# Best Practices for Creating and Conducting

# **Educational Escape Rooms:**

## A Comprehensive Guide for Teachers

## Title
Best Practices for Creating and Conducting Educational Escape Rooms: A Comprehensive Guide for Teachers

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# Table of Contents

# 1. Introduction

## 1.1. Aims and scope of the document

The objective of this document, titled "Best Practices for Creating and Conducting Educational Escape Rooms: A Comprehensive Guide for Teachers" (or "IGLUE Best Practices" for short), is to present guidelines and recommendations for helping teachers of any educational level and knowledge area to design, build, execute, and evaluate educational escape rooms considering different formats (physical, virtual, and hybrid) and delivery modes (face-to-face and remote). The guidelines and recommendations defined in this document (also referred to as practices) cover the whole life cycle of educational escape rooms and have been organised according to the phases of this cycle: design, build, execution, and evaluation. We do not intend for these guidelines and recommendations to be taken by teachers as fixed steps that must be followed in a specific order when adopting educational escape rooms; rather, the goal is to allow each teacher to choose which practices to follow and how and in what order to apply them. In this regard, we should mention that even though the practices described in this document can be applied to any level of education and field of knowledge, teachers are responsible for adapting them to their needs and those of their students.

The target audience of this document is teachers of any educational level and knowledge area who are willing to use educational escape rooms in their teaching practice. The role of teachers when implementing an educational escape room in an educational setting should be that of a designer, builder and supervisor. In these experiences, teachers are in charge of designing the escape room according to the learning objectives and the students' characteristics, developing and testing all the required resources, and executing and supervising the activity. On the other hand, in educational escape rooms, students participate as players, generally organised into teams, who must solve a series of puzzles in a limited time. Thereby, students actively engage with the activity, which provides them with an opportunity to improve both their hard and soft skills.

In order to present a structured account, we have started by defining what an educational escape room is (Section 1.2) and its benefits (Section 1.3). These sections will help the reader to know the main characteristics of educational escape rooms, as well as to understand why using this type of learning activity can be a positive experience for students of any level of education and discipline. We continue by proposing a life cycle for educational escape rooms (Section 2) and outlining a reference workflow for creating and conducting these activities (Section 3). Subsequently, we describe a wide range of guidelines and recommendations for helping teachers interested in using educational escape rooms (Section 4), which have been categorised according to the phases of the proposed life cycle: design, build, execution, and evaluation. Finally, there are three annexes: Annex 1 lists a wide range of resources that may be useful for teachers when building an educational escape room, Annex 2 includes suggestions on how to use generative artificial intelligence tools for creating content for educational escape rooms, and Annex 3 contains a series of examples of how educational escape rooms can be realistically applied in different educational settings.

It should be noted that the guidelines presented in this document are intended to be technology-agnostic. By this, we mean that the reader should not expect to find guidelines for specific digital tools or resources here. We made this decision because software evolves

rapidly and continuously. Therefore, we believe that any guideline dependent on a specific software runs the risk of becoming obsolete in a short period of time. However, we have included in Annex 1 a list of digital resources that may be useful for teachers when creating content for an educational escape room. Furthermore, since educational escape rooms should not be alien to generative artificial intelligence, we have included in Annex 2 some recommendations on how to use this technology for creating content for these activities. Another aspect of this document worth highlighting is that the proposed practices have been defined by considering eco-friendliness, accessibility, inclusion criteria, and EU values.

We believe this document will be of use to those teachers who want to explore new practices that complement their traditional classes, motivate their students and make them think outside the box. By providing best practices on how to create and conduct educational escape rooms, we aim for this document to become a bedside book for any teacher interested in escaping monotony. Embark with us on this journey of motivation, excitement and willingness to improve education through escape rooms!

## 1.2. What is an educational escape room?

Escape rooms are typically defined as "live-action team-based games where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal (usually escaping from a room) in a limited amount of time" (Nicholson, 2015, p. 1). However, it should be clarified that although participants usually play in teams, these games can also be played individually.

Escape rooms began as a mere form of entertainment. Still, they were later embraced by the educational sector as innovative pedagogical tools for active learning, which led to the emergence of educational escape rooms. Educational escape rooms can be defined as games designed with educational purposes in which the participants, usually organised in teams, must solve a series of puzzles within a specified time frame by discovering clues, accomplishing tasks, and applying field-specific knowledge and skills. Therefore, according to this definition, educational escape rooms would be a type of game-based learning activity. Below, we describe the main characteristics that educational escape rooms usually have:

1. **Goal-oriented**: there is a specific goal or mission that participants must accomplish in order to win (e.g., solving a mystery, escaping from a room, or finding a hidden treasure).
2. **Time-limited:** participants should achieve the final goal or mission within a given time frame.
3. **Puzzle-based**: educational escape rooms consist of a series of puzzles, which may or may not be arranged sequentially. For the purpose of this document, an escape room puzzle is understood as an interactive challenge with a verifiable solution that is presented to the participants and whose resolution allows them to significantly progress in the escape room.
4. **Narrative-based**: educational escape rooms are expected to be built around an engaging and consistent narrative that seeks for participants to be immersed in the experience. The narrative of an educational escape room refers to its specific story, including its theme or setting, the role of the participants, their allies, the conflicts, and the reasons for trying to accomplish the final goal.
5. **Clues**: typically, while playing an escape room, participants can discover clues in the environment that help them solve puzzles. In the context of educational escape rooms, a clue is understood as a piece of information or an item (physical or digital) that has

been deliberately included in the environment for participants to find while playing and that provides some kind of information or enables to perform an action that is useful or necessary for solving some puzzle of the escape room and therefore progress in the activity. Clues can take various forms, such as messages hidden in the environment (e.g., a value-symbol equivalence written on a whiteboard), physical objects (e.g., a key necessary to open a drawer), virtual resources (e.g., a PDF file or a video containing helpful information for decrypting a message) or QR codes.

6. **Distractors:** many escape rooms include distractors in order to modulate their difficulty. In the context of educational escape rooms, a distractor is understood as a piece of information or an item (physical or digital) that has been included deliberately in the environment and that appears to be relevant for completing the escape room puzzles but that it is not actually necessary nor does it help participants to progress in the activity. Distractors can take various forms, such as misleading clues (also called "red herrings"), unnecessary objects, extra data or tasks, fake solutions, or noises.

7. **Hints:** it is very common for participants in an educational escape room to receive help to solve the puzzles in the form of hints. Although both hints and clues help participants progress in an educational escape room, there are key differences between these two elements:

   - The main purpose of hints is to help participants solve puzzles in case they get stuck or have a low probability of successfully completing an escape room. In contrast, the main purpose of clues is to provide all participants with information and/or items needed to complete an escape room regardless of their performance. Completing an educational escape room can and often does require participants to discover and use clues, but it never requires participants to obtain hints. Therefore, clues are an essential part of escape rooms, while hints are optional.

   - Clues are always present in the environment and can be discovered by the participants, whereas hints are never present in the environment and for participants to obtain them, they must be delivered by a supervisor or automatically by a hint management system. Hints provided automatically by a system are referred to as automated hints. Regarding the delivery of hints, it should also be pointed out that it is very common for participants of an escape room to be allowed to request hints, although they may also be provided without prior request, for example, at the initiative of the activity's supervisors.

   - Clues are expected to have a reason consistent with the escape room's narrative to exist, whereas hints are usually completely unrelated to this narrative.

   Considering all these, a hint can be defined in the context of educational escape rooms as an optional piece of information that can be delivered to the participants to help them solve the puzzles of the escape room.

Educational escape rooms can be applied to almost any course, knowledge area, and level of education. In fact, they have already been used to teach a wide range of topics across various fields, including healthcare (Quek et al., 2024), computing (López-Pernas et al., 2019a; Gordillo & López-Fernández, 2024), physics (Bräuninger et al., 2024), mathematics (Psyllou, 2024), business management (Paz Gil et al., 2023), economics (Aguirre Acosta et al., 2023), history (Calle-Carracedo et al., 2022), linguistics (Santamaría Urbieta & Alcalde Peñalver, 2019; Alcalde Peñalver & Santamaría Urbieta, 2020), and education (Manzano-León et al., 2021). The list could go on, demonstrating the remarkable versatility of educational escape rooms across diverse academic disciplines and educational settings.

## 1.3. What are the pedagogical benefits of educational escape rooms?

Many studies have been conducted over the past few years to examine the pedagogical benefits of using educational escape rooms, as demonstrated by several systematic literature reviews and meta-analyses published in academic journals (Fotaris & Mastoras, 2019; Veldkamp et al., 2020; Lathwesen & Belova, 2021; Makri et al., 2021; Taraldsen et al., 2022; Kim et al., 2024; López-Pernas, 2024). Although research on educational escape rooms is still in its early stages, the studies conducted so far have shown that these activities can be used across a wide range of educational levels and disciplines and that they are becoming increasingly popular among teachers. Furthermore, these studies have already provided evidence on several benefits associated with the use of educational escape rooms. Below, we outline the main pedagogical benefits that educational escape rooms can offer to students in the teaching-learning process:

- Increase motivation and engagement. There is solid evidence that educational escape rooms can positively impact student motivation and engagement.
- Acquisition of knowledge and development of hard skills. Many studies have reported educational escape rooms that result in improved student learning outcomes in these areas. In this regard, it is worth pointing out that some studies have proved that well-designed educational escape rooms can be more effective than traditional lectures.
- Development of soft skills. Educational escape rooms can provide students with valuable opportunities to develop soft skills such as critical thinking, problem-solving, time management, communication, teamwork, leadership and conflict resolution.
- Promote active learning and real-world application of knowledge and skills. Educational escape rooms require students to engage actively with content, solve problems and apply knowledge and skills in a specific environment. Thus, these activities can provide students with the opportunity to use what they have learned in contexts that closely resemble real-world situations.

# 2. The life cycle of an educational escape room

Since this document describes practices that can be applied at different points throughout the life cycle of an educational escape room, we have decided to propose a definition of this life cycle, identifying and defining its phases, and to organise the described practices according to these phases.

The educational escape room life cycle proposed and considered in this document is shown in Figure 1:
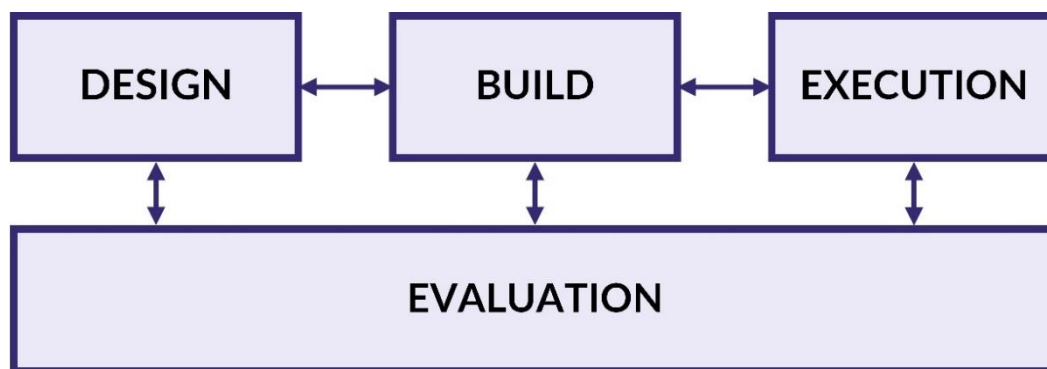


**Figure 1**: Life cycle of an educational escape room

The proposed life cycle considers the following four phases:

- **Design**. This phase covers all the activities performed to elaborate the design of the educational escape room. These activities include identifying the target audience, defining the learning objectives, selecting the format and delivery mode, choosing the participation mode and team size, establishing the duration, conceiving the narrative, designing and organising the puzzles, determining the difficulty, planning the mechanisms that will be used to provide help to participants (including a hint approach if hints are used), and defining the strategy for grading students.
- **Build**. This phase covers all the activities performed to build the educational escape room according to its design. These activities include the crafting, printing, development and/or acquisition of all the resources necessary to execute the escape room, including the instructions, props, clues, puzzles, and hints.
- **Execution**. This phase covers the execution of the educational escape room with its intended audience, the activities performed in order to prepare this execution that are not related to the building of the escape room (e.g., organising shifts, sending instructions, explaining the rules, and setting up the location), and the complementary activities performed alongside the escape room (e.g., introductory video lessons and debriefing sessions), with the exception of those aimed at evaluating the escape room (which are considered to be part of the evaluation phase).
- **Evaluation**. This phase covers all the activities performed to evaluate the whole educational escape room, any of its components or its design, regardless of the time point at which they are performed. Examples of these activities include testing puzzle designs with paper prototypes, trial runs, pre-tests and post-tests, and administering questionnaires.

The phases of the proposed life cycle can be carried out sequentially or in parallel, without a specific order, and each phase can be carried out several times. For example, an educational escape room can be progressively created through an iterative process in which, in each iteration, work is dedicated to designing, building, and testing the escape room. Then, this educational escape room can be executed and evaluated with real students. Afterwards, its design and puzzles can be updated based on the evaluation results to enhance the escape room for future executions. The four phases of the proposed life cycle can be carried out sequentially once, in which case an educational escape room would be designed, built based on its design, executed, and evaluated. However, it should be noted that this is just one possibility, and it is not our intention to recommend this process. In fact, Section 4 contains guidelines that, for instance, recommend testing educational escape rooms throughout their development process, as well as redesigning educational escape rooms during their building under certain circumstances.

Section 4 of this document contains one subsection for each phase of the life cycle described above. Thereby, Section 4 contains the following subsections: 4.1 Design, 4.2 Build, 4.3 Execution, and 4.4 Evaluation. Each of these subsections describes good practices that teachers can apply during its associated phase.

# 3. Workflow for creating and conducting educational escape rooms

There is no single order in which the phases of the life cycle for educational escape rooms proposed in Section 2 can be carried out. Similarly, the activities within each of these phases do not need to follow a fixed sequence. Furthermore, the activities can be performed in different ways and not all of them are always necessary. Therefore, in order to create and conduct an educational escape room, a teacher should choose which activities to perform and the order in which they will be performed, as well as which practices to follow and how to apply them. Teachers should make these decisions based on their specific context, their own needs and those of the target audience of the educational escape room, and the desired characteristics of the escape room and the educational interventions that involve it.

The number of possible workflows that teachers can follow to create and conduct an educational escape room successfully is huge. For this reason, we do not aim to provide a rigid workflow with fixed steps that must be followed strictly and in a specific order. Instead, in order to assist teachers interested in using educational escape rooms, we outline below a reference workflow for creating and conducting these activities that we believe suitable for a wide range of cases and that teachers can follow as it is, adapt it to specific needs, or use it for inspiration in determining their own workflow. In addition to outlining this reference workflow, in Section 4 we describe good practices that teachers can apply when using or adapting it.

The reference workflow includes the following steps for creating and conducting an educational escape room:

1. Identify the target audience of the educational escape room and the educational setting where it is expected to be conducted.
2. Define the learning objectives. Initially, it is possible to define just the overarching topics covered by the educational escape room, but eventually, these topics should be detailed through specific learning objectives. When defining the learning objectives, both hard and soft skills should be considered.
3. Choose the format (physical, virtual or hybrid), delivery mode (face-to-face or remote), participation mode (individual or in teams), and duration (i.e., time limit) of the educational escape room. If team participation is allowed, also choose the size of the teams. For virtual or hybrid escape rooms, identify the digital tools and technologies needed or desired to conduct the activity, including those intended to enable or facilitate participant collaboration.
4. Define how assistance will be provided to the participants. This step includes determining whether the educational escape room will be supervised and, if so, how. It also includes defining how participants will be provided with help for solving the puzzles when needed. If hints are used, the approach for delivering them should be defined.
5. Decide whether the educational escape room will be offered as a graded activity and, if so, how grades will be calculated, and how the activity will fit within the corresponding syllabus if it is offered as part of a course or study program.

6. Craft the narrative of the educational escape room. This step includes defining the storyline, setting, context and final goal or mission.
7. Choose the type of puzzle structure (linear or non-linear), determine the number of escape room puzzles, and design them one by one. Try to adjust the difficulty of the puzzles so that the escape room can be completed by the target audience within the allotted time. The design of the puzzles should specify all elements that will be part of the escape room, including all clues and distractors. This design should also indicate, for each puzzle, its solution, the actions that participants must perform to solve it, and the learning objectives covered.
8. Test each puzzle individually by using prototypes (e.g., paper resources or digital mockups). If errors or improvements are identified during these tests, redesign the puzzles and test them again.
9. Test the whole educational escape room by using prototypes and refine it based on the test result.
10. Build the educational escape room according to its design. This step includes crafting, printing, developing and/or acquiring all the resources necessary to conduct the escape room with its target audience, including instructions, props, clues, puzzles, and hints.
11. Test and refine the educational escape room as follows:
    a. Review the narrative and check that every puzzle, task, clue and resource presented to the participants has a reason consistent with it to exist.
    b. Test each puzzle individually and refine the puzzles based on the test results.
    c. Test the whole educational escape room and refine it based on the test result.
12. Prepare the execution of the educational escape room: organize the desired shifts and decide whether asynchronous participation will be allowed, provide participants with initial instructions, and set up the location and all resources required to execute the activity.
13. Execute the educational escape room with its target audience and evaluate its impact on participants' perceptions and learning.
14. Improve the educational escape room for future executions based on the collected data and the lessons learned.

# 4. Guidelines
## 4.1. Design
### 4.1.1. Defining appropriate learning objectives

Establishing learning objectives for an educational escape room is an essential step to ensure that the activity is educationally effective. For this reason, we recommend that the design of an educational escape room be elaborated carefully to ensure that the learning objectives are clearly defined and aligned with the target audience and the intended educational outcomes. Moreover, since learning objectives have a major influence on many of the decisions that must be made when designing an educational escape room, we also recommend starting the design process of an educational escape room by identifying the target audience and the educational setting where it is expected to be conducted, and then defining its learning objectives according to this audience, this setting and the intended educational outcomes.

Educational escape rooms allow students to apply their knowledge and skills and learn by doing, which facilitates the retention and understanding of concepts and the development of skills. Defining the learning objectives of an educational escape room requires defining specific and measurable statements that describe the knowledge and skills that the participants are expected to acquire or deepen by playing the escape room. The learning objectives can describe both hard skills and soft skills. Hard skills (sometimes called technical or specialised skills) are specific, teachable abilities or knowledge sets that can be measured and are typically acquired through formal education or training (e.g., project management, web programming, Spanish proficiency, knowledge of historical events, and piano playing), whereas soft skills are a set of transversal skills that include, among others, communication, teamwork, leadership, critical thinking, problem-solving, conflict resolution, and time management. To make the learning objectives assessable, it is recommended to use action verbs (e.g., analyse, identify, and apply).

Lastly, it should be noted that the following aspects must be considered when defining the learning objectives of an educational escape room:

- The skills and knowledge level of the target audience.
- If the activity is conducted within a course, the course syllabus and the planned date of execution for the escape room.
- Whether the escape room will be used to teach new concepts or develop new skills, or if it is intended as a review activity.

Various examples of learning objectives defined for educational escape rooms can be found in Annex 3.

## 4.1.2. Choosing an appropriate format and delivery mode

Escape rooms can be classified into three types based on their **format**:

1. **Physical.** Physical escape rooms are those that require participants to interact with physical elements and that lack virtual elements. Generally, they include tangible clues and puzzles. Among the physical items typically included in these escape rooms are locked boxes, padlocks, jigsaws, magnetic pieces and ultraviolet flashlights. Frequently, and especially in the educational sector, physical escape rooms are conducted face-to-face and thus require participants to be physically present at a specific location. However, an escape room of this type can also be printed or packaged in a physical box in the same way as conventional board games, allowing participants to transport it and play it at their home or another location of their choice. In this regard, it is worth mentioning that escape rooms packaged in physical boxes are often referred to as "boxed escape rooms" or "escape room board games".

2. **Virtual.** Virtual escape rooms are those in which all elements are virtual. Therefore, all the clues that participants can find and all the puzzles they can interact with are virtual. Virtual escape rooms require participants to use some device to play, regardless of whether they are conducted face-to-face or remotely. Frequently, they can be played using only a device with a web browser or a specific software application (e.g., a computer, laptop, tablet, or smartphone). However, some virtual escape rooms may require using more specialised devices such as virtual reality headsets and controllers.

3. **Hybrid.** Hybrid escape rooms are those that combine physical and virtual elements. These escape rooms usually incorporate physical puzzles but may also include virtual puzzles and require participants to use some device to play. Like physical escape rooms, hybrid escape rooms are frequently conducted face-to-face. Nevertheless, they can also be conducted remotely if delivered to participants through boxes containing all the necessary physical materials or if participants are allowed to print these materials.

As for the **delivery mode**, escape rooms can be delivered through two modes:

1. **Face-to-Face**. An escape room is considered to be conducted face-to-face when all participants are physically present in the same location so that they interact physically with each other. In general, when an escape room is conducted face-to-face, it is supervised by individuals present in the same location as the participants or, if video surveillance is used, by individuals in a nearby room.

2. **Remote.** An escape room is considered to be conducted remotely when participants, instead of being physically present in the same location, play the game from different locations of their choice. Typically, when an escape room is conducted remotely, participants play by using their own devices (e.g., personal computers or smartphones), as well as digital tools and technology. Communication between teammates is usually conducted via video conferencing tools, which not only enable participants to communicate in real time through audio, video, and text chat but also to perform additional actions such as sharing the screen or digital documents. Escape rooms that are conducted remotely can be supervised by using these tools, as well as specialised software. However, on many occasions, these escape rooms are offered as unsupervised asynchronous learning activities that can be done by the participants whenever they choose within a set time frame.

On the one hand, physical and hybrid escape rooms can include physical elements, which provide very interesting possibilities for designing puzzles and making the experience more engaging for participants. For instance, if only virtual elements are used, it is not possible to build escape room puzzles that require players to explore a real place, assemble a physical object with their own hands, use their sense of touch or smell, or employ real instruments such as a telescope, a microscope, or an oscilloscope. Furthermore, some puzzles may be more engaging for participants if they incorporate physical elements. For example, revealing a hidden message using a flashlight for invisible ink or redirecting a laser beam using mirrors can be much more motivating when using real items than when performing the same actions in a virtual world.

On the other hand, virtual escape rooms are more reusable and generally have a lower environmental impact compared to physical and hybrid escape rooms (see Guidelines 4.2.1 and 4.2.2). Furthermore, virtual escape rooms, unlike physical and hybrid ones, can generally be conducted remotely easily and cost-effectively, which makes them more accessible for participants who may face barriers to attend in-person sessions, such as those with physical disabilities, caregiving responsibilities, health concerns, or geographical constraints. In this regard, it should be noted that although it is possible for a physical or hybrid escape room to be conducted remotely, this option is generally more complex and expensive, as participants must receive the physical materials and their associated instructions before starting. This can be done, for example, by shipping or hand-delivering a box with all the necessary physical materials (which is a good option for escape rooms designed to be played like a board game) or by requesting participants to print a PDF file.

For their part, hybrid escape rooms seek to offer the advantages of both physical and virtual escape rooms. These escape rooms offer greater possibilities than physical or virtual ones since they can include and combine physical and digital elements. The physical elements can provide hands-on, tangible experiences, while the digital ones can add highly interactive challenges such as puzzles based on virtual reality or driven by software, as well as features like automated hints and gamification elements. For example, a hybrid escape room can result from enriching a physical escape room with a virtual reality puzzle and a software application that enables participants to request hints when they are struggling or from enhancing a virtual escape room with tangible puzzles that require participants to explore a room, arrange a series of objects under a light source and open a mysterious box. Using digital elements in hybrid escape rooms can also increase their reusability and reduce their environmental impact. Despite their benefits, hybrid escape rooms may not be the best option in all cases since they share some drawbacks with physical and virtual escape rooms. On the one hand, as indicated above, hybrid escape rooms are less reusable and, generally, have a higher environmental impact and are more complex to be conducted remotely than virtual ones. On the other hand, the reliance on digital tools and technologies can introduce technical difficulties and usability issues. Furthermore, supervising and monitoring a hybrid escape room can be more complex because participants can perform actions in the physical world and the virtual world.

With respect to the delivery modes, conducting escape rooms face-to-face allows participants to communicate and collaborate in person, enables mastery of the environment (e.g., lighting, sound, and decoration), offers a wide range of possibilities for interacting with physical elements, and eases the supervision, control, and monitoring of the activity. However, conducting escape rooms remotely eliminates the need for a physical space, removes geographical barriers, and enables accommodating larger groups without worrying about physical space limitations.

Next, we provide our recommendations for choosing the format and delivery mode of an educational escape room. If an educational escape room is going to be conducted in a face-to-face or blended course or study program, then we recommend conducting the escape room face-to-face whenever possible. In this regard, if it is not possible to allow the participation of all interested students in one single session, then multiple shifts may be offered (see Guideline 4.3.1). When conducting an educational escape room face-to-face, we recommend choosing the physical or hybrid format only if the inclusion of physical elements provides a significantly better experience than what could be obtained using only virtual elements and if there is no need to allow remote participation. In any other case, we recommend choosing the virtual format since virtual resources are more reusable and generally eco-friendlier than physical ones, and virtual escape rooms can be conducted remotely in an easy and cost-effective way. When conducting a virtual educational escape room face-to-face, we recommend offering additional remote shifts (see Guideline 4.3.1) if there are barriers that prevent some students from attending in person and the escape room does not require participants to use resources they do not have (e.g., virtual reality headsets). If an educational escape room is going to be conducted in a distance course (e.g., in an online course) or study program, then we recommend choosing the virtual format and conducting the activity remotely.

Regarding the remote delivery mode, we recommend choosing a virtual format for all educational escape rooms that need or are expected to be conducted remotely, regardless of whether they are going to be used in a face-to-face, blended, or distance course or study program. If opting to conduct physical or hybrid educational escape rooms remotely, we recommend providing them to students through physical boxes (i.e., as boxed escape rooms). However, this alternative is generally more expensive, time-consuming, and less eco-friendly. Additionally, it may involve logistical challenges, make team building difficult, and make the escape room harder to supervise. Finally, when educational escape rooms are conducted remotely, teachers may also consider the possibility of offering them as asynchronous learning activities that students can start at any time within a set time frame (see Guideline 4.3.1).

## 4.1.3. Choosing an appropriate participation mode and team size

When designing an educational escape room, it is very important to decide on the participation mode (i.e., whether students will participate individually or in teams) and, if team participation is allowed, the minimum and maximum size of the teams.

Many educational escape rooms are designed to be played in teams in order to provide opportunities to foster the development of soft skills such as communication, teamwork and leadership. Next, the main advantages of conducting educational escape rooms with teams are described. First, students must communicate effectively to share information, discuss strategies, and solve problems together. Additionally, the success of an educational escape room depends on collaboration and teamwork. Students can learn to trust their peers, delegate tasks, and work together toward a common goal, as well as to assume leadership roles. In such a capacity, they should work on team organisation, decision making, and even motivate each other. As is the case with any type of group activity, conflicts among team members can arise while playing an educational escape room due to time pressure, unequal participation or lack of leadership. Therefore, utilising a team-based educational escape room is an excellent opportunity for students to become adept at managing and resolving conflicts constructively. Additionally, working closely with other students fosters the development of

empathy and understanding towards the different skills, strengths, and weaknesses of peers, making the escape room an inclusive activity.

Conducting educational escape rooms in small teams (2 to 4 students) facilitates communication and close collaboration among team members. This is an ideal size for activities that require high levels of concentration to solve established challenges. However, it could be problematic if the workload is excessive for participants or if the teams have a significant imbalance in skills and knowledge. If educational escape rooms are conducted by medium-sized teams (5 to 7 students), the distribution of tasks and responsibilities can be more balanced, promoting diversity of ideas and approaches to solve the puzzles. Although, if there is not adequate coordination and communication, difficulties in execution may arise. In the case of large teams, understood as those which have 8 or more students, working together in educational escape rooms could be very enriching due to the diversity of skills and knowledge of its members, especially for those escape rooms where multiple tasks can be performed in parallel. However, in these cases it could be more difficult to keep all team members engaged and coordinated, with effective communication being a stumbling block to this end, especially in escape rooms conducted remotely. Therefore, it is recommended that students agree consensually on the role of each member as well as defining the communication channels and expectations among them from the beginning. This way, there will be a higher likelihood of all members feeling involved throughout and enjoying a greater sense of ownership during the experience.

The team size is a key element of the design of any educational escape room that should be determined by considering, at least, the target audience, the expected number of participants per shift, the format and delivery mode, the available space and equipment if the escape room is conducted face-to-face, the digital tools and technology employed, the learning objectives, the puzzle structure and design, the help mechanisms, and the duration and difficulty of the escape room. On most occasions, teams made up of between 2 and 7 members are a good option for an educational escape room.

Finally, it should be noted that it is also possible to design an educational escape room to be played individually. This option allows students to work at their own pace and make independent decisions. Moreover, it fosters personal responsibility and self-management and provides a more personalised approach because students can focus on their own strengths and areas of interest. We recommend choosing the individual participation mode for an educational escape room only if forming teams is not possible, requires significant effort or significantly hinders students from participating in the activity, or if the learning objectives do not include any objective related to teamwork. Individual participation is of special interest for educational escape rooms offered as remote asynchronous learning activities since in these cases it allows any individual student to play the escape room from anywhere, at any time.

## 4.1.4. Establishing an appropriate duration

The duration of the experience is a crucial aspect when designing an educational escape room. Durations that are too short could prevent students from mastering meaningful learning objectives, while durations that are too long increase the risk of students becoming tired or losing interest. Furthermore, it should be noted that the duration of an educational escape room limits the number and complexity of the puzzles that can be included.

In most documented experiences of educational escape rooms, participants are given between 1 and 2 hours to solve all the puzzles and complete the activity. In most cases, designing an educational escape room to fit within this time range (1-2 hours) is a good option. In the event that a longer duration is needed to conduct an educational escape room, the possibility of reducing the scope of the activity (e.g., by reducing the number of addressed learning objectives) or designing several shorter escape rooms should be considered.

When deciding on the appropriate duration for an educational escape room, it is important to consider all complementary activities that are intended to be carried out, such as introductory sessions, pre-tests and post-tests, and debriefing sessions. We recommend setting the total duration of the experience (including the educational escape room and its complementary activities) to between 1 and 2 hours. In this regard, an advantage of designing educational escape room experiences to last 1-2 hours is that it facilitates their incorporation into courses because lectures and practical sessions usually have this same duration.

Regarding the duration of individual puzzles, these can have very different expected durations depending on their difficulty and the help provided to participants during the educational escape room. Most puzzles require participants to spend between 10 and 40 minutes to complete them, and educational escape rooms lasting around 1-2 hours commonly have 3-10 puzzles. However, sometimes shorter puzzles (occasionally with little or no educational elements) are included to increase motivation. If a puzzle requires participants more than 30 minutes to complete, the possibility of dividing it into smaller puzzles should be considered. The number of puzzles to be included in an educational escape room should be large enough for covering the desired learning objectives (e.g., one puzzle per learning objective) but small enough to allow the participants to complete the activity in a reasonable time (e.g., 1-2 hours) and pace. In this regard, the duration of an educational escape room can be modified while maintaining the number of puzzles constant by adjusting their difficulty and the amount and quality of help provided to the participants.

## 4.1.5. Crafting a consistent and engaging narrative

The narrative of an educational escape room refers to its specific story, including its theme or setting, the role of the participants, their allies, the conflicts, and the final goal. A well-crafted narrative serves as the spine of any educational escape room, as it makes the game more engaging and immersive and, at the same time, provides a context for the puzzles presented and the tasks that need to be performed in order to solve them. If an educational escape room has a consistent and engaging narrative, it is more likely to motivate participants and produce positive impacts on their learning.

Below, we include some recommendations aimed at making the narrative of an escape room consistent:

- Ensure that every puzzle, task, clue, and resource presented to the participants has a reason to exist that is consistent with the narrative. This suggestion seeks to avoid the presence of elements that feel disconnected or random, as this can reduce immersion.
- Connect all puzzles through the narrative.
- Maintain coherence across all elements. For instance, if an educational escape room is set in a medieval town, participants should not encounter modern objects (e.g., a smartphone) unless they are justified by the story.
- Maintain consistent tone and style.
- Give participants compelling reasons why they should accomplish the final goal.
- Provide a justification of why the final goal has to be achieved within a given time frame.

Next, we include some recommendations aimed at making the narrative of an escape room engaging:

- Define a clear storyline or plot.
- Define the setting, context, and final goal clearly.
- Establish a strong and vivid setting (e.g., a historical era, a futuristic world, or a real-life scenario).
- Define the participants' roles clearly (e.g., detectives, scientists, time travelers, or students locked down in a school).
- Start with a strong hook to capture participants' attention from the very beginning.
- Develop interesting characters whose actions influence the story. These characters can be allies, antagonists or neutral characters. Thus, they may offer clues or background information, yet they can also create obstacles for the participants.
- Incorporate mystery and suspense.
- Incorporate surprises and unexpected twists (e.g., the unmasking of a traitor).
- Incorporate a satisfying conclusion. Who does not like a happy ending? When telling or listening to a story, we usually enjoy a satisfying conclusion; therefore, when thinking about a narrative for an educational escape room, we recommend providing a clear and rewarding resolution. This could be, for example, escaping a locked room, solving a complex mystery, or reaching a final destination.

## 4.1.6. Structuring the puzzles appropriately

Since educational escape rooms are comprised of puzzles, the organisation of puzzles is a key aspect of their design. As shown in Figure 2, the structure of puzzles in an escape room can be mainly of two types:

**Linear**: in an escape room with a linear puzzle structure, the puzzles are arranged in sequence in such a way that each puzzle cannot be completed until the previous ones have been solved, which forces participants to solve the escape room puzzles in a specific order.

**Non-linear**: in an escape room with a non-linear puzzle structure, there is no single order in which participants must solve the puzzles, but, at certain times, there are multiple puzzles that participants can solve without following a specific order.

**Linear**          **Non-linear**
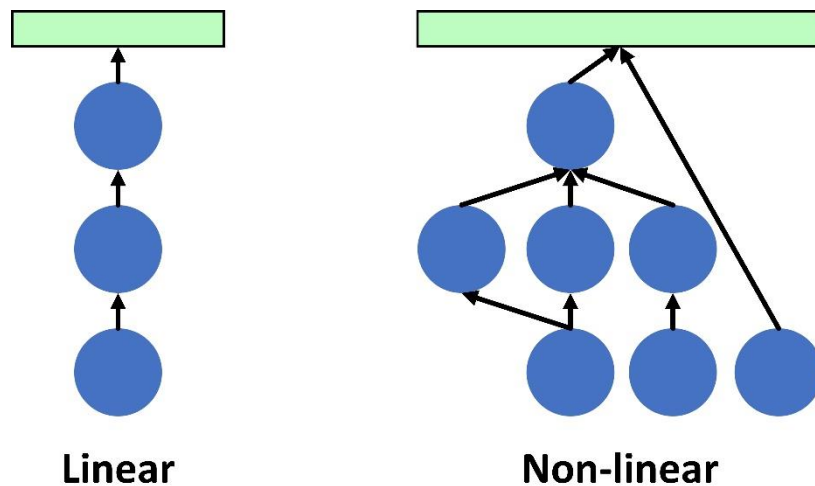
**Figure 2**: Types of puzzle structures in escape rooms

Each of these types of puzzle structures has its own advantages and disadvantages. On the one hand, using a linear puzzle structure in an educational escape room ensures that all team members face all puzzles, which provides every participant with the opportunity to achieve all the learning objectives of the activity. Another advantage of using a linear puzzle structure is that it makes the educational escape room easier to monitor and thus facilitates the provision of timely help to those participants who need it. Moreover, educational escape rooms with a linear puzzle structure are easier to design and test because there is a single order in which puzzles can be solved.

On the other hand, educational escape rooms with a non-linear puzzle structure allow participants to choose which puzzles to tackle first from those available, fostering their autonomy and requiring them to make planning-related decisions, which can enhance their motivation as well as soft skills such as decision-making and strategic thinking. Furthermore, in this kind of escape rooms, team members can split up to work on different puzzles simultaneously, allowing each participant to contribute in a different way based on their skills and knowledge. In these cases, the role played by communication and coordination is even more crucial than when using a linear puzzle structure. Therefore, using a non-linear puzzle structure in an educational escape room can be beneficial for the development of certain soft skills such as communication, teamwork, leadership, and delegation. Another advantage of educational escape rooms with a non-linear puzzle structure is that they can provide more personalised experiences by providing multiple paths for different student profiles. Lastly, it should be noted that some real situations cannot be suitably simulated through linear puzzle structures, making it necessary in such cases to resort to non-linear puzzle structures.

When designing an educational escape room, an appropriate puzzle structure should be chosen based on the desired goals. For example, if a teacher aims to ensure that all participating students have the opportunity to achieve all of the escape room's learning objectives, a linear puzzle structure would be appropriate. Conversely, if the teacher prioritises the development of soft skills such as teamwork, leadership and decision-making, a non-linear structure might be more suitable. In this regard, it is important to highlight that every educational escape room, regardless of its puzzle structure, can be used to enhance soft skills.

Lastly, regardless of the puzzle structure used, it is always advisable to connect the different escape room puzzles through an engaging and consistent narrative (see Guideline 4.1.5).

## 4.1.7. Designing appropriate puzzles

It is highly recommended that every puzzle in an educational escape room meets the following requirements:

- The solution to the puzzle should be unique and easily verifiable in an objective way.
- The participants must be able to find the solution to the puzzle within the allotted time using the available resources.
- The probability that participants will solve the puzzle through trial and error should be very small.
- The puzzle should not have irreversible states so that participants, regardless of their past actions, should always have the opportunity to solve it.
- Participants should be clear about when they have solved the puzzle. A good practice is for the puzzle to include visual or auditory feedback.
- The puzzle should have a reason to exist consistent with the narrative.
- The puzzle should be connected or related to other escape room puzzles.
- The puzzle should be tied to specific educational goals and combine educational and playful elements.

When combining educational and playful elements, achieving an appropriate balance between them is important. If the puzzles of an educational escape room lack educational elements, then its instructional effectiveness will be very low. On the contrary, if these puzzles lack playful elements, then the escape room might fail to motivate the participating students, which is one of the essential goals of game-based learning. In some educational escape rooms, in order to produce a temporary increase in the motivation of the participants, it might be a good idea to include a short puzzle (for example, the first one) that is purely fun and has no educational elements. However, the majority of puzzles should combine educational and playful elements in order for the educational escape room to have an appropriate balance between the educational and game parts.

An approach that has proven useful for designing educational escape room puzzles is to intertwine educational content with game mechanics often employed in ludic escape rooms (i.e., escape rooms designed primarily to provide entertainment) in such a way that solving the puzzles requires the participants to apply field-specific knowledge and skills, as well as perform actions typical of ludic escape rooms (e.g., finding hidden symbols, deciphering codes, assemble objects, identifying patterns, hearing sounds, observe lights or open locked boxes, drawers or safes). A list of common actions that players are required to perform to succeed in ludic escape rooms can be found in a white paper that presents the results from a survey answered by 175 escape room facilities worldwide (Nicholson, 2015). Regarding this matter, we would like to mention that playing ludic escape rooms is a very interesting option for teachers to spark ideas and stimulate their creativity.

## 4.1.8. Establishing an appropriate difficulty

Existing research evidences that the more puzzles students solve during educational escape rooms, the more they learn (López-Pernas et al., 2019b). Therefore, the difficulty of an educational escape room should be high enough to captivate participants but low enough to allow them to solve the puzzles and learn. Based on this idea, it is recommended that educational escape rooms be designed with the goal of keeping participants in a state in which they are neither over-challenged nor under-challenged at all times.

When establishing the difficulty of an educational escape room, several factors need to be considered:

- The age, knowledge, skills and experience of the expected participants (i.e., the target audience). Consideration should be given not only to knowledge and skills directly related to the specific topics addressed by the educational escape room (e.g., trigonometry knowledge in the case of a math escape room) but also to soft skills (e.g., divergent thinking and teamwork), which are often useful for success in escape rooms. Moreover, in the case of virtual educational escape rooms, the digital competence of the target audience may significantly influence their performance.
- The setting in which the educational escape room is going to be conducted. Regarding this issue, it should be considered that the behaviour and cooperation of the participants during the educational escape room may be different depending on whether it is done in person or remotely, the number of resources (e.g., computers) available, the ambience of the environment, and the participants' familiarity with the environment.
- The participation mode (individual or in teams) and the size of the teams.
- The learning objectives. In this regard, it must be considered whether the activity will be used to reinforce previously taught concepts or to teach new concepts.
- The estimated duration of the experience.
- Guidance and help provided to the participants.

Adjusting the difficulty of an educational escape room is even more complicated than doing so for a ludic escape room because educational escape rooms combine educational and playful elements and their difficulty usually depends on both elements. For instance, if a puzzle intertwines educational content with game mechanics, the difficulty of solving it will depend on how difficult it is to master the educational content, how difficult it is to understand the game mechanics involved, and how difficult it is to perform the required actions according to the educational content and the game mechanics. Therefore, both educational and playful elements should be considered when adjusting the difficulty of puzzles in educational escape rooms.

An interesting approach is to design the escape room puzzles in such a way that they are of increasing difficulty. This approach reduces the likelihood of the participants getting stuck on the first puzzles, which could be very discouraging or frustrating for them. In this regard, a good practice is to make the first puzzle of the educational escape room extremely easy in order to motivate participants and facilitate them getting started with the activity. This approach based on incremental difficulty is easy to implement in educational escape rooms with a linear puzzle structure (see Guideline 4.1.6). In educational escape rooms with a non-linear puzzle structure, it can also be implemented (e.g., in each of the paths). However, there are some limitations since, in this type of escape rooms, there is no single order in which the participants must solve the puzzles. In educational escape rooms with a non-linear puzzle structure, it is advisable to combine easy and difficult puzzles.

Besides varying the puzzles, there are several ways to modulate the difficulty of an educational escape room that can be helpful for achieving the desired balance:

- Increase or decrease the time available for participants to solve the puzzles (i.e., the duration of the escape room).
- Altering the clues. The more clues are provided, the easier it will be for participants to solve the escape room puzzles. Another factor that affects the difficulty is how easy it is to find the provided clues.
- Add distractors (e.g., in the form of misleading clues, unnecessary objects and superfluous data) in order to increase the difficulty of a certain puzzle or the whole escape room.
- Change the approach employed for delivering hints to the participants. For instance, the difficulty of an escape room can be decreased by increasing the maximum number of delivered hints, increasing the quality or quantity of the information provided by the hints, or allowing participants to request hints for specific aspects of the puzzles. Similarly, the difficulty of an escape room can be increased by decreasing the quality or quantity of the information provided by the hints, establishing a minimum time between hints or imposing a cost (e.g., a lower ranking position) per hint requested.
- Change the size of the teams. Smaller teams can find the activity more difficult due to fewer minds working together, while larger teams may find it easier due to a greater pool of ideas, skills and experience.

## 4.1.9. Defining how to provide participants with timely help

Providing the necessary assistance to the participants of an educational escape room is essential for the activity's success. Hence, this aspect should always be considered when designing an educational escape room. In this regard, participants may require different types of help while executing an educational escape room.

On the one hand, it is quite common for participants to get stuck while trying to solve an escape room puzzle. This can occur because they lack the necessary knowledge or skills to solve the puzzle or due to other reasons, such as difficulties in understanding the game mechanics or the need for a clue that they have not yet found or that they have overlooked. If participants remain stuck at one puzzle for too long, there is a risk of them getting bored, frustrated or even angry. This could also be counterproductive from a pedagogical perspective, as it would prevent participants from engaging with all the puzzles. Therefore, it is crucial to provide participants with help for solving the puzzles during the execution of educational escape rooms.

On the other hand, during an educational escape room, participants may encounter incidents that teachers did not expect (e.g., a computer that fails to boot because of a hard drive failure, a web resource not loading properly due to the use of a web browser without adequate HTML5 support, or an invisible ink flashlight that does not turn on because the battery is dead) or have questions about the activity not directly related to the puzzle solutions (e.g., doubts about the rules of the escape room or the grading criteria).

Different mechanisms can be used to provide each type of help. To assist participants in solving puzzles, we recommend delivering hints using an appropriate strategy. A description of various useful approaches for delivering hints is included at the end of this section. To help participants in case of incidents or additional doubts, we recommend resorting to supervisors whenever possible. In educational escape rooms conducted face-to-face, supervisors can attend to the incidents and resolve the doubts in person. In contrast, in educational escape

rooms conducted remotely, a video conference room can be set up for this purpose (see Guideline 4.3.4).

Delivering hints is a great way to help participants solve the puzzles during an educational escape room, which, as indicated above, is crucial for the activity's success. Many different approaches can be followed to deliver hints. Choosing an appropriate approach is very important because it will influence the duration, difficulty and effectiveness of the educational escape room. Below are several recommendations for delivering hints to participants during an educational escape room:

- Use pre-created hints instead of providing custom hints devised on the spot. We recommend creating hints for each escape room puzzle and then using them during the escape room. Thereby, the same hints are available for all participants.
- Limit the frequency or number of hints. In order to encourage participants to strive to complete the puzzles, a good option is setting a minimum amount of time that they must wait from receiving a hint until they can receive another one. Another option is to limit the maximum number of hints a team (or an individual in the case of single-player escape rooms) can obtain. This option has the disadvantage that participants that run out of hints will be at risk of getting stuck for the rest of the escape room, but it has the advantage of giving participants greater ability to manage their resources. For example, when using this option, if a team receives a hint that it feels is not useful, it can decide to ask for an additional hint instead of having to wait.
- Require participants to pay some cost every time they request a hint. Thereby, participants are incentivised to persist in finding solutions to the puzzles before seeking help for this purpose. The cost can be the same for all hints or can be different depending on the complexity of the puzzle for which the hint is requested and/or the usefulness of the requested hint. The cost of a hint can be of different types:
  - **Time penalty**. The time a team or participant has available for completing the escape room may be reduced each time a hint is requested. This approach causes each team or participant to have a different time limit, which creates difficulties in supervised escape rooms since it makes it harder to correctly monitor the progress of all participants. Moreover, this approach prevents a common countdown to be displayed for all participants and makes the provision of help through global communications less effective. Therefore, applying time penalties is not recommended for supervised educational escape rooms where several teams (or individuals in the case of individual participation) play simultaneously.
  - **Score reduction**. If participants can earn score points during an escape room (e.g., by solving puzzles or finding items), then it is possible to pay hints with them.
  - **Drop in the leaderboard**. If the escape room has a leaderboard that displays all participating teams or individuals, then the number of requested hints can be used when determining their positions on the leaderboard.
  - **Extra effort**. Participants also can pay a hint by performing tasks that require additional effort. An interesting practice that has yielded good results in several educational escape rooms is to require participants to pass a quiz with a few self-grading questions on concepts related to the learning objectives in order to obtain a hint. The questions can be chosen at random from a poll or a question bank on each attempt, and the number of questions and the grade necessary to pass the quiz can be adjusted (e.g., participants can be required to answer 4 out of 5 questions correctly). This practice has several benefits. Firstly, it can be used to encourage students to review concepts and materials that complement the rest of

the educational escape room. Secondly, it allows to easily modulate the required effort (which influences the frequency with which participants request hints) by changing the length of the quiz. Thirdly, it also allows to easily modulate the difficulty of the escape room by adjusting the pass criteria of the quiz.

- o **Grade reduction**. If the educational escape room is a graded activity, it is possible to apply grade penalties for requesting hints. However, these penalties should be applied with great caution as they may cause participants to be too reluctant to ask for help and thus be counterproductive to their learning. Generally, a better option is to use costs for hints that do not transcend beyond the escape room, such as score reductions, drops in the leaderboard or extra tasks.

Although this practice does not impose a strict limit on the number of hints participants can obtain, it clearly contributes to limiting the number of delivered hints.

- Create multiple hints for each puzzle, arrange them in sequence so that they are in increasing order of usefulness, and deliver hints in order (i.e., a hint cannot be delivered until the prior ones of the puzzle have been delivered). An interesting practice could be to create three hints for each puzzle in such a way that:
  - o The first hint indicates which clues and resources are needed to solve the puzzle and provide some vague help.
  - o The second hint provides more useful information to solve the puzzle.
  - o The third hint gives away the solution to the puzzle.

This practice prevents participants from getting stuck indefinitely (even in unsupervised escape rooms) and when combined with other practices (e.g., limit hint frequency) it also encourages participants to strive to solve all puzzles. Naturally, this practice can be adapted to specific puzzles and settings (e.g., by modifying the number of hints per puzzle).

- Organise the hints of multi-task puzzles into different categories and allow participants to choose the category from which they receive the hints. If hints are provided for a puzzle that requires completing several tasks without using categories, then there is a risk of providing useless hints to participants. For example, if solving a puzzle requires finding six hidden symbols and a team only needs one more to find, any hint related to the symbols they already found will be useless. Using one category per symbol makes it possible to deliver useful hints to the teams in all cases. Besides creating a category for each task required to solve a puzzle, sometimes it is also useful to create a "general" category with hints related to the whole puzzle. In this regard, it is worth pointing out that it is possible to create multiple hints for each hint category of each puzzle and arrange them in sequence in the same way as explained in the above recommendation.

- Deliver free hints to lagging participants or suggest them to request hints. If a team or individual player is at high risk of not being able to complete an escape room at a given moment, it is highly recommended to help that team or player, either by providing a hint directly or by suggesting to request a hint.

- Use on-the-spot hints as a fallback in supervised escape rooms when no more pre-created hints are available. In some cases, a team or player can remain stuck in a puzzle even after obtaining all the pre-created hints of that puzzle. In these cases, it could be useful to allow the team or player to request a new hint from a supervisor, who can provide a custom hint devised on the spot. Naturally, this option can only be used in supervised escape rooms. In unsupervised escape rooms, it is recommended to use automated hints and provide final hints with the solution in order to prevent participants from getting stuck indefinitely.

## 4.1.10. Defining the strategy of student grading

Educational escape rooms test participants' knowledge and/or skills and hence they can be used as assessment activities for which students receive a grade. When designing an educational escape room, it is important to decide whether students will be graded and, if so, how their grades will be calculated. Furthermore, when an educational escape room is offered as a graded activity within a course or study program, it is also necessary to decide how it will fit within the syllabus as a graded activity.

On the one hand, offering an educational escape room as a non-graded activity allows students to play without the pressure of assessment and to focus on learning. On the other hand, grading the students that participate in an educational escape room can encourage them to take the activity seriously and give their full effort. In our opinion, although educational escape rooms allow to assess students, these activities should be conducted with the primary goal of facilitating active learning. Furthermore, it must be taken into account that the level of difficulty of educational escape rooms does not only stem from students' mastery of the learning objectives but also the difficulty of the game elements, which often require creativity and thinking outside the box. Therefore, we recommend that educational escape rooms either be offered as non-graded activities or as formative assessment activities in which the score obtained has little influence on the students' final grade. For incorporating a graded educational escape room into a syllabus, we recommend using one of the following approaches:

- Include the escape room as an optional extra credit activity, where the score obtained is added on top of the final grade of a course.
- Include the escape room as a mandatory or optional activity, where the score counts as a small percentage toward the final grade of a course.

In this regard, it should be pointed out that including educational escape rooms as mandatory activities can increase student participation but for some students could lead to stress or lack of involvement.

Regarding the calculation of students' grades, the following options are available:

- Award students points just for participating in the educational escape room. This basic form of assessment removes the performance pressure from the students, who can focus on learning and enjoying the experience. Furthermore, if grades are calculated based on student performance, the motivation to obtain a good grade could lead some students to cheat in such a way that the solutions to the escape room puzzles are revealed. This form of assessment discourages such behaviour.
- Award students a pass/fail grade depending on whether they successfully complete the educational escape room or not. We do not recommend this form of assessment because students who are close to completing the activity will receive the same failing grade as those who make no effort and barely make any progress.
- Score students proportionally to their percentage of completion of the educational escape room (e.g., based on the solved puzzles). This form of assessment allows to reward students' performance in a more accurate and fair way than if binary (pass/fail) grades were assigned.
- Score students based on their performance in the activity by considering multiple factors such as the puzzles solved, the time spent solving each puzzle, the weight of each puzzle, and the hints obtained. For example, in an educational escape room with 5 puzzles, students could be scored as follows:

- +1 point for solving puzzle 1.
- +1 point for solving puzzle 2.
- +2 points for solving puzzle 3.
- +2 points for solving puzzle 4.
- +3 points for solving puzzle 5.
- +1 point for solving all puzzles in less than 1 hour.
- -0.2 points per hint obtained.

This form of assessment allows to calculate grades in a more accurate and fair way than the prior ones. Furthermore, it allows encouraging students not to over rely on hints to advance in the educational escape room, which may be beneficial in some scenarios. However, this form of assessment is more complex since it requires monitoring more data.

Other information that teachers could find useful for grading the participating students in team-based educational escape rooms is how well they worked as a team, what role they played within their teams, and what their individual contribution was. Unfortunately, monitoring this information reliably and automatically seems unattainable with the current technology, and therefore it should be determined manually (e.g., through teacher observation, student peer assessments or 360-degree evaluations), which is not feasible or reliable in many cases.

## 4.1.11. Designing the escape room with accessibility and inclusivity in mind

When a teacher decides to design an educational escape room, they should do everything possible to make it fully accessible to all students. Accessible and inclusive education is fundamental for sustainable development and social equity, as reflected in the United Nations 2030 Agenda (UNESCO, 2022) and in European legislation (Council of the European Union, 2020; European Parliament, 2021). Sustainable Development Goal 4 (SDG 4) establishes the need to ensure inclusive, equitable, and quality education and to promote lifelong learning opportunities for all. It is necessary to eliminate the barriers that prevent access to education, ensuring that all people, regardless of their gender, ethnic origin, disability, or socioeconomic status, can access quality education, in addition to improving educational mobility. Likewise, the Charter of Fundamental Rights of the European Union (European Parliament, 2021) recognises education and access to vocational and continuous training as a fundamental right. However, recent studies, such as the one commissioned by the Documentation and Research Center on Disability (CEDID) (Real Patronato sobre Discapacidad, 2023), emphasise the need to transform educational centres and universities into inclusive and accessible spaces. This includes adapting infrastructures and educational methodologies to meet the needs of all students, especially those with disabilities. We must take these adaptations into account because students with functional diversity continue to encounter numerous access barriers in education (García-González et al., 2021; García-González et al., 2023).

For all these reasons, and in our responsibility as teachers for the education of the future of society, we must eliminate any type of barrier that prevents our students from accessing education. In this particular case, we must do everything possible to ensure that all of them can enjoy educational escape rooms. Evidently, each student is different, and therefore, the educational needs that may arise in our daily teaching are multiple. However, from this guide, we want to outline those needs that we consider most prevalent and representative of our

classrooms. Thus, we will describe what aspects are fundamental to consider in order to design an accessible and inclusive educational escape room.

We will start by discussing physical adaptations. In case of running an educational escape room face-to-face, we should ensure that the rooms are spacious enough to allow access for wheelchairs and other mobility devices, and that these rooms are accessible, so it may be necessary to use ramps and wide doors. Additionally, we will need to use adjustable furniture to accommodate students with different physical needs (Real Patronato sobre Discapacidad, 2023; Ramírez Quesada & Jesús Villa, 2023). An interesting possibility for teachers to make educational escape rooms more accessible is to offer participants additional shifts allowing remote and/or asynchronous participation in case there are barriers preventing them from attending the escape room in person (see Guideline 4.3.1). In the event that a teacher wishes to use virtual or hybrid educational escape rooms, it is important to ensure that the interfaces of the virtual resources are intuitive and easy to use for all students, including those with physical disabilities.

Sensory adaptations will also be necessary for students with visual and auditory impairments. Therefore, we should provide adequate and adjustable lighting in addition to using tactile and auditory signage (Dietrich, 2018; Ramírez-Vásquez & Rosas-Escalona, 2023). If the educational escape room we use incorporates audio and video content, we should include subtitles and transcriptions for them (Agrimi et al., 2024).

On a cognitive level, providing clear and simple instructions and using visual supports such as pictograms, images, or diagrams is necessary to facilitate understanding. For single-player educational escape rooms, we can allow additional time for students with cognitive disabilities to complete tasks (Herrera et al., 2024; Screpnik et al., 2024). When the educational escape rooms are played in teams with students of varying learning levels, adjustments should focus on the help provided, offering more hints, prompts and increased teacher support rather than extending the time limit.

Finally, we cannot forget the need to offer assistive technology, especially if we run a virtual or hybrid educational escape room. We should verify that the virtual resources are compatible with assistive devices such as adapted keyboards and special mice (Mateen et al., 2023; Monreal Bartolomé et al., 2024), as well as with screen reading software for students with visual disabilities (Ramírez-Vásquez & Rosas-Escalona, 2023; Agrimi et al., 2024). Furthermore, on some occasions, we may need to use augmentative and alternative communication tools for students with communication difficulties (Valverde Esteve & Tordera Salvador, 2023).

By considering these aspects, needs and adaptations, teachers can design more inclusive and accessible educational escape rooms that will have higher capacity to meet the needs of all students.

# 4.2. Build

## 4.2.1. Building the escape room with reusability in mind

Improving the reusability of educational materials allows for minimising cost, saving time, reducing the environmental impact and enhancing the quality of learning experiences. To achieve these benefits in the field of educational escape rooms, these activities should be built in such a way that they can be reused and adapted in the future in an easy, economic and sustainable way. Below, we include some recommendations for any teacher to improve the reusability of their educational escape rooms:

- Use virtual resources whenever possible, as long as they do not pose any significant limitations (see Guideline 4.1.2). These resources can be reused indefinitely without degradation, can be easily stored, and are usually easy to modify.
- In the case of using physical resources:
  - Use printable resources (e.g., paper-based puzzles or 3D-printed objects) that can be easily reproduced for future use.
  - Use materials that can withstand repeated use.
- Build the educational escape room and all its puzzles in such a way that they are easy to reset. It should be easy to return the educational escape room to its starting state before each game.
- Store all digital files in a trusted digital repository and make backup copies. The stored files should include the final files and all the source files (e.g., a Word document used for generating a PDF file, a Photoshop file used for generating an image, or the source code of a software application).
- Create instructions that contain all the information necessary for a teacher to properly execute the educational escape room, including the setting for which the activity was designed, the required resources, the learning objectives, the participation mode and team size, the duration, the description of the narrative, the structure and solution of the puzzles, and the help mechanisms.

## 4.2.2. Using resources with low environmental impact

When building an educational escape room, the environmental impact of the resources employed for this purpose should be taken into account. Escape room creators should, to the extent possible, use resources with a low environmental impact, that is, resources that minimise harm to the environment during their extraction, production, use and disposal.

A very effective and recommendable way to reduce the environmental impact of an educational escape room is to use virtual resources instead of physical ones. Although virtual resources do require energy for devices and Internet usage, they generally have a smaller overall environmental footprint compared to physical materials (e.g., paper, plastic or wood) because they can be reused indefinitely without degradation, do not generate physical waste, and eliminate the need for producing and transporting physical materials. However, it should be noted that virtual resources have certain drawbacks, as they limit the game mechanics that can be used to design the escape room and the actions the players can perform (see Guideline 4.1.2). Therefore, on some occasions, the use of physical resources can provide worthwhile added value.

We recommend that the use of physical resources to build an educational escape room be limited to those cases in which the activity is going to be carried out face-to-face and the inclusion of these resources provides significant added value. If the escape room is going to be conducted remotely or if it is going to be conducted in person but a similar experience can be achieved using virtual resources instead of physical ones, then we recommend building the activity using virtual resources. Besides building escape rooms where all resources are virtual and escape rooms where all resources are physical, it is possible to build hybrid escape rooms by combining virtual and physical resources, which allows to take advantage of the benefits of both types of resources.

In the case of using physical resources to build an educational escape room, we recommend the use of sustainable and recyclable materials whenever possible. For instance, paper, cardboard and eco-friendly inks can be used to craft an immense variety of props, clues, and puzzles for escape rooms. In the case of printing objects with 3D printers, sustainable and recyclable materials (e.g., PLA and wood filaments) are also available for this purpose.

## 4.2.3. Considering changing the design of the escape room to make it easier to build

Building all the necessary components to conduct an educational escape room can turn out to be much more complicated than initially anticipated during the design phase. For example, it could happen that a group of teachers needs to create a specific resource to build an escape room puzzle and realises that the digital tools they have do not allow them to easily create the resource with all the necessary requirements, or that they cannot create it by printing paper or 3D objects. In this situation, in order to build the desired puzzle, teachers could develop a software application from scratch or craft an object by hand. The problem with these possible solutions is that they would require a great deal of work and skill (in addition, if the object were to be crafted by hand, the resource obtained could have low reusability). One possible alternative for teachers in these situations is to modify the design of the escape room to simplify its construction. For instance, in the prior situation, teachers could slightly modify the puzzle (and the narrative if necessary) so that the required resource can be authored with a certain digital tool or printed using conventional or 3D printers.

On many occasions, the effort invested in changing the design of an educational escape room will be offset by the reduction in the effort required to build the activity. For this reason, we recommend that teachers, whenever significant difficulties are encountered during the process of building an educational escape room, consider the possibility of changing the original design of the activity to simplify its construction. The design of the educational escape room can also be reviewed to identify possible measures to improve its reusability (see Guideline 4.2.1) and reduce the environmental impact of the employed resources (see Guideline 4.2.2).

# 4.3. Execution

## 4.3.1. Considering scheduling shifts and allowing asynchronous participation

Before conducting an educational escape room, it should be decided whether the activity will be run through one or more scheduled shifts and whether asynchronous participation will be allowed. Running an educational escape room in a single scheduled session for all participants requires less effort than running the activity across multiple scheduled shifts. Furthermore, if only one session is conducted, students cannot receive information from other peers who have performed the escape room before them. However, in some cases, running an educational escape room in a single session is not possible (e.g., due to space or equipment limitations). In other cases, while it may be possible, it might not be the best option. In this regard, it should be noted that running an educational escape room across multiple scheduled shifts rather than in a single session offers several benefits:

- Facilitates student participation as there are multiple scheduled time slots in which they can play the escape room. Teachers can offer several scheduled shifts for playing the educational escape room and let each participant choose which shift they want to enrol. If the escape room is going to be conducted in a course in which students enrol in different groups, then an interesting alternative for teachers is to hold a scheduled shift for each of these groups.
- Reduces the number of simultaneous participants, which eases the supervision, control and monitoring of the activity, as well as the provision of timely help. Furthermore, fewer simultaneous participants contribute to create a better environment by reducing the likelihood of noise, chaos and distractions.
- Allows teachers to divide the participating students into different groups according to certain criteria (e.g., the students' prior knowledge of the topic being addressed or their player profile) and conduct the escape room for each of these groups in a different shift.
- Can make an educational escape room more accessible in the case that remote shifts are offered in addition to face-to-face shifts. By offering remote shifts, educational escape rooms become more accessible to students who may face barriers to attend in-person sessions, such as those with physical disabilities, caregiving responsibilities, health concerns, or geographical constraints.

Based on the information provided above, we consider that running an educational escape room in a single scheduled session for all participants is an acceptable option when each and every one of the following conditions is met:

- All participants can play the escape room simultaneously in an environment that has the intended characteristics.
- It is possible to supervise, control and monitor the activity in an appropriate way, as well as to provide all participants with timely help.
- The participants have no problem conducting the activity at the scheduled time.

If any of the above conditions are not met, then the possibility of running the educational escape room across multiple scheduled shifts should be considered.

In addition to running educational escape rooms through one or more scheduled shifts, teachers can offer them as asynchronous learning activities that students can start at any time within a set time frame. It is also possible for teachers to offer both scheduled shifts and asynchronous participation for an educational escape room. Asynchronous participation allows for great flexibility but comes with a major drawback: teachers cannot supervise the students who participate asynchronously unless they dedicate an overwhelming effort, as these students can start playing at any time. Therefore, students who participate asynchronously generally lack the benefits associated with the supervision of the educational escape room (see Guideline 4.3.4). For this reason, we recommend using supervised scheduled shifts whenever possible and allowing asynchronous participation only in those cases where conducting these shifts is not possible or requires an unaffordable effort.

## 4.3.2. Providing participants with initial instructions

Before starting the execution of an educational escape room, we strongly recommend to provide participants with initial instructions outlining the rules of the educational escape room, the learning objectives covered, the grading criteria, and all the actions that they must carried out before starting the activity (e.g., enrol in one of the available shifts, bring headphones to class, review topic 3). If the escape room uses digital tools or platforms, it is also advisable to guide participants in navigating them to ensure everyone feels confident using the interface.

The rules of an educational escape room can contain various information such as its final goal and time limit (i.e., how to win); the minimum and maximum size of the teams; whether participants are allowed to consult course materials, access the Internet, or talk with classmates; indications for identifying areas and items that are not part of the game; description of prohibit behaviours like breaking, forcing, or damaging props or equipment; a list of objects that can or cannot be touched, moved, or manipulated; instruction of how to use certain devices; the mechanisms available to request help in case of doubts, incidents or getting stuck in a puzzle; and descriptions of complementary activities such as pre- and post-tests, questionnaires, and debriefing sessions. The rules can also contain recommendations for the participants, such as sharing ideas, findings, and strategies among team members, asking for help when needed, and taking notes during the activity.

We recommend providing the initial instructions to participants through a text document (e.g., a PDF file), which can be accompanied by an explanatory video. The instructions should be provided well in advance so that participants can read them carefully before playing the educational escape room. We also recommend keeping these instructions as concise as possible to minimize the risk of participants not reading them entirely.

## 4.3.3. Preparing the escape room for its execution

Before participants start playing an educational escape room, it is important to ensure that the escape room is in its starting state and that the location where it will take place is ready. In the case of virtual educational escape rooms, in which all resources are virtual, it is usually sufficient to check that all resources are in their initial state and can be accessed by the participants. In the case of educational escape rooms that involve physical elements and are designed to be conducted face-to-face, teachers can carry out the following actions to prepare the activity:

- Start by setting up the location appropriately, accommodating either individual or collaborative work, and guaranteeing enough space for participants.
- Place all components of the escape room (props, clues, puzzles, etc.) in its location and organise the space in such a way that the activity is in its starting state.
- Verify that all components can be accessed securely and without damaging the environment.
- Remove or lock items that are not essential to the activity (e.g. plants, drawers, cabinets, or doors not used in the game).
- Identify and mark those areas and items that are not part of the game (e.g., fire extinguishers). This can be done by using tapes or ropes that delimit physical spaces and by placing visible signs or labels such as "Do Not Touch" or "Do Not Enter".
- Adjust the lighting, decorations, ambient sound, and other environmental factors to create the intended mood.
- In case of using consumable materials, ensure that there are enough supplies for all rounds of play and that they are easy to replace after each game.
- Include backup items that could be used in case something breaks or does not work properly.

Moreover, in those cases, we recommend conducting a quick test before starting a new execution of an educational escape room to check that everything works as intended.

## 4.3.4. Supervising the escape room whenever feasible

Supervising an educational escape room during its execution is always beneficial because it allows for ensuring that the rules are followed, monitoring and controlling the activity in real-time, assisting participants with any incidents or doubts, resolving conflicts, and helping the participants solve the puzzles when necessary through hints delivered by supervisors. In educational escape rooms conducted face-to-face, supervisors can be in the same location as participants and communicate with them in person. Another option that can be considered in these escape rooms is to allow participants to be alone in a locked room while the supervisors are in a separate room using video surveillance to observe the activity and walkie-talkies or other devices to communicate with the participants. In educational escape rooms conducted remotely, a video conference room can be set up to supervise the activity. In this case, an interesting option is that only one member of each team joins the room and acts as representative of his/her team.

The supervisors of an educational escape room should know all the details of the activity (including the solution to all puzzles) and be familiar with the topics and learning objectives addressed. The number of supervisors needed to supervise an educational escape room properly depends on several factors, such as the number of participants, team size, delivery mode (face-to-face or remote), format (physical, virtual or hybrid), location characteristics, puzzle design, difficulty, and processes established to provide help. In most cases, 1

supervisor per 5–10 teams allows for adequate supervision of the educational escape room. Notwithstanding, this ratio must be adjusted based on the specific characteristics of each experience.

Educational escape rooms can also be conducted without supervision. However, since having supervision is always advantageous for these activities, we recommend supervising educational escape rooms whenever feasible and achievable with reasonable effort. The use of unsupervised educational escape rooms should be limited to those cases in which supervision is not possible or requires an unaffordable effort, such as when educational escape rooms are offered as asynchronous learning activities (i.e., activities that can be done by the students whenever they choose within a set time frame) or through MOOCs (Massive Open Online Courses) with a huge number of participants. Educational escape rooms that are intended to be run without supervision should be created with this fact in mind in order to reduce as much as possible the likelihood of participants needing assistance. In these cases, we recommend using automated hints and providing final hints with the puzzle solutions (see Guideline 4.1.9), as well as paying special attention to the preparation of the instructions and the testing of the escape room.

## 4.3.5. Monitoring participants while playing the escape room

It is of vital importance to monitor the participants of an educational escape room while playing, as this allows to provide them with timely help (see Guideline 4.1.9), to motivate them through gamification elements such as points and leaderboards (see Guideline 4.3.7), to grade them based on their performance in the educational escape room (see Guideline 4.1.10), and to collect data that could be useful for improving the activity for future executions (see Guideline 4.4.3).

The monitoring of an educational escape room should enable to track the progress and performance of each participating player and team at all times. We recommend collecting, as part of the monitoring process, at least the following data for each team (in single-player escape rooms, we consider each player to be a one-member team for monitoring purposes):

- The puzzles solved by the team. This data helps track the team's progress in completing the educational escape room, indicating whether it has finished the activity. If the escape room features a linear puzzle structure, it also indicates which puzzle the team is currently facing. Furthermore, this data allows for estimation of the team's probability of successfully completing the escape room at any time during the execution. Therefore, it can be used to determine if the team is falling behind and needs additional help.
- The time point at which the team completed each of the solved puzzles. This data provides insights into the performance of the team and allows the teachers to detect whether the team is stuck, which would indicate that it might need help solving a puzzle. This data also helps estimate the team's probability of successfully completing the escape room more accurately.
- The hints delivered to the team. This data prevents the delivery of duplicated hints, allows to limit the number of hints delivered to the team, and provides insights about the amount of help provided to the team.
- In case of limiting the frequency of hints: the time point in which the team obtained each hint.
- In case students' grades need to be calculated based on their performance in the educational escape room or their attendance to the activity: the members of the team who participated in the escape room and their corresponding identifiers.

In most cases, the data mentioned above is sufficient to adequately monitor the participants of an educational escape room. Nevertheless, additional data can be collected as part of the monitoring process such as data related to the discovery of clues, interactions between participants, steps performed for solving puzzles, or failure attempts to solve puzzles. The more detailed the information collected, the greater the knowledge of the educational escape room that can be gained from it.

The monitoring of an educational escape room can be performed manually by the supervisors based on their observations or automatically using software tools. If the participant-supervisor ratio in an educational escape room is small, it is possible for the supervisors to manually monitor the activity by collecting, for each team, the minimum data set suggested above (i.e., puzzles solved and time points in which they were solved, hints delivered and time points in which they were delivered, and the members attending). Nonetheless, manual monitoring might not be feasible for educational escape rooms targeting large groups. Furthermore, this type of monitoring requires more effort, is more prone to errors, and greatly limits the amount and type of data that can be collected. Therefore, we strongly recommend to monitor educational escape rooms automatically by using reliable software tools.

## 4.3.6. Helping participants to solve the puzzles when necessary

It is of crucial importance to provide the participants with timely help in an educational escape room. In order to achieve this goal, during the execution of an educational escape room it is highly recommendable to provide participants with help for solving the puzzles by delivering hints according to a hint approach planned during the design phase. See Guideline 4.1.9 for more information about hint approaches.

Even if the planned hint approach is adequate, certain circumstances may require small adjustments during the course of the educational escape room. If, at a certain time, a significant number of participants is at risk of not completing the escape room (e.g. because their knowledge is lower than expected or because they have less time than expected due to an incident that caused the activity to start late), then it might be advisable to adopt one or several of the following measures:

- Provide one or more free hints to all participants. A reasonable option would be to provide a hint for each of the puzzles that participants at risk of not completing the activity are facing.
- Give an extra hint each time a participant obtains one.
- Reduce the cost of requesting hints (if any).

## 4.3.7. Motivating participants while playing the escape room

Motivating participants in an educational escape room is vital for the activity to be successful. Next, we propose some measures that teachers can take to boost motivation throughout an educational escape room:

- Show participants the remaining time to complete the escape room using a countdown timer and give periodic updates to indicate this time. This measure instils urgency and excitement.
- Show participants their progress toward completing the escape room. A simple way of representing the progress of a team or a participant is to show the percentage of

puzzles solved or the number of puzzles solved and the total number of puzzles of the escape room.

- Show participants a leaderboard that displays all participating teams or individuals. This leaderboard can show various information about each team or player such as their position, the number of puzzles solved or the amount of awarded points. The points awarded by each team or player could be based on different factors, such as the number of puzzles solved, the time required to solve the puzzles, or the number of hints obtained. This measure helps foster friendly competition by displaying participants' performance in real time.
- Encourage collaboration and communication among team members. This measure aims to make the experience more enjoyable and rewarding.
- Offer participants encouraging words and praise for their efforts, celebrate their milestones and accomplishments throughout the game, and congratulate them every time they solve a puzzle.
- Offer small rewards or certificates for top performers or for those who complete the escape room on time.

By using gamification features such as countdown timers, leaderboards, and point systems, along with progress recognition and positive reinforcement, teachers can cultivate a motivational environment that keeps participants engaged while achieving educational goals.

## 4.3.8. Conducting a debriefing session

Conducting a debriefing session after playing an educational escape room can be very positive, as it allows students to reflect on their experience, consolidate their learning, and connect the activity to established academic objectives. This post-activity discussion can enhance their learning process while providing teachers with valuable insights into what worked and what could be improved.

This debriefing session should be set in a positive tone, as teachers should acknowledge students' effort and participation, regardless of their success in completing the puzzles. It is also advisable to use open-ended questions when possible to facilitate discussion and encourage students to share their experiences. We recommend focusing on the challenges they encountered, the strategies that worked best for them, and the moments they felt most confident and successful. Ask students to reflect on how they collaborated, how they managed the allotted time and, if the escape room was played remotely using digital tools, how they interacted with them. This discussion, although informal, can assist students to think critically about their problem-solving, teamwork, and leadership strategies, as well as to identify strategies that may help them in future tasks.

This session allows to discuss both successes and challenges, but it is also an excellent opportunity to connect the educational escape room to the course's learning objectives clearly. Establishing these links allows to enhance students' understanding of how the educational escape room integrates into their learning journey and to emphasise the relevance of the skills practised.

Finally, we recommend concluding the debriefing session by celebrating students' achievements. Recognise their efforts and highlight creative or effective strategies they have used. Remember to connect the escape room experience with upcoming lessons or activities. Discuss how the skills practised during the educational escape room could be relevant in future tasks. By framing the escape room as part of a larger learning journey, students are more likely to see its value and remain engaged.

# 4.4. Evaluation

## 4.4.1. Testing the escape room thoroughly before its execution

The presence of errors in educational escape rooms can have very negative consequences, as they may prevent or hinder participants from progressing and, consequently, prevent or hinder participants from achieving the learning objectives. In this regard, it is worth pointing out that the presence of an error in an educational escape room can lead to significant confusion, as participants may be unsure whether the error is unintentional and needs to be fixed or if it has been deliberately included as part of the game and thus the escape room is functioning as intended. In these situations, participants may waste time trying to solve an unsolvable puzzle or address an unintended error, reducing the time available for meaningful learning activities. Additionally, errors can disrupt immersion and excitement in an educational escape room, leading to reduced motivation. Taking all of this into account, it becomes clear that thoroughly testing an educational escape room before participants play it is essential for its success.

In order to test an educational escape room thoroughly, we recommend conducting the following workflow after building it:

1. Review the narrative and check that every puzzle, task, clue and resource presented to the participants has a reason consistent with it to exist.
2. Test each puzzle individually and refine the puzzles based on the test results. When testing a puzzle, perform at least the following checks:
   o Verify that the physical and/or virtual resources of the puzzle work as intended.
   o For physical puzzles, ensure there are no safety hazards (e.g., sharp objects, heavy items that might fall, etc.).
   o Ensure that it is possible for participants to solve the puzzle with the information and resources available at the time when the puzzle is expected to be solved. Furthermore, confirm that participants can clearly identify when they have solved the puzzle.
   o Ensure that solving the puzzle enables participants to progress in the escape room (e.g., by providing new information or by unlocking a new puzzle, clue or resource).
   o Check if the puzzle aligns with the learning objectives of the escape room.
   o Test if the puzzle's difficulty matches the target audience's skills and knowledge level.
   o In case of using hints, review the hints of the puzzle and check that they are helpful for solving it.
   o Check how the puzzle behaves when participants make failed attempts at solving it. The puzzle should not have irreversible states so that participants, regardless of their past actions, should always have the opportunity to solve it.
3. Test the whole educational escape room and refine it based on the test result. During this testing, the following checks should be performed:
   o Verify that the instructions provided to the participants have all necessary information and are clear and easy to understand.
   o Check that all puzzles are connected through the escape room's narrative.
   o Test if the escape room can be completed (i.e., if all the puzzles can be solved) by the target audience within the allotted time frame. Furthermore, confirm that participants can clearly identify when they have successfully completed the escape room.

- Verify that the escape room covers all the intended learning objectives.
- Check if the escape room can be supervised, monitored and controlled as intended.
- If the escape room is going to be conducted face-to-face, ensure that the location is appropriate and free from safety risks.
- In case of using hints, verify that the delivery of hints works as intended.
- If the participating students are going to be graded based on their performance in the educational escape room or their attendance to the activity, verify that all data necessary for grading can be obtained.

Additionally, it would also be helpful to conduct a trial run of the educational escape room with users who have not been involved in its creation (e.g., volunteer students or teachers unrelated to the activity) before executing it with its intended users. This trial run can be added to the previous workflow as an additional step after step three. An important factor to consider when organising a trial run is that participants should have the skills and knowledge necessary to successfully complete the educational escape room.

## 4.4.2. Testing the escape room from the early stages of development

The sooner an error is detected in an educational escape room, the less effort and cost will be required to fix it. For instance, if an error is detected during a trial run after building an educational escape room, fixing it might require updating a virtual resource or modifying and reprinting items. However, if the same error were detected during the design of the escape room and before starting building it, fixing it would only require updating the design, saving significant time and lowering costs. Therefore, we recommend starting to test educational escape rooms during their design.

Next, we propose some measures that teachers can use to test an educational escape room during its design:

- Test the puzzles of the escape room and the whole activity using simple prototypes made from paper or by employing digital mockups.
- Test the technology and digital tools intended to be used for building and/or running the escape room through proofs of concept.
- Check that every puzzle, task, clue and resource considered in the design has a reason consistent with the narrative to exist, as well as that all puzzles are connected through it.
- Present the design of the escape room (including its learning objectives, narrative and puzzle structure) to students or other teachers to get early feedback.

Lastly, it is worth remarking that, in addition to testing an educational escape room during the early stages of development, it is also crucial to thoroughly test the activity after building it, as explained in Guideline 4.4.1.

## 4.4.3. Evaluating the impact of the escape room on participants' perceptions and learning

We recommend that, when running an educational escape room with its intended audience, the participants' perceptions toward the activity and its impact on the participants' learning be evaluated. There are different data collection instruments that teachers can use to carry out these evaluations such as questionnaires, interviews, focus groups, pre- and post-tests, video recordings, and logs. The data collected in these evaluations can be very useful to determine whether participants achieved the intended educational goals and improve educational escape rooms for future editions.

Using questionnaires can provide valuable insights into an educational escape room and typically requires little effort from both participants and teachers. Therefore, we recommend that a questionnaire is always administered to participants after completing an educational escape room in order to collect their perceptions. Using questionnaires to gather participants' perceptions has been one of the primary approaches for assessing the impact of educational escape rooms. Notably, there are currently no validated questionnaires specifically designed to evaluate educational escape rooms. Instead, ad-hoc questionnaires, like the ones published in (López-Pernas et al., 2019a) and (Gordillo et al., 2020), or adaptations of instruments designed for assessing gamified or game-based learning activities such as GAMEX (Eppmann et al., 2018) can be employed.

Other methods that teachers can use for evaluating participants' perceptions include interviews and focus groups. These methods allow for deeper exploration and clarification of thoughts, providing a more holistic understanding of how participants perceive the escape room. However, they require more time from both participants and teachers.

When running an educational escape room, in addition to collecting participants' perceptions, it is also valuable to objectively measure the learning gains experienced by them as a result of participating in the activity. An effective way to perform this measurement is through the use of pre-tests and post-tests as follows:

1. Prepare the test that will be used both as pre-test and post-test. This test must be able to be graded objectively and must allow to evaluate the intended knowledge and/or skills of the participants. In many cases, it can be a good option that this test consists only of multiple-choice questions.
2. Distribute the pre-test to participants just before they begin the educational escape room and give them a specific amount of time to complete it.
3. Conduct the educational escape room.
4. Distribute the post-test to participants immediately after they complete the educational escape room or when the time limit expires and give them the same amount of time to complete it as they were given for the pre-test.
5. Calculate the learning gain of each participant by subtracting the pre-test score from the post-test score. The calculated learning gains will provide strong evidence on the instructional effectiveness of the educational escape room.

The use of pre-tests and post-tests allows teachers to obtain strong evidence of the instructional effectiveness of an educational escape room through the calculation of learning gains. Nevertheless, it increases the effort that teachers must make to conduct the experience and demands more time from the participants, which may sometimes need to be compensated by reducing the time allocated to the escape room. Therefore, we recommend evaluating an educational escape room using pre-tests and post-tests whenever there is some scepticism regarding its effectiveness or if a rigorous evaluation of its effectiveness is

desired. In this regard, it is worth noting that an excellent way to evaluate the effectiveness of novel learning activities, such as educational escape rooms, is through the use of randomised controlled trials that compare the novel activity to a conventional approach by using pre- and post-tests. An example of these trials can be found in an article authored by Gordillo & López-Fernández (2024), in which the instructional effectiveness of an educational escape room is analysed and compared with that of traditional teaching through a randomised controlled trial with a pre- and post-test design.

Teachers can collect qualitative data about how participants interact during an educational escape room through direct observation. This data can provide valuable insights into various aspects of the experience that might not be captured through quantitative methods like questionnaires or tests. For example, it can showcase the dynamics of participant collaboration during gameplay, helping to understand how the activity influences the development of soft skills such as communication, teamwork, leadership and conflict resolution. Although evaluating an educational escape room through direct observation offers interesting possibilities, it has important drawbacks: it is unreliable due to the high likelihood of overlooking important data; the collected data is prone to observer bias; it is time-consuming; participants may alter their behaviour simply because they know they are being observed (a phenomenon known as the Hawthorne effect); and it only captures external behaviours, not emotions or thoughts. Therefore, we do not recommend using direct observation to evaluate educational escape rooms. Instead, a better alternative is using video recordings, which reduce observer bias and allow for the collection of observational data in a more reliable way. However, it should be considered that using video recordings as an evaluation instrument requires more time and effort, as well as the setup of cameras or other devices to obtain the recordings. For this reason, our recommendation is to limit the use of video recordings for the evaluation of educational escape rooms to those cases in which it is necessary or desired to assess in depth soft skills such as teamwork, leadership, communication or conflict resolution.

Teachers can also gather data on the participants' interactions throughout an educational escape room from logs automatically generated by software applications or hardware devices (López-Pernas et al., 2023). This data can help to understand how participants behave during an educational escape room by providing insights into participants' decision-making processes, time management, and problem-solving strategies. Although logs can be automatically generated, analysing them and drawing conclusions about the participants' behaviour from their data is often difficult for individuals without experience in data analysis. Furthermore, it should be considered that some of the participant interactions deemed meaningful for the intended analysis may not be automatically recorded in logs. Some of the virtual resources with which participants interact may lack logs or record only some of the interactions deemed meaningful. In addition, the physical interactions performed during hybrid or physical escape rooms will not be automatically logged unless specialised hardware is used. Taking all of this into account, our recommendation is to use logs for evaluating an educational escape room only when the following conditions are met:

- There is a strong interest in analysing the behaviour of participants during the escape room.
- All the participant interactions deemed meaningful for the intended analysis can be automatically recorded in logs; if not, part of these interactions can be automatically recorded in logs, and the rest can be reliably collected using other instruments.
- Qualified personnel are available to perform the intended analysis.

Finally, keep in mind that it is possible and often advisable to combine different instruments for evaluating the impact of an educational escape room on participants' perceptions and learning.

# Annex 1

## Resources for creating content for educational escape rooms

# I. Physical resources

## A. Printable resources not suitable for digital use

- **Thingiverse**
  URL: https://www.thingiverse.com
  **Description:** One of the largest repositories of free 3D models available on the Internet. It is a go-to resource for anyone with access to a 3D printer, whether for personal, educational, or professional purposes.

- **Decoder wheel**
  URL: https://dabblesandbabbles.com/printable-secret-decoder-wheel
  **Description:** A printable template for constructing a wheel to decode and encode text messages.

- **Scratch blocks**
  URL: https://scratched.gse.harvard.edu/resources/vector-scratch-blocks.html
  **Description:** Printable Scratch programming blocks.

## B. Hand-made resources

- **Scytale**
  URL: https://www.youtube.com/watch?v=Iwf4rZXVXjw
  **Description**: This video tutorial shows how to use everyday items to create a Scytale, an ancient cryptographic tool used by the Spartans for encoding and decoding messages.

- **Postcard decoder**
  URL: https://www.instructables.com/secret-postcard-decoder
  **Description**: Instructions on how to craft a postcard decoder that can be used to encode and decode messages written in postcards.

- **Scratch-off cards**
  URL: http://artmind-etcetera.blogspot.com/2009/05/ how-to-make-scratch-off-lottery-tickets.html
  **Description**: Instructions on how to craft scratch-off cards.

# II. Virtual resources

## A. Virtual resources suitable for print and digital use

- **QR Code Generator**
  URL: https://www.qr-code-generator.com
  Description: A free tool for generating QR codes.

- **A Message in Points**
  URL: https://www.worksheetworks.com/math/geometry/graphing/message-from-points.html
  Description: A tool for creating grids filled with labeled points, each containing a hidden message that can be revealed by matching coordinates with the labeled points.

- **The Teacher's Corner Printable Worksheets**
  URL: https://worksheets.theteacherscorner.net
  Description: Generators for creating various types of resources such as word searches, crosswords, and mazes.

- **MetroMapMaker**
  URL: https://metromapmaker.com
  Description: A tool for creating custom metro maps.

## B. Interactive encoders and decoders

- **PhonoPaper**
  URL: https://www.warmplace.ru/soft/phonopaper
  Description: An application available on iOS, Android, and Linux that allows encoding sounds into pictures, as well as playing sound encoded into pictures.

- **Codes and secret messages**
  URL: https://www.theproblemsite.com/reference/mathematics/codes
  Description: Encoding messages using numerical and symbolic systems.

- **PigPen cypher**
  URL: https://simonsingh.net/The_Black_Chamber/pigpen.html
  Description: A visually engaging cipher system that uses geometric shapes to represent letters.

- **Enigma**
  URL: https://www.101computing.net/enigma-machine-emulator
  Description: A web emulator of the historical Enigma machine used during World War II to encrypt secret messages.

- **Caesar cypher**
  URL: http://nosolomates.es/?page_id=760
  Description: Tool to encrypt and decrypt texts using the Caesar cypher method.

## C. Tools for creating audio and video

- **Synthesia**
  **URL:** https://www.synthesia.io
  **Description:** Synthesia uses AI to create realistic video avatars.

- **Plotagon**
  **URL:** https://www.plotagon.com
  **Description:** This tool enables the creation of animated videos.

- **WeVideo**
  **URL:** https://www.wevideo.com
  **Description:** A video editing platform that can be used to create and edit videos, as well as add effects, transitions, and more.

- **Voki**
  **URL:** https://www.voki.com
  **Description:** A tool for creating speaking avatars.

- **Pictory**
  **URL:** https://pictory.ai
  **Description:** This AI-powered tool helps create short and engaging videos from text content.

- **VoiceChanger**
  **URL:** https://play.google.com/store/apps/details?id=com.baviux.voicechanger
  **Description:** A mobile app for altering audio files by applying different voice effects.

## D. Tools for creating images

- **Midjourney**
  **URL:** https://www.midjourney.com
  **Description:** AI-powered tool to produce images from text prompts.

- **DALL·E 2**
  **URL:** https://openai.com/index/dall-e-2
  **Description:** DALL·E 2 can create realistic images and art from text descriptions.

- **Adobe Firefly**
  **URL:** https://www.adobe.com/products/firefly.html
  **Description:** This AI-powered tool allows for the creation of high-quality images and graphics.

# E. Tools for creating scenes

- **Thinglink**
  **URL:** https://www.thinglink.com
  **Description:** A tool that enables the creation of visually rich environments where participants can explore and interact with hotspots. It supports a wide variety of media, including 360-degree images, videos, and text.

- **ViSH**
  **URL:** https://vishub.org
  **Description**: ViSH provides authoring tools that can be used for creating interactive 2D scenes and environments.

# F. Virtual and augmented reality tools

- **ARLOOPA**
  **URL:** https://play.google.com/store/apps/details?id=com.arloopa.arloopa
  **Description:** ARLOOPA is an application for augmented reality experiences available in multiple languages. In educational escape rooms, it can be used for allowing players to discover clues by scanning real-world objects.

# G. Tools for managing and creating escape rooms and puzzles

- **Escapp**
  **URL:** https://github.com/iglue-project/escapp
  **Description:** Escapp is a free and open-source web platform for creating, conducting, and sharing computer-based educational escape rooms. It assists teachers with content and puzzle creation, escape room distribution, student registration, team formation, puzzle solution verification, progress monitoring, hint management, and grading. Any teacher or educational organization can deploy their own Escapp instance using the software available at https://github.com/iglue-project/escapp. Additionally, a public Escapp instance is available at https://escapp.es, allowing any teacher to try out and use Escapp.

- **Breakout EDU**
  **URL:** https://store.breakoutedu.com
  **Description:** Breakout EDU is a paid web platform that allows teachers to create virtual and hybrid educational escape rooms, buy kits with a wide range of physical resources (resettable locks, lockable boxes, invisible ink pens, UV flashlights, red lens decoders, etc.) designed for educational escape rooms, and access to a digital library with more than 1000 educational escape rooms.

- **Genially**
  **URL:** https://genial.ly
  **Description:** Genially can be used to create escape room-like video games.

- **Room Escape Maker**
  **URL:** https://roomescapemaker.com
  **Description:** A free online editor that allows to create point-and-click games with puzzles, clues, and locks.

- **Digital lock generator**
  URL: https://eduescaperoom.com/generador-candado-digital
  **Description:** A tool for creating virtual locks.

- **Google Forms**
  URL: https://docs.google.com/forms
  **Description:** Google Forms can be formulated as locks where players must input the correct answers to progress. It can automatically register participants' responses.

## H. Other virtual resources

- **Interacty**
  URL: https://interacty.me
  **Description:** An interactive content creation platform that enables teachers to create various types of activities, such as crosswords, matching games, timelines, hidden object games, spot-the-difference games, and spinning wheels.

- **Zeoob**
  URL: https://zeoob.com
  **Description:** Online simulators for creating fake social media posts with comments.

- **Thinfi**
  URL: https://thinfi.com
  **Description:** A tool that allows shortening and adding password protection to links.

- **Google Earth**
  URL: https://blog.google/products/earth/new-google-earth-creation-tools
  **Description:** Google Earth can be used for creating interactive virtual tours.

- **Spinning wheel**
  URL: http://vishub.org/webapps/178
  **Description:** A digital spinning wheel that provides number-color equivalences.

- **Jigsaw puzzles**
  URL: https://im-a-puzzle.com
  **Description:** An online platform for creating drag-and-drop interactive jigsaw puzzles.

# Annex 2

**Recommendations on how to use generative artificial intelligence tools for creating content for educational escape rooms**

Recent advances in artificial intelligence (AI), especially generative AI, have the potential to ease and enhance the process of creating an educational escape room (Fotaris et al., 2023). Here, we present several aspects in which this technology can be helpful for escape room creation, along with practical examples.

# I. Tools based on large language models (e.g., ChatGPT)

Tools based on large language models (LLMs) such as ChatGPT, Claude, or Copilot can assist creators of educational escape rooms in several aspects.

## Defining learning objectives

Tools based on LLMs can significantly streamline the process of defining appropriate learning objectives. They provide tailored suggestions, assist with phrasing, and facilitate alignment with established educational frameworks like Bloom's Taxonomy. These tools can generate objectives that are clear, specific, measurable, and actionable. Below is an example of a prompt that can be used to generate learning objectives:

| User prompt |
| --- |
| *I am designing an educational escape room for [target audience, e.g., high school students] on the topic of [subject/topic, e.g., renewable energy]. The goal is to teach players specific knowledge and skills in an engaging way. Can you help me define 3–5 clear, measurable learning objectives for this escape room? The objectives should include observable actions (e.g., analyze, solve, evaluate) and align with higher-order thinking skills. Please consider both subject-specific content and soft skills like teamwork.* |

| Tool output |
| --- |
| 1. *Classify different types of renewable energy sources based on their environmental impact.*<br>2. *Analyze energy consumption data to identify areas for improvement in efficiency.*<br>3. *Solve a puzzle that involves calculating the carbon footprint of various transportation methods.*<br>4. *Evaluate the pros and cons of different renewable energy solutions in a group discussion.*<br>5. *Collaborate with teammates to design a sustainable energy plan for a fictional city.* |

## Crafting narratives

Tools based on LLMs can quickly propose creative narratives based on a given topic or theme. They can adjust the tone, complexity, and style to fit the audience, whether it is young students, college learners, or professionals. Tools based on LLMs can embed educational content naturally into the storyline, ensuring that the narrative serves both engagement and learning goals. Below is an example of a prompt that can be used for this purpose:

**Tool output**

*You are part of an elite digital forensics team called in to stop a cyberattack on the city's power grid. A notorious hacker group, 'ShadowByte', has infiltrated the system, threatening to shut down the power supply unless their demands are met. Your mission is to locate their hidden digital headquarters and neutralize the attack by solving challenges at each stage: identifying phishing emails that contain key clues, decrypting encoded passwords to access secure servers, and isolating malware to prevent further system damage. The clock is ticking, and the city's fate is in your hands!*

## Designing puzzles

Tools based on LLMs can play a vital role in the puzzle design process by generating creative ideas, embedding educational content into puzzles, and tailoring difficulty levels to the target audience. These tools can also suggest a variety of puzzle types (e.g., logic puzzles, ciphers, and hands-on activities) while ensuring they align with learning objectives. Additionally, tools based on LLMs can help teachers refine puzzle prompts, create engaging narratives around puzzles, and even test for clarity and solvability. Below is an example of a prompt that can be used for this purpose:

**User prompt**

*Design three puzzles for an educational escape room on renewable energy for middle school students. The puzzles should include solving a riddle, matching items, and a hands-on activity, all tied to understanding renewable vs. non-renewable energy sources.*

**Tool output**

*Riddle Puzzle:*
*"I am bright and powerful but not alive. I rise each day and give energy to thrive. What am I?"*
*(Answer: The Sun)*
*Participants must solve the riddle to unlock the first clue, which explains how solar power works.*

*Matching Puzzle:*
*Participants are given a set of cards with energy sources (e.g., wind, coal, solar, natural gas) and their descriptions. They must match the sources to "Renewable" or "Non-Renewable" categories to progress.*

*Hands-On Activity:*
*Using a small kit with batteries, wires, and a light bulb, participants must build a simple circuit powered by a renewable energy source (e.g., a hand-crank generator). Once the circuit lights the bulb, they receive the final clue to escape.*

# Creating hints

Tools based on LLMs can generate contextual, progressively detailed hints that maintain the challenge while nudging participants toward the solution. They can provide hints tailored to the puzzles and the storyline, suggest hints that escalate from subtle nudges to more explicit guidance, and even dynamically create additional hints based on participant struggles during gameplay. Below is an example of a prompt that can be used for this purpose:

| User prompt |
| --- |
| *Here is a puzzle I created for a biology-themed escape room: Participants must decode a sequence of letters (A, T, G, C) to identify a DNA sequence that spells out the name of a specific protein. The DNA code uses the rule: A pairs with T, G pairs with C. Provide a series of three hints in increasing levels of detail for this puzzle.* |

| Tool output |
| --- |
| *Subtle Hint:*<br>*"Think about the building blocks of DNA and how they pair up. Each letter in the sequence has a natural partner."*<br><br>*Moderate Hint:*<br>*"A pairs with T, and G pairs with C. Try matching each letter in the sequence to its pair to uncover the hidden message."*<br><br>*Explicit Hint:*<br>*"Use the pairing rule: A=T and G=C. Replace each letter in the sequence with its pair. The resulting sequence will spell out the protein name."* |

# Scripting introductory videos

An introductory video can be used to illustrate the narrative of the escape room, provide the necessary context, and immerse participants in the storyline. Using this type of video is a great way to generate excitement and anticipation. Tools based on LLMs can help script these videos by generating engaging and concise content that aligns with the escape room's narrative and learning objectives. Below is an example of a prompt that can be used for this purpose:

| User prompt |
| --- |
| *Write a 90-second script for the introductory video of an escape room on cybersecurity. The storyline involves stopping a group of hackers who are threatening to leak sensitive data. Include a sense of urgency, introduce the participants' mission, and provide instructions for starting the first puzzle.* |

| Tool output |
| --- |
| *The screen flickers, and a shadowy figure appears, their voice distorted.*<br><br>*'Attention, agents! This is a Code Red emergency. A hacker group known as ShadowByte has infiltrated the city's secure data systems. They're threatening to leak sensitive information unless we meet their demands. But we don't negotiate with cybercriminals—we outsmart them.* |

> *Your mission is critical: You must track their movements, uncover their hidden codes, and shut down their operations before time runs out. Each clue you find will bring you closer to stopping them, but beware—ShadowByte has laid traps to throw you off course.*
>
> *Your first task is waiting at the terminal in front of you. Decode the encrypted file to locate their server access point. Time is of the essence—good luck, agents. The city is counting on you!'*
>
> *The screen glitches and goes dark, leaving only the countdown timer visible.*

## Other uses

Beyond the examples illustrated, many other uses of tools based on LLMs are possible. Here are some more examples:

- **Accessibility:** tools based on LLMs can automatically adapt puzzles and content for participants with diverse needs, such as providing simplified language for younger audiences, generating tactile or braille instructions, or offering alternative auditory puzzles for visually impaired players.
- **Multilingual support:** tools based on LLMs can translate the storyline, instructions, and puzzles into multiple languages, enabling diverse groups to participate and enhancing global accessibility.
- **Content localization:** beyond language translation, tools based on LLMs can localize content culturally, adjusting puzzles, storylines, or references to resonate with specific audiences.
- **Help for testing:** tools based on LLMs can simulate a variety of player behaviours to test the functionality of an educational escape room, helping to identify areas of confusion and opportunities for improvement.
- **Speech-to-text integration:** integrating tools based on LLMs with speech-to-text can allow players to interact with an escape room using natural language, enhancing immersion and making the game more accessible for participants with physical or mobility constraints.
- **Real-time hints:** tools based on LLMs can generate context-sensitive hints during gameplay to provide tailored guidance.

# II. Image generation tools (e.g., Midjourney)

Visual elements play a crucial role in setting the atmosphere and immersing participants in an escape room. There are AI-based tools such as Midjourney and DALL·E that have the ability to efficiently generate high-quality thematic images, making them useful for creating the visual elements of an escape room. When using such tools for this purpose, one of the most challenging aspects is maintaining a consistent visual style and coherence across different scenes. Additionally, it is often necessary to modify an existing image. Below, we describe some strategies that can be helpful when creating images for an escape room using AI-based image generation tools.

## Common style
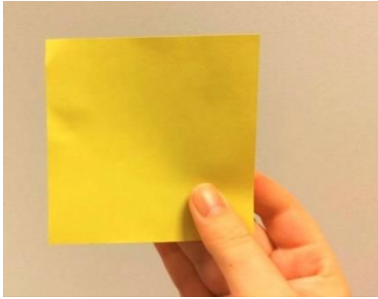
When using tools like Midjourney or DALL·E, specifying a common style in prompts helps achieve consistent results. For example, Pixar's colorful, soft, and slightly exaggerated 3D style usually works well for escape rooms aimed at a wide audience, especially younger players. This style strikes a balance between realism and fantasy, offering vibrant, immersive visuals. Below is an example of how to generate an image with Midjourney using a prompt that specifies Pixar's style:

| User prompt |
| --- |
| `/imagine picnic, leftovers, blue table cloth, pixar style --ar 16:9` |



Tool output

# Using an image as input

Tools like Midjourney allow creators to input one or more images as a base for generating new visuals. This feature is useful for ensuring characters or settings look consistent across scenes and expanding on an existing environment by adding new details. Below is an example of how to use an existing image as input in Midjourney.

| User prompt | Provided image |
|---|---|
| `/imagine`<br>`https://s.mj.run/sample_image`<br>`holding post-it, up close, blurred`<br>`background, pixar style --ar 16:9` |  |

| Tool output |
|---|
|  |

# Vary region

Region editing enables users to modify specific parts of an image while keeping the rest intact. This is especially useful for adding new objects or elements to an existing scene, updating visuals based on feedback, evolving puzzle requirements, and enhancing details such as modifying lighting, colors, or props. Below is an example of what can be achieved from region editing, in this case using DALL·E 2.

| **User prompt:** Create a scene of a room with a table with a book on top, pixar style. | [Select area to be edited] | **User prompt:** No book or anything. |
|---|---|---|
| **Tool output** | | **Tool output** |
|  |  |  |

## Final remarks

AI-powered image generation tools like Midjourney and DALL·E have introduced many new possibilities for creating visual elements for escape rooms. Beyond being used as static images, the visuals generated by these tools can also be used to build interactive scenarios that integrate various elements. For example, by using tools presented in Annex 1, such as Genial.ly or Thinglink, it is possible to transform a set of images into a truly interactive digital environment that can be used for creating escape rooms.

# III. Additional considerations

We have seen in this section that generative AI tools can offer valuable support in the creation of educational escape rooms. However, when using these tools, users should be aware of some ethical, privacy, social and pedagogical issues. Firstly, truthfulness and accuracy are among the main concerns, as AI-generated content may contain errors or misleading information, requiring careful verification by users. Bias is another concern, since AI models are trained on vast datasets that may reflect societal biases, potentially leading to unintended stereotypes in game narratives, characters, or puzzles. Additionally, when using AI-generated content, inclusion and accessibility should be taken into account to ensure that escape rooms are designed for a diverse student population. Data privacy is also crucial when AI tools collect or process data, emphasising the need for compliance with ethical guidelines and data protection laws. Finally, it is important to note that AI should be seen as an assistive tool rather than a replacement for teachers' creativity.

# Annex 3

## Examples of educational escape rooms

# The vaccine of Doctor Darwin

## 1. Context

- **Educational level**: Higher education.
- **Knowledge area**: Software engineering.
- **Topics:** Software requirements specification, software modeling, UML (Unified Modeling Language).
- **Learning objectives (LOs)**:
  O1. Understand and interpret specifications of use cases.
  O2. Understand and interpret UML use case diagrams.
  O3. Understand, interpret and create UML class diagrams.
  O4. Understand and interpret UML sequence diagrams.
  O5. Understand and interpret UML activity diagrams.
  O6. Understand and interpret UML state machine diagrams.
  O7. Develop the following soft skills: communication, teamwork, leadership and problem-solving.

## 2. Main characteristics

- **Format and delivery mode**: Virtual, face-to-face.
- **Participation mode and team size**: Teams of 3 to 5 members.
- **Duration:** 2 hours.
- **Resources required:** A computer with Internet connection and a web browser; headphones.
- **Accessibility:** Web resources compliant with WCAG (Web Content Accessibility Guidelines). Videos and audios have transcripts available. Additional shifts allowing remote participation in case there are barriers preventing some students from attending to the scheduled face-to-face shifts. Closer monitoring for students with curricular adaptations and extra help if necessary.

## 3. Description

The escape room begins with the viewing of a video recording containing a confidential statement from the President of Spain, recorded in his presidential office, in which he warns that an extremely deadly virus threatening the survival of humanity has been discovered. In this video, the president explains that a researcher who was investigating a vaccine for the virus has disappeared, but that the computer crimes unit of the national police managed to retrieve a software application developed by this researcher, which they are convinced that can be used to generate a vaccine for the lethal virus. However, although several software modeling diagrams and documentation created by the researcher himself could be retrieved and examined by the agents, none of them succeeded in using the application for this purpose. For this reason, the president resorts to the participants, as the world's greatest experts in software engineering, in order to discover how to use the software application designed by the researcher to produce the required vaccine and thereby save the nation and the world. Lastly, before saying goodbye and wishing the participants the best of luck on their mission, the president warns them that the vaccine must be generated within two hours, because otherwise the antigens currently available for its production will become tainted. After watching the video, participants are provided with a classified computer forensics report prepared by the computer crimes unit of the national police. This report

contains more details about the disappearance of the researcher who was investigating the virus, information on the software application developed by him including the URL of a web server on which the application was deployed, and a photo of his work desk taken as evidence for the investigation. From this point forward, participants have to access the web application developed by the missing researcher using the URL included in the computer forensics report and begin solving the puzzles of the escape room one by one with the ultimate goal of generating the vaccine for the deadly virus before the time runs out.

The escape room is comprised of a total of 5 puzzles arranged in sequence so that participants need to solve them in order. A countdown timer showing the remaining time to complete the escape room and a leaderboard including all participating teams is displayed throughout the entire experience. Teams are ranked on the leaderboard based on the escape room puzzles they have solved, and in the event of a tie, by the time taken to solve them.

## 4. Puzzles

| No. | Name and Description | LOs |
|---|---|---|
| 1 | **Name**: Log in to the web app.<br>**Description**: Participants need to enter a password to log in to the researcher's web application. They can figure out this password by looking at the photo of the researcher's work desk attached to the computer forensics report. This way, they can notice a photo of a dog hanging on the wall behind this desk, with a name handwritten on it in marker. If the participants enter this name (which is the dog's name) as the password, they will log in to the application, thereby completing the puzzle. | O7 |
| 2 | **Name**: Access the email inbox.<br>**Description**: At this point, participants are seeing the main page of the web application and can start exploring it. This page includes several elements, including buttons to access the researcher's email inbox, a file repository, and the vaccine generator. However, accessing the email inbox requires new credentials, a folder in the file repository is locked, and the vaccine generator button is not enabled. To solve this puzzle, participants need to access the email inbox by performing the following actions:<br>1. Find the email address of the researcher in a draft paper located in the file repository.<br>2. Read the requirements specification stored in the file repository, which includes use cases and their corresponding UML diagrams. This way, participants can figure out that the researcher's email password has four digits and that each of them is related to a specific UML sequence diagram.<br>3. Search for the four UML sequence diagrams in the file repository and interpret them. Participants need to figure out that each of these diagrams represents a journey through different cities around the world.<br>4. Use an interactive map available in the file repository to draw the path of each of the four journeys represented by the UML sequence diagrams, and take note of the number that appears on the map when drawing each path. | O1, O2, O4, O7. |

| | | |
|---|---|---|
| | 5. Deduce the order in which the four obtained numbers must be arranged to form the researcher's email password based on the use cases.<br>6. Enter the email address and the email password of the researcher to access his email inbox. | |
| 3 | **Name**: Access the locked folder.<br>**Description**: To solve this puzzle, participants must access the locked folder in the file repository by performing the following actions:<br>1. Examine the email inbox to find an email in which the missing researcher informs one of his colleagues that he has added additional security to the web application by restricting access to a folder. This email also contains a link to an interactive periodic table and an attached file that contains an UML activity diagram.<br>2. Access the periodic table by using the link found in the email.<br>3. Determine the actions that must be performed in the periodic table to reveal the desired passcode by interpreting the UML activity diagram attached to the email.<br>4. Select a series of chemical elements on the periodic table in a specific order (which can be found out by correctly interpreting the UML activity diagram) and take note of the unveiled passcode.<br>5. Introduce the passcode to access the locked folder. | O5,<br>O7. |
| 4 | **Name**: Access the vaccine generator.<br>**Description**: At this point, participants can access new files, including a set of audio files and a virtual jigsaw. Furthermore, the vaccine generator button is now enabled. To solve this puzzle, participants must access the vaccine generator by performing the following actions:<br>1. Listen to the audio files. Participants can quickly realize that these files are voice notes recorded by the missing researcher as a logbook while he was designing the web application so he would not forget any details of the software design.<br>2. Complete the jigsaw by selecting 6 pieces from a set of 24 and placing each one in its correct position. Each of these pieces is a different fragment of a UML class diagram. To complete the jigsaw, participants must assemble the UML class diagram of the web application, positioning the pieces according to the clues given in the voice recordings.<br>3. Press the vaccine generator button and enter the code revealed by completing the virtual jigsaw in order to access the vaccine generator. | O3,<br>O7. |
| 5 | **Name**: Generate the vaccine.<br>**Description**: At this point, participants are presented with a virtual control panel with dozens of buttons and configuration options. To solve the last puzzle and complete the escape room, they must generate the vaccine for the deadly virus by controlling a DNA synthesiser through this control panel. Participants can succeed in this mission by performing the following actions:<br>1. Read the DNA synthesiser user manual, which includes an UML state machine diagram illustrating how this device can be used to produce a vaccine. Participants can find the link to this manual by reading the instructions provided by the web application along with the control | O6,<br>O7. |

panel. The UML state machine diagram contains six different symbols, each used to represent a different value or element (e.g., DNA and RNA).
2. Find the equivalence of the six symbols included in the UML state machine diagram by examining the web application and the computer forensics report provided at the beginning of the escape room.
3. Figure out the name of the virus by reading a draft paper available in the file repository.
4. Generate the vaccine by controlling the DNA synthesizer and interpreting the UML state machine diagram included in the user manual in order to execute the correct steps. The correct execution of these steps requires participants to know all symbol-value equivalences and the name of the virus.

When a team successfully generates the vaccine, completing the escape room in this way, a final message from the President of Spain congratulating the team members is displayed, and the screen fills with confetti.

## 5. Support

Teams can request hints for a specific puzzle and, in case of puzzles 4 and 5, also for specific tasks within the puzzle. To receive a hint after making a request, teams must answer correctly at least four out of five multiple-choice questions about the topics addressed by the escape room. These questions are randomly chosen from a question bank on each attempt. A team can make multiple attempts to obtain a hint, but once it obtains one, it must wait five minutes before requesting another. Multiple hints are available for each puzzle: puzzles 1–3 each have 3 hints; puzzle 4 has 7 hints, 1 for general help and 1 for each specific piece of the jigsaw solution; and puzzle 5 has 11 hints, 1 for each symbol and 5 for the vaccine generation. When multiple hints are available for a specific puzzle or task, they are delivered to teams in a specific order, from least to most useful. In these cases, the first hint indicates which clues and resources are needed to solve the puzzle/task and offers advice on finding them, the intermediate hints provide increasingly helpful information on how to determine the solution of the puzzle/task, and the last hint reveals the solution. In addition to allowing teams to request hints, free hints will also be provided to lagging teams.

In all scheduled shifts, the escape room will be supervised by at least one teacher to assist participants with any incidents or questions. In face-to-face shifts, supervisors will be in the same classroom as the students, while in remote shifts, supervisors will communicate with students via the Zoom video conferencing tool.

## 6. Participant assessment

The escape room will be offered to students as an optional graded activity, and the score they achieve will be added to their final course grade. Students will be awarded 0.2 points simply for participating in the escape room, as long as they play until time runs out or complete all the puzzles before that.

# Cyanide poisoning in the Baltic Sea

## 1. Context

- **Educational level**: Higher education.
- **Knowledge area**: Biomedicine.
- **Topics:** Cyanide poisoning, academic inquiry.
- **Learning objectives (LOs)**:
  O1. Formulate and test hypotheses.
  O2. Become aware of the sources of cyanide poisoning and genetic susceptibility.
  O3. Understand stop codons.
  O4. Communicate with healthcare professionals.
  O5. Interpret lab results.
  O6. Develop the following soft skills: creative thinking and teamwork.

## 2. Main characteristics

- **Format and delivery mode**: Virtual, face-to-face.
- **Participation mode and team size**: Teams of 3 members.
- **Duration:** 45 minutes.
- **Resources required:** A computer with Internet connection and a web browser.
- **Accessibility:** The escape room is designed in such a way that it can be completed remotely by biomedicine students, making it possible to offer additional shifts that allow remote participation if necessary.

## 3. Description

The escape room is aimed at raising awareness about the many sources of cyanide poisoning and at outlining the process of academic inquiry. In the story, a group of interns in a biomedical lab are camping to gather samples in the Baltic Sea to test for cyanide. One member of the group gets cyanide poisoning, and their friends need to find out what caused the poisoning.

## 4. Puzzles

| No. | Name and Description | LOs |
|---|---|---|
| 1 | **Name**: DNA test results.<br>**Description**: One of the group members discovers the patient's handbag, which contains a commercial genetic test report. The students are presented with the test results, which show a series of genes. Their task is to identify any altered genes, and determine if there is a genetic predisposition or condition that could explain the patient's cyanide poisoning. | O2, O6. |
| 2 | **Name**: Sauna.<br>**Description**: The scene contains a traditional sauna room, complete with wooden benches, a stove, and a water container containing water collected from the Baltic Sea. Students must carefully examine the contents of the sauna and identify the water as a potential source of cyanide poisoning. | O2, O6. |

| No. | Name and Description | LOs |
|-----|---------------------|-----|
| 3 | **Name**: Food.<br>**Description**: The scene presents a variety of food items, including bread, fruits, nuts, and snacks, laid out on a table. Among these items there are plums seeds. Students must carefully examine the food and identify plum seeds as a potential source of cyanide. This puzzle highlights the importance of understanding how certain foods, even those commonly consumed, can pose health risks. | O2, O6. |
| 4 | **Name**: Insecticide.<br>**Description**: The scene is set on the beach, where a collection of items, including insecticide and sunblocks, are placed close to the tent. Students must examine the items and identify the insecticide as a potential source of cyanide exposure. Some insecticides contain cyanide-based compounds, which can be hazardous. This puzzle emphasizes the importance of recognizing common household products that may contain toxic substances. | O2, O6. |
| 5 | **Name**: Articles.<br>**Description**: The scene presents a collection of six scientific articles. Students must carefully read and analyze the articles to determine which ones are relevant to the patient's condition and the investigation into cyanide poisoning. This challenges students to critically evaluate scientific literature, identify relevant information, and apply it to the scenario. It shows the importance of evidence-based decision-making in scientific investigations. | O1, O2, O6. |
| 6 | **Name**: Stop Codon.<br>**Description**: The scene shows a computer screen with a login prompt requiring a password. Nearby, students can find a DNA sequence riddle that includes a stop codon (e.g., UAA, UAG, or UGA) and whose resolution reveals the computer password. This puzzle combines molecular biology concepts with problem-solving skills. | O3, O6. |
| 7 | **Name**: Water Sample.<br>**Description**: The scene presents a computer screen displaying water sample test results collected from the Baltic Sea. Students must determine if the cyanide levels in the water are within safe limits according to health safety standards. This puzzle emphasizes the importance of environmental monitoring and understanding safety thresholds for toxic substances like cyanide. | O1, O5, O6. |
| 8 | **Name**: Doctor.<br>**Description**: The scene shows the patient's follow-up medical records. To solve this puzzle, students must examine the records to find the initials of the patient's doctor and, once identified, use them to locate the doctor's room based on the nameplates. This puzzle encourages attention to detail and reinforces the importance of thorough documentation in the medical field. | O4, O6. |

| No. | Name and Description | LOs |
|-----|----------------------|-----|
| 9 | **Name**: Conversation.<br>**Description**: The scene shows a conversation with the doctor, presented as a series of multiple-choice questions. Students must engage with the doctor by answering questions about the patient's symptoms, potential sources of cyanide exposure, and the diagnostic process. Correctly answering the questions will lead to the proper diagnosis of the patient's condition. This puzzle tests students' understanding of cyanide poisoning, including its sources and effects, while also simulating a real-world interaction with a medical professional. | O4, O6. |

## 5. Support

- Participants are allowed to request hints (max. 1 hint every 5 minutes).
- Several pre-made hints for each puzzle. Increasingly helpful hints if requested repeatedly.
- The escape room will be supervised by at least one teacher to assist participants with any incidents or questions.

## 6. Participant assessment

The escape room will be offered to students as a non-graded activity.

# Deactivating the bomb

## 1. Context

- **Educational level**: Higher education.
- **Knowledge area**: Computer science, software engineering.
- **Topics:** Programming, debugging, GitHub, front-end development, web technologies (HTML, CSS, and JavaScript), React, Redux, and REST APIs.
- **Learning objectives (LOs)**:
  O1. Use GitHub for downloading a code repository.
  O2. Understand HTML, CSS, and JavaScript basics.
  O3. Understand the package.json file of a React application and start the application.
  O4. Debug a React application using the web browser console.
  O5. Invoke JavaScript functions.
  O6. Render lists in React using the map function.
  O7. Know the React lifecycle methods.
  O8. Understand the Flexbox layout mode.
  O9. Know the Redux architecture.
  O10. Perform an asynchronous request to a REST API.
  O11. Enhance communication, teamwork and problem-solving skills through pair programming.

## 2. Main characteristics

- **Format and delivery mode**: Hybrid, face-to-face.
- **Participation mode and team size**: Teams of 2 (pair programming).
- **Duration:** 2 hours.
- **Resources required:**
  - A computer with:
    - Windows or Ubuntu.
    - Internet connection and a web browser.
    - Git client.
    - Node.js and npm or yarn.
    - Text editor supporting HTML, CSS, JavaScript, and React (e.g., Visual Studio Code or Sublime Text).
  - Scissors.
- **Accessibility:** The escape room is designed to accommodate large groups in a single session. The introductory video has transcripts available. Closer monitoring for students with curricular adaptations and extra help if necessary.

## 3. Description

Students must work in pairs to solve puzzles involving programming challenges to deactivate a bomb and save their kidnapped professor. The activity integrates both physical and virtual puzzles, providing an engaging way to reinforce programming concepts. The story presents a video of the students' teacher who has been kidnapped by the evil teachers from the electronics department who have assembled a bomb that is going to blow up the school in 2 hours. Students need to make use of their programming skills to deactivate the bomb remotely by fixing and using a React application.

## 4. Puzzles

| No. | Name and Description | LOs |
|-----|----------------------|-----|
| 1 | **Name**: Downloading the bomb-deactivating application.<br>**Description**: The students are given the unfinished version of a web application to deactivate bombs through a link to a GitHub repository. They need to correctly download the codebase of this application to their computer. | O1, O11. |
| 2 | **Name**: Starting the bomb-deactivating application.<br>**Description**: The students need to correctly start the bomb-deactivating application by installing the dependencies and running the right command in the terminal. | O3, O11. |
| 3 | **Name**: Loading the first screen.<br>**Description**: Upon running the application, the students are faced with several errors that they need to fix to be able to load the web interface. | O4, O11. |
| 4 | **Name**: Advancing to the second screen.<br>**Description**: The students are presented with a Morse code in audio form that tells them the name of the JavaScript function to execute in the browser console in order to advance to the next screen. | O5, O11. |
| 5 | **Name**: Showing the bomb parts.<br>**Description**: The students need to modify the code of the application by using React's map function to display the bomb components. | O6, O11. |
| 6 | **Name**: Deactivating the bomb.<br>**Description**: The students need to determine the right order in which they need to toggle off the components of the bomb. This order is obtained from identifying the correspondence between these components and the React lifecycle phases in a picture of the professor's office. | O7, O11. |
| 7 | **Name**: Triggering the bomb's cooling mechanism.<br>**Description**: To solve this puzzle, the participating students must trigger the bomb's cooling mechanism by performing the following actions:<br>1. Complete a physical color grid challenge using knowledge of Flexbox layout mode and symbol substitution, obtaining a layout of colors as a result.<br>2. Assemble a physical jigsaw that requires to understand and identify four key Redux architecture components, use the jigsaw to match these four components to colors obtained in the prior step, and put the colors in a specific sequence according to this matching.<br>3. Analyze a printed JavaScript code snippet. The output of this code reveals how to position a color roulette in order to find the correct match between colors and numbers. Thereby, from the color sequence previously obtained, students can obtain a four-digit code.<br>4. Perform an API request using the code obtained in the prior step as port number in order to trigger the bomb's cooling mechanism. | O2, O8, O9, O10, O11. |

## 5. Support

- Participants are allowed to request hints (max. 1 hint every 5 minutes).
- Several pre-made hints for each puzzle. Increasingly helpful hints if requested repeatedly.
- Participants need to pass a short quiz (4 out of 5 correct answers) for obtaining a hint.
- The escape room will be supervised by at least one teacher to assist participants with any incidents or questions.

## 6. Participant assessment

The escape room will be offered to students as an optional graded activity. Participation earns a baseline score and successful completion of puzzles provides additional points. The score obtained in the escape room is added on top of the final course grade.

# Laura and the unexpected substitution: a high school mystery

## 1. Context

- **Educational level**: Higher education.
- **Knowledge area**: Educational psychology, psychobiology.
- **Topics:** Developmental psychology during adolescence and main theoretical models of the teaching and learning process applied to educational stages that include adolescence (secondary education, baccalaureate, and vocational training).
- **Learning objectives (LOs):**
  O1. To understand how students learn, think, feel, and interact.
  O2. To anticipate students' needs.
  O3. To properly plan an effective educational response.
  O4. To implement appropriate and motivating didactic strategies.
  O5. To optimize communication with families.
  O6. To help identify students with specific educational support needs and plan their educational response with other involved professionals.

## 2. Main characteristics

- **Format and delivery mode**: Virtual, remote.
- **Participation mode and team size**: Teams of up to 4 students, with individual participation mode if necessary.
- **Duration:** 1 hour.
- **Resources required**: A computer with Internet connection and a web browser.
- **Accessibility:** The escape room is equipped with visual elements (interactive images and videos) and sound elements (audio and interactive acoustic elements), with a simple interface that ensures proper usability for most students with functional diversity.

## 3. Description

Laura, a new teacher, steps into a high school to fill in for a colleague on long-term medical leave. After her first day, the principal is impressed by her dedication and efficacy, prompting him to confine her to the school over an extended holiday weekend. His goal is for Laura to pinpoint the key educational issues hindering the school from ranking among the top in the city. The principal plans to stay in touch to support her work during this time and will release her once the task is complete. While locked in, Laura reaches out to her former university classmates for assistance, seeking their guidance in uncovering various educational challenges and proposing solutions to enhance the quality of education for the students. The escape room aims to (1) put into practice the knowledge and skills developed in a Master's course on learning and personality development, (2) to review all the content of this course in a playful manner in the weeks leading up to the exam, and (3) to reduce pre-exam anxiety levels.

## 4. Puzzles

| No. | Name and Description | LOs |
|---|---|---|
| 1 | **Name**: Finding the phone.<br>**Description**: Laura must locate her phone and decide on the most suitable educational viewpoint to address the school's challenges. | O1, O3. |
| 2 | **Name**: The Principal's email.<br>**Description**: Using clues from a mother's email found in the principal's office, Laura identifies key problems in student's poor academic performance. | O2, O4, O5. |
| 3 | **Name**: Unlocking student motivation.<br>**Description**: Laura recalls a conversation with a student about teacher practices. Participants must analyze sociometric and motivational traits using interactive locks to identify the next major problem. | O1, O2, O4. |
| 4 | **Name**: The classroom puzzle.<br>**Description**: Students help Laura solve an anagram to access the cabinet containing a teacher's exam notes. These clues reveal the type of learning being assessed and its implications. | O1, O2, O3, O4. |
| 5 | **Name**: The Counselor's filing cabinet.<br>**Description**: Laura discovers a jigsaw puzzle in the guidance counselor's room. Completing it provides information on a gifted student and prompts the final quiz on inclusive education and support strategies. | O1, O2, O6. |

## 5. Support

Pre-made hints are available for each puzzle upon request.

## 6. Participant assessment

The escape room will be offered to students as a mandatory graded activity. The first three students or teams of students with the best times will receive the following extra points in the continuous assessment of the course, with a maximum weighted score of 4: +0.5, +0.25, and +0.1.

# Barbara and the quest for the potion

## 1. Context

- **Educational level**: Secondary education, higher education.
- **Knowledge area**: Spanish language.
- **Topics:** Spanish spelling, vocabulary and grammar.
- **Learning objectives (LOs)**:
  O1. To develop advanced Spanish language skills.
  O2. To differentiate between commonly confused Spanish words (e.g., *porqué* vs. *porque*, *dónde* vs. *donde*).
  O3. To apply proper capitalisation rules in Spanish.
  O4. To enhance listening comprehension through contextualised audio tasks.
  O5. To identify linguistic errors in written and audiovisual content.
  O6. To develop critical thinking and problem-solving skills.
  O7. To apply theoretical concepts to practical challenges.
  O8. To engage independently with the activity, showcasing initiative and personal accountability for progress and success.

## 2. Main characteristics

- **Format and delivery mode**: Virtual, remote.
- **Participation mode and team size**: Individual.
- **Duration:** 1 hour.
- **Resources required**: A computer with Internet connection and a web browser.
- **Accessibility:** The escape room can be adapted to different needs. Puzzles can be simplified by providing multiple-choice options instead of open-ended answers, and participants can receive a glossary of challenging words and phrases. Concerning adaptations for accessibility, participants with visual impairments can be provided with text-to-speech options for written puzzles and audio-only versions of certain puzzles. Furthermore, compatibility with screen readers can be ensured for these participants. Participants with hearing impairments can be provided with subtitles for all audio and video content. As for learning disabilities, clear, large fonts and high-contrast text can be used. Lastly, additional hints can be offered to support participants who are struggling.

## 3. Description

Barbara has not had much luck in love. Whenever she meets someone new, she discovers that he struggles with spelling and frequently makes errors in his text messages. For her, this is a crucial quality in a man. Consequently, she believes she must find out what is wrong with her and seeks the assistance of a witch. The witch reveals that she is under a curse, and to lift it, she must gather four ingredients for a potion she needs to drink. These ingredients are challenging to locate, requiring her to travel the globe. The four countries she must visit to collect the potion's ingredients are Mexico, Canada, Italy, and China. Throughout her journey, she will encounter nine distinct puzzles. The witch will assist her during this quest. Will Barbara break the curse? Can she find a love that is free of spelling errors?

## 4. Puzzles

| No. | Name and Description | LOs |
|-----|----------------------|-----|
| 1 | **Name**: Barbara's passport and first destination. <br> **Description**: Barbara must locate her passport in her room and find where she will first travel. | O6, O8. |
| 2 | **Name**: Plane tickets and suitcase. <br> **Description**: Barbara must use her computer to buy the plane tickets that will take her to her first destination. Also, she will need to pack her suitcase with necessary objects. | O6, O8. |
| 3 | **Name**: On the plane. <br> **Description**: Barbara must complete the first spelling puzzle that deals with the use of commas in the Spanish language. | O1, O5, O8. |
| 4 | **Name**: In Mexico. <br> **Description**: Barbara will look for the first ingredient of the potion. For that, she must complete some sentences with the correct words (*porqué, porque, conque, agravar, sobre todo, calla, aparte, a ver*, etc.). | O1, O2, O5, O8. |
| 5 | **Name**: In Canada. <br> **Description**: Barbara will look for the second ingredient of the potion. For that, she must listen to an audio and complete some sentences with the correct words. | O1, O2, O6. |
| 6 | **Name**: In Italy. <br> **Description**: Barbara will look for the third ingredient of the potion. For that, she will have to know whether some words in Spanish must be written with capital letters (*La Rioja, Unión Europea, Premio Princesa de Asturias, Código Civil, suajili, decatlón, magistrado, paleozoico*, etc.). | O1, O3, O5, O7, O8. |
| 7 | **Name**: In China. <br> **Description**: Barbara will look for the fourth ingredient of the potion. For that, she will have to complete some sentences with the correct forms of the words (*dónde, adonde, donde, cuanto, cuánto*, etc.). | O1, O2, O5, O7, O8. |
| 8 | **Name**: Back home I. <br> **Description**: Barbara will have to drink the potion and find out if the curse has been broken. | O6, O8. |
| 9 | **Name**: Back home II. <br> **Description**: Barbara will watch a video and must identify the number of spelling mistakes mentioned in a TV program. | O1, O4, O5, O7, O8. |

## 5.  Support

Pre-made hints are available for each puzzle upon request.

## 6. Participant assessment

The escape room will be offered to students as an optional graded activity. Participation earns a baseline score and successful completion of puzzles provides additional points. The score obtained in the escape room is added on top of the final course grade.

# The PixelCore crisis: Rescuing the arcade

## 1. Context

- **Educational level**: Higher education (beginners in game development).
- **Knowledge area**: Computer science, game development.
- **Topics:** Unity basics, 2D game mechanics, visual scripting.
- **Learning objectives (LOs)**:
  O1. Navigate and operate Unity's interface and tools to manage 2D game development workflows.
  O2. Import, configure, and manipulate 2D sprites to construct interactive game environments.
  O3. Implement player movement using Unity's Visual Scripting system.
  O4. Set up and configure collisions and triggers to enable object interactions in a 2D game.
  O5. Design and implement a basic scoring system using Visual Scripting logic.
  O6. Debug and optimize Visual Scripting graphs to ensure proper game functionality.
  O7. Integrate learned elements to create a functional 2D game prototype within Unity.

## 2. Main characteristics

- **Format and delivery mode**: Virtual, remote.
- **Participation mode and team size**: Teams of 2-3 members.
- **Duration:** 2 hours.
- **Resources required:**
  - A computer with Unity installed.
  - Unity Visual Scripting tools.
- **Accessibility:** Extra help for students with special needs if necessary.

## 3. Description

Participants are transported to the PixelCore arcade, a once-thriving hub for gamers and game developers alike. The arcade's mainframe, which powers its virtual game worlds, has malfunctioned due to a mysterious glitch caused by an unknown virus. The glitch has corrupted the core systems, leading to chaos within the arcade's digital landscapes: sprites are misaligned, player controls are unresponsive, collision systems are erratic, and scoring mechanisms are broken. Without immediate intervention, the entire arcade could be permanently lost, taking with it the valuable gaming history it holds.

As aspiring game developers, participants are tasked with becoming the arcade's saviours. They must navigate through various digital environments within PixelCore, each presenting unique challenges designed to teach essential skills for creating and fixing game mechanics in Unity. By completing these challenges, participants will not only restore order to the arcade but also gain the knowledge and confidence needed to create their own games in Unity using Visual Scripting.

The journey begins with understanding the Unity interface, locating essential tools, and configuring assets to set up a stable environment. Next, participants dive deeper, learning to manage 2D sprites, develop player mechanics, and resolve the arcade's chaotic collision systems. Afterwards, they implement a basic scoring system and, finally, troubleshoot a pre-written Visual Scripting graph to identify and fix the virus-triggered bugs.

Their ultimate goal is to reboot the arcade's core systems and showcase their newly developed functional 2D game prototype. This journey not only saves the arcade but also sets participants on the path to becoming skilled Unity developers.

## 4. Puzzles

| No. | Name and Description | LOs |
|-----|----------------------|-----|
| 1 | **Name**: Interface overload.<br>**Description**: The arcade's main control panel is malfunctioning and players must navigate Unity's interface to find the essential tools required to diagnose and repair the system. They will explore Unity's hierarchy, scene view, and inspector panel to understand how game objects are structured and manipulated. | O1 |
| 2 | **Name**: Sprite savior.<br>**Description**: The visual elements of the arcade's game have been corrupted. Players must import, configure, and position 2D sprites correctly within the game scene to restore the environment. | O2 |
| 3 | **Name**: Visual scripting hero.<br>**Description**: The game's character is unresponsive. Players must use Unity's Visual Scripting system to create and apply a movement script that allows the character to navigate the environment. | O3 |
| 4 | **Name**: Collision confusion.<br>**Description**: Objects in the arcade world are either passing through each other or not reacting at all. Players must configure collision and trigger components to restore proper in-game interactions. | O4 |
| 5 | **Name**: Score keeper.<br>**Description**: The arcade's scoring system has been disabled. Players must implement a basic scoring mechanism using Visual Scripting, ensuring points are awarded for specific actions. | O5 |
| 6 | **Name**: Final debug.<br>**Description**: The arcade's game is almost fully functional, but errors in the Visual Scripting graphs are causing unexpected behaviour. Players must debug and optimise the script to stabilise the system. | O6 |
| 7 | **Name**: The PixelCore reset.<br>**Description**: The arcade is now operational, but the final step requires integrating all repaired components to complete the restoration. Players must combine all their work into a functioning game prototype. | O7 |

## 5. Support

Virtual assistant to guide participants when they request help.

# 6. Participant assessment

The escape room will be offered to students as an optional graded activity. Grading will be based on the following factors:

- Successful completion of each puzzle.
- Quality and functionality of the final game prototype.
- Team collaboration and problem-solving approach.
- Self-assessment and reflection on learning outcomes.

# NeoSim: Restoring the virtual world

## 1. Context

- **Educational level**: Higher education (beginners in game development).
- **Knowledge area**: Computer science, game development.
- **Topics:** Unity 3D environment, C# scripting, game physics.
- **Learning objectives (LOs)**:
  O1. Navigate and manipulate Unity's 3D environment to create and manage game objects.
  O2. Design and populate a 3D scene with assets, adjusting transformations and organisation.
  O3. Write and debug C# scripts to implement character movement and object interactions.
  O4. Apply Unity's physics system to control object behaviour and simulate realistic mechanics.
  O5. Configure and adjust lighting and shadows to enhance the visual quality of a 3D scene.
  O6. Identify and resolve syntax and logic errors in pre-existing C# scripts.
  O7. Integrate all developed components to construct a functional 3D game prototype.

## 2. Main characteristics

- **Format and delivery mode**: Virtual, remote.
- **Participation mode and team size**: Teams of 2-3 members.
- **Duration:** 2.5 hours.
- **Resources required:** A computer with Unity and Visual Studio installed.
- **Accessibility:** Extra help for students with special needs if necessary.

## 3. Description

Participants are drawn into NeoSim, a groundbreaking virtual reality simulation designed by a legendary game developer. This advanced simulation was meant to be a masterpiece, showcasing the limitless potential of Unity's 3D environment and C# scripting. However, a critical system malfunction has caused NeoSim to destabilise, trapping its creator inside. The virtual world is now crumbling, with environments breaking apart, characters frozen mid-motion, and physics behaving unpredictably. Without immediate intervention, both the creator and NeoSim could be lost forever.

As budding game developers, the participants are called upon to save the day. To succeed, they must enter NeoSim and repair its corrupted systems by tackling a series of 3D game development challenges. They begin by learning how to construct and populate a virtual 3D world, setting the stage for their rescue mission. From there, they venture deeper into the simulation, coding scripts to enable character movement and restoring realistic physics to the environment. As the journey progresses, they must also bring light back to the fractured world by configuring Unity's lighting and shadow systems, bringing NeoSim to life once more.

The challenges become increasingly complex as participants encounter glitches that require debugging pre-written C# scripts, testing their ability to problem-solve and optimise game code. In a climactic final test, they must integrate all their newly acquired skills to stabilise NeoSim and complete a fully functional 3D level, unlocking the portal that frees the trapped creator.

The experience is not just a rescue mission, it's a transformative journey into the art and science of 3D game development. By the end of their adventure, participants will have mastered foundational skills in Unity, C# scripting, and game design, equipping them to create their own 3D worlds while ensuring that NeoSim lives to inspire future generations of developers.

## 4. Puzzles

| No. | Name and Description | LOs |
|-----|---------------------|-----|
| 1 | **Name**: World builder.<br>**Description**: The simulation's core environment has been corrupted, leaving a blank space. Players must use Unity's 3D environment tools to create and structure the scene, placing essential assets and adjusting their positions. | O1, O2. |
| 2 | **Name**: Scripting savior.<br>**Description**: The avatar inside the simulation is unresponsive. Players must write and apply a C# script that enables movement and interaction, restoring the avatar's control. | O3 |
| 3 | **Name**: Physics fix.<br>**Description**: Objects inside the virtual world are floating or behaving unrealistically. Players must configure Unity's physics properties, such as gravity and Rigidbody settings, to restore realistic object behaviour. | O4 |
| 4 | **Name**: Lighting lab.<br>**Description**: The simulation is stuck in complete darkness. Players must adjust lighting, shadows, and reflections to properly illuminate the world and improve visual clarity. | O5 |
| 5 | **Name**: Debugging dungeon.<br>**Description**: A critical system error has caused logic issues in the simulation. Players must inspect pre-existing C# scripