies. Active learning encompasses various innovative approaches, such as flipped classrooms and project-based learning, among others. These techniques foster the development of students, enhancing their technical expertise, interpersonal skills, teamwork abilities, and leadership qualities. Additionally, active learning has been shown to positively influence the learning process (Rao et al., 2018).

This paper presents the work conducted in two courses from the Computer Science degree curriculum at Jaume I University, both centered on advanced database topics: Database System Design (EI1038) and Database System Design and Implementation (EI1052). Currently, the learning methodology for these courses is based on Project-Based Learning (PBL). This approach has been developed as part of the educational innovation project entitled "Fostering Active Learning through Computational Sustainability Projects in Advanced Database Courses". In particular, we describe and analyze a specific

active session in the form of an escape room that was formulated to review the advanced database concepts taught during the.

The rest of the paper is organized as follows: Section 2 reviews the state of the art on the use of escape rooms in higher education. Section 3 describes our approach to implement escape rooms as a learning activity for database courses. Section 4 analyzes the assessment of the activity and its outcomes. Finally, Section 5 presents the conclusion and potential directions for future work.

2. Escape rooms for higher education

Educational escape rooms are an innovative pedagogical approach that integrates game-based learning principles to enhance student engagement and foster collaborative problem-solving skills. Originating from recreational escape rooms, this methodology has been adapted for educational purposes to create immersive, challenge-based learning experiences. In these activities, students work in teams to solve puzzles, decode clues, and complete tasks within a set timeframe, all while engaging with course content in a dynamic and interactive environment (Clarke et al., 2017). An educational escape room is a scenario-based learning activity where students must solve interconnected puzzles to achieve a specific goal, such as “escaping” a virtual or physical room. The challenges are designed to align with learning objectives, ensuring that the activity reinforces key concepts and skills. This approach not only stimulates critical thinking and creativity but also promotes teamwork and effective communication among participants (Hermanns et al., 2017).

In recent years, educational escape rooms have gained traction in higher education across various disciplines. For instance, Borrego et al. (2017) implemented an escape room in a chemical engineering course, where students tackled puzzles related to process engineering concepts. Similarly, López-Pernas et al. (2019) reported on the use of escape rooms in a programming course, highlighting their potential to motivate students and make abstract concepts more tangible. These studies consistently demonstrate that escape rooms are effective in creating an engaging learning environment that encourages active participation and improves the course contents comprehension.

The primary advantage of educational escape rooms is their ability to foster active learning and improve soft skills such as collaboration, leadership, and time management. They also provide a novel way to contextualize theoretical knowledge, making learning more meaningful and memorable (Veldkamp et al., 2020). However, challenges such as the significant time investment required for design and setup, as well as the need for careful alignment with learning objectives, must be addressed to maximize their educational value.

3. Escape room for a databases course

Following this trend, we designed and implemented an educational escape room to enhance students' learning process in advanced databases and improve their soft skills. The students of both courses developed the activity together in the same classroom. The activity took place during the 12th week of the semester, when the students had already received all the theoretical and practical aspects of the subject. It was a voluntary activity for the students and lasted two and a half hours of a regular theoretical session.

Students were divided into the same groups they used for the PBL projects, ensuring they are familiar with each other and their teamwork dynamics. Out of the 50 students enrolled in both courses, 38 participated in the activity. Most groups consisted of four members, except for two of them, which had three members each.

The game combined database exercises with traditional escape room elements, such as locks. The storyline revolved around a thief who had stolen a chemical component and placed a bomb to destroy the laboratory. Students had to work with two different databases: one containing information about users, data connections, and logs, and another related to chemical components, risks, storage, and transport. Both databases were populated with a large volume of data. Additionally, two scripts were developed to dynamically feed the databases with new relevant data during the escape room activity, as if the thief was maliciously accessing them.

Students had to connect to a specific database server and develop a specific audit to retrieve a key number that unlocked a cryptex. Inside the cryptex, they found a set of clues directing them to another classroom, where hidden hints were revealed using an ultraviolet flashlight. This information led them back to the original room, where they had to solve a three-digit combination to open the lock securing a box. The box contained additional clues to access another database server and uncover critical information about the thief and a four-letter code. This code unlocked a final box that provided instructions for stopping the thief's activities. In the final stage, after successfully thwarting the thief, the students obtained a new code to unlock a final box containing an “explosive”. They had to deactivate it to complete the mission.

