

ESCAPING THE PATHOGEN: AN EDUCATIONAL ESCAPE ROOM AS AN ASSESSMENT TOOL FOR MICROBIAL PATHOGENESIS SUBJECT IN HIGHER EDUCATION

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Abstract

This study presents the design, implementation, and evaluation of an Educational Escape Room (EER) employed as a summative assessment tool within the Microbial Pathogenesis elective course for the Bachelor's Degree in Biochemistry and Biomedical Sciences. The primary objective was to develop a gamified resource aligned with the principles of the European Higher Education Area (EHEA), facilitating the integration of theoretical and practical contents regarding the emerging pathogen *Vibrio vulnificus*. The activity was implemented in a 'hall escape' format with a sequential puzzle structure, incorporating tasks based on real laboratory practices such as pathogen isolation, multiplex PCR identification, antibiograms, and virulence factor characterization. Results from the pilot and final implementation demonstrate high student engagement, significant activation of creative thinking, and a positive perception of the activity as an effective, sustainable, and replicable assessment strategy that fosters transversal competencies including teamwork and critical thinking under pressure.

Keywords: Educational escape room, gamification, higher education, microbial pathogenesis, summative assessment.

1. Introduction

In recent years, the landscape of Higher Education has undergone a significant transformation, moving away from traditional content-centred models towards student-centred approaches that prioritise 'learning to learn' (López, 2020). Within the framework of the European Higher Education Area (EHEA), there is a growing emphasis on active methodologies that promote student autonomy, critical reflection, and collaboration. Among these methodologies, gamification—the use of game design elements in non-game contexts—has emerged as a powerful strategy to enhance academic performance and motivation (González-de la Torre et al., 2024).

Specifically, the Educational Escape Room (EER) has gained traction as an innovative teaching and assessment tool. Unlike recreational escape rooms, EERs integrate curricular content into their puzzles, requiring students to master specific knowledge and skills to advance and 'escape' within a limited time (López-Belmonte et al., 2020). While the literature documents successful experiences in health sciences, including nursing and pharmacy, there remains a need to standardise criteria for their implementation as summative assessment tools in biomedical sciences.

2. Design

The activity focuses on *Vibrio vulnificus*, an aquatic pathogen of relevance to public health because, due to climate change, it is spreading to regions where it was not traditionally found, causing serious diseases such as sepsis (Carmona-Salido et al., 2026). The EER was structured as an escape room, allowing multiple groups to play simultaneously in a single room without the need for complex physical alterations to the university infrastructure.

2.1. Narrative and structure

The narrative immersed students in a simulated public health crisis. Participants received a mysterious email from a fictional researcher, 'Dr M.L.', requesting urgent assistance to identify a pathogen

causing an infection acquired in the Albufera Natural Park. Upon arrival, an introductory video set the scene, initiating a 40-minute countdown. The game followed a sequential or linear path, where the solution to one puzzle provided the code or key to unlock the next. This structure was chosen to facilitate the monitoring of student progress and to ensure that the entire team focused on a single complex task at a time, thereby fostering debate and consensus.

2.2. Puzzle configuration

The EER comprised six main puzzles (Figure 1), each corresponding to a specific practical unit of the course syllabus regarding *V. vulnificus*. The puzzles were designed to be scientifically rigorous while maintaining ludic characteristics:

- Puzzle 1 (Isolation): Students identified colony morphology on selective media (TCBS, VVM) to distinguish *V. vulnificus* (yellow on VVM, green/translucent on TCBS).
- Puzzle 2 (PCR Identification): Participants analysed a simulated electrophoresis gel using a transparency overlay to determine the presence of virulence genes (*vvhA*, *pilF*, *fpcrp*).
- Puzzle 3 (Antibiogram): Students interpreted E-test strips to determine Minimum Inhibitory Concentration (MIC) and resistance profiles.
- Puzzle 4 (Enzymatic Activities): Analysis of protease activity and haemolysis in wild-type versus mutant strains.
- Puzzle 5 (Theoretical Concepts): A matching game reinforcing terms like immune evasion and bacteriophages.
- Puzzle 6 (Horizontal Gene Transfer): Analysis of bacterial conjugation diagrams to identify donor, recipient, and helper cells.

2.3. Materials

To bring this educational escape room to life, simple, accessible, and sustainable materials were chosen, proving that educational innovation does not necessarily require a large financial investment. The design of the challenges was a purely artisanal process, where every element was handmade to create an immersive and safe experience for the students.

The project's "toolbox" combined everyday items with specific adaptations for the laboratory environment:

- Stationery and organisation: Envelopes, printed notes, worksheets, and posters with specifically designed iconography (such as the fish and human symbols) were used to guide the narrative and the puzzles.
- Security and progression systems: Cardboard boxes, trays, and physical padlocks were used to structure the game. Access to the challenges was managed via strips of paper taped to the flaps of the boxes, which could only be released by deciphering the corresponding codes.
- Adapted laboratory equipment: To ensure safety in a conventional classroom, glassware was replaced with plastic tubes. A key detail in their manual preparation was covering the clues with Sellotape to protect them from contact with liquids and ensure they remained intact throughout the activity.
- Game pieces and logic: Individual letter tiles were handcrafted for students to manipulate and form scientific terms. Likewise, visual and logical diagrams were designed and printed for the conceptual puzzles.

This manual assembly was complemented by the use of accessible technology and an introductory video—edited specifically for the project—which transported the students into the "clinical case" scenario they were tasked to solve.

3. Objectives

The primary objective of this study was to develop a gamified resource aligned with the principles of the European Higher Education Area (EHEA), facilitating the integration of theoretical and practical contents regarding the emerging pathogen *V. vulnificus*. Specific objectives included:

1. To demonstrate that an EER can serve as a rigorous, low-cost, and scalable summative assessment tool.
2. To evaluate technical knowledge alongside soft skills such as teamwork and critical thinking under pressure.
3. To foster student well-being by reducing the anxiety typically associated with traditional exams.

4. Methods

4.1. Context and participants

The study was conducted with fourth-year students of the Degree in Biochemistry and Biomedical Sciences from the University of Valencia (Spain). The cohort consisted of 32 enrolled students, organised into four groups of eight participants to ensure equitable participation and collaborative problem-solving. The EER was designed as a summative assessment of the laboratory practicals for the Microbial Pathogenesis elective.

4.2. Implementation and validation

A pilot trial was conducted with two students prior to the main event to identify potential design flaws and refine the clarity of the clues. Based on this pilot, adjustments were made to the visibility of initial clues and the visual cues on simulated E-test strips. Evaluation of the final implementation was conducted using the Gameful Experience Scale (GAMEX) to measure dimensions such as enjoyment, absorption, and creative thinking (Parra-González & Segura-Robles, 2019). Additionally, a survey was used to assess student perception of the activity as an assessment tool.

5. Discussion

The results of this study align with previous research suggesting that EERs promote active learning and student motivation. By transforming the assessment into a narrative-driven challenge, the activity succeeded in shifting the students' focus from passive memorisation to the active application of knowledge.

5.1. Student engagement and perception

The GAMEX scale results revealed a highly positive reception. "Enjoyment" scored a mean of 4.9/5, and "Absorption" reached 4.47/5, indicating high immersion, as it was also showed in other studies (Grupel et al., 2022; Arrue et al., 2025). Crucially, the 'Negative Effect' dimension was very low (1.35/5), confirming that despite the pressure, students did not feel frustrated. Regarding the "Dominance" dimension (3.29/5), the moderate score suggests that groups functioned through consensus rather than individual dominance, a desired outcome for developing transversal skills. Survey data indicated that 100% of participants would repeat the experience. Students rated the EER highly for fostering teamwork (4.92/5) and agreed it was a valid tool for assessing knowledge (4.8/5).

5.2. Pedagogical implications

A key finding is the successful use of the EER for summative assessment. While often used for formative purposes, this study demonstrates that with rigorous design, EERs can effectively evaluate complex technical competencies (López-Pernas et al., 2019). The sequential structure ensured that students engaged with every content block, preventing them from bypassing critical learning outcomes. Furthermore, the 'hall escape' format proved logistically viable and sustainable for university classrooms.

6. Conclusions

The implementation of an Educational Escape Room in the Microbial Pathogenesis course has proven to be an effective, motivating, and rigorous strategy for summative assessment. The activity successfully integrated theoretical and practical concepts related to *Vibrio vulnificus* within a stimulating environment. The study concludes that:

- **High Acceptance:** The format is highly valued by students for its ability to reduce assessment anxiety while maintaining academic rigour.
- **Competence Acquisition:** The EER effectively validates the acquisition of specific technical skills and transversal competencies.
- **Sustainability:** The design is economically viable and easily replicable in standard university settings. Future iterations could consider expanding the scope to include wet-lab elements or adapting the narrative to other pathogens, supporting the wider adoption of gamification to train adaptable scientists.

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Figure 1. Sequence of the challenges developed during the Educational Escape Room

A: First challenge consisting of the identification of the selective and differential media plates used for the isolation of *V. vulnificus* with its characteristic growth. B: Confirmatory test using multiplex PCR, in which the hazard to animal or human public health is analysed. C: Epsilometry for the analysis of the minimum inhibitory concentration of the isolated pathogen. D: Enzymatic assay to study the gelatin hydrolytic capacity of the isolate. E: Four questions related to aspects of the practical sessions or characteristics of the pathogen that the students must answer. F: Final challenge in which the knowledge acquired regarding triparental conjugation is demonstrated.

A "Si en las prácticas has estado atento/atenta/atente, ¿a *Vibrio vulnificus* más específicamente en qué placas encuentras?"

B

Para confirmar, debemos realizar el gel de electroforesis con los diferentes productos que se han obtenido de una PCR del ADN de diferentes bacterias. Este ADNha sido obtenido por la lisis de las mismas mediante estufación.

C

Concentración	OD	Concentración mínima inhibidora (CMI)	Resultado
1. Inoculada	0.08	0.001-0.01	Inoculada
2. Inoculada	0.07	0.001-0.01	Inoculada
3. Inoculada	0.02	0.001-0.01	Inoculada
4. Inoculada	0.01	0.001-0.01	Inoculada
5. Inoculada	0.005	0.001-0.01	Inoculada

¿Cuál es el valor de la concentración mínima inhibidora obtenida en cada placa con el E-Test contra *Vibrio vulnificus*?

D

De entre 3 medios con 18 y 20 minutos, en cuál crece que se observa actividad que se deba a la enzima PROTEASA de una bacteria. Pinta bien...

E

A qué hacen referencia las siguientes definiciones:

- Resuluto a *Vibrio Vulnificus*, se agrava considerablemente en exceso de la zona, impide el desarrollo de los patógenos del complemento y dificulta su fagocitosis. Es decir, reduce resistencia al Sistema inmunitario hasta humano.
- Se hace de forma vertical para conseguir un índice con un número determinado de células o bacterias.
- DNA viral que se integra en el cromosoma bacteriano hospedador y puede quedar en estado latente.
- Zona en la que se reduce el crecimiento bacteriano y/o se da la muerte bacteriana in vitro por presencia de fagos.

1 2 3 4

F

En los diferentes conjugaciones realizadas y sus posibles resultados tenemos:

- *E. coli* como célula donadora.
- *E. coli* como célula helper.
- *Vibrio vulnificus* como célula receptora.

1. CAPSULA 2. DILUCIÓN 3. PROFAGO 4. CALVA

1. OCHO 2. CUATRO 3. NUEVE 4. TRES

¿A qué célula se refiere cada definición?

- Célula receptora resultante de una conjugación biparental que solo contiene el plásmido conjugativo de la bacteria donadora.
- Célula helper resultante de la conjugación triparental que contiene el plásmido conjugativo de la bacteria donadora y su propio plásmido móvil.
- Célula receptora resultante de la conjugación triparental que solo contiene el plásmido móvil de la bacteria helper.
- Célula donadora que contiene su propio plásmido conjugativo y el plásmido móvil de la bacteria receptora.