4. Results

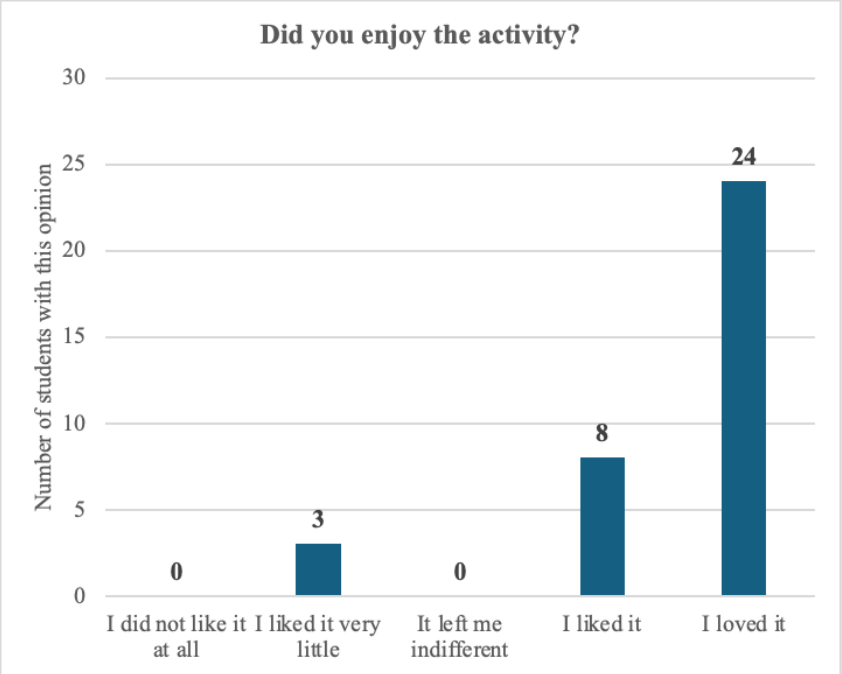
Once the activity was completed, the students were asked to complete an anonymous survey designed to assess their level of satisfaction with the escape room experience. By gathering feedback on their perceptions and experiences, we aimed to determine the effectiveness of the escape room as an educational tool and its potential to enhance engagement and comprehension in the context of database-related concepts.

There were three main aspects asked in the survey with respect to the engagement and comprehension impact of the activity, with several fixed answers offered (following a Likert scale) for each of them:

- Question: "Did you enjoy the activity?" Possible answers: "I did not like it at all" (1), "I liked it very little" (2), "It left me indifferent" (3), "I liked it" (4), and "I loved it" (5).
- Question: "Would you like to have more activities like today's in this or the other courses?" Possible answers: "No, I don't want to do anything like this again" (1), "I'd prefer not to have more activities like this" (2), "I don't mind" (3), "I'd like it" (4), and "I'd love it" (5).
- Question: "Do you think the game has helped you better understand the concepts of the course?" Possible answers: "No, I was focused on the game" (1), "Yes, but only in very few aspects" (2), and "Yes, in all the aspects covered in the game" (3).

In total, 35 students answered the survey. Figures 1-3 summarize the survey answers to each of the mentioned questions. Regarding the first question (see Figure 1), it is evident that most of the students enjoyed the activity. In fact, 69% of them loved the activity, 23% liked it and only 9% liked it very little, which means that more than 90% of them had fun solving the proposed exercises.

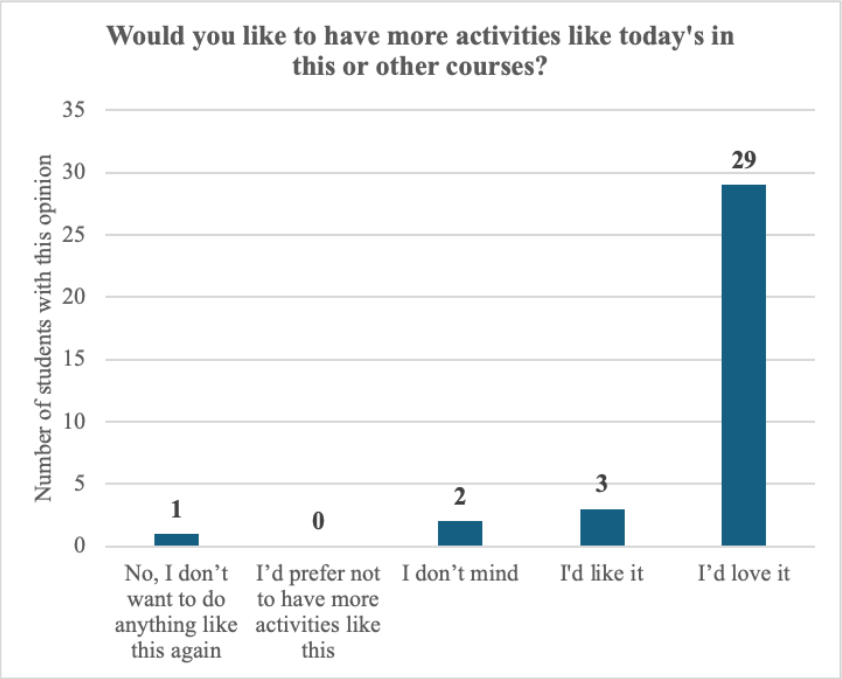
Figure 1. Students and enjoyment opinion about the escape room.



With respect to the second question (Figure 2), 91% of the students are in favor of solving similar activities in the future (actually, 83% of them would love to), just 6% do not mind about it, and only one student (3%) would not like to do anything similar again.

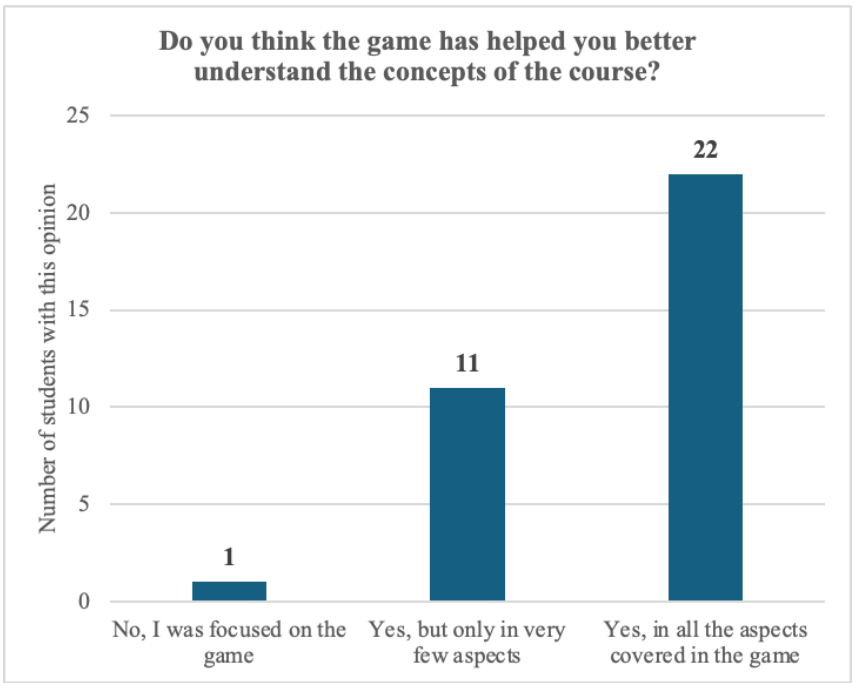
p-ISSN: 2184-044X e-ISSN: 2184-1489 ISBN: 978-989-35728-8-7 © 2025

Figure 2. Students' interest in using escape rooms to learn.



Finally, considering the third question, 65% of the students stated that the activity helped them better understanding all the concepts covered, 32% improved their knowledge regarding part of the concepts, and just one student (3%) felt too focused playing that did not gain any better understanding. This means that all except one student felt that the activity helped them assimilate the course contents, which was the main purpose of the exercise. Note that this question was left blank in one of the surveys and that is the reason why only 34 answers were gathered.

Figure 3. Escape room as a tool to understand and reinforce database concepts.



Considering the Likert scale, out of a maximum of 5, the average was 4.5 for the first question, and 4.7 for the second; and, out of a maximum of 3, the average was 2.6 for the third question. In our humble opinion, the results were extremely positive, and the students clearly stated that their engagement and enjoyment of the game was high, and that their course knowledge improved. All in all, this means that the activity was useful to consolidate the contents comprehension while having fun during the process.

5. Conclusions and future work

Active learning is an effective approach to enhance students' learning experiences. Implementing methods such as PBL and active group sessions, as demonstrated in this paper, fosters not only technical expertise but also essential soft skills, including teamwork, critical thinking, and leadership.

Escape rooms in the learning process are highly effective tools that integrate recreational and educational elements into a single and engaging activity. By encouraging teamwork, critical thinking, and problem-solving skills, these activities create an immersive and interactive learning environment that fosters active participation and enhances knowledge retention. Furthermore, escape rooms can be tailored to suit a wide range of educational objectives, making them versatile and adaptable to different subject areas and age groups.

In our example, we designed and implemented an educational escape room to enhance students' learning process in advanced databases. Students must apply their database knowledge to solve a set of puzzles and advance in the story line to reach the final problem solution.

The surveys conducted showed that most students valued positively the activity, highlighting that they did not only enjoy it, but felt their knowledge reinforced. The teamwork element further reinforced collaborative problem-solving skills, which are essential in real-world database management scenarios.

This positive reception and evident learning gains have encouraged other teachers involved in the innovative project to adapt the escape room as a learning tool in hardware-related subjects. As part of the future work, we plan to conduct similar activities on other courses, and extended versions of this experience in future years for the same courses, covering more concepts.

Acknowledgements

This work has been developed under projects "*Fostering Active Learning through Computational Sustainability Projects in Advanced Database Courses" and "Building Knowledge Together: Fostering Collaborative Learning in the Classroom"* funded by University Jaume I in the frame of the "call for grants for educational innovation projects" for year 2024.

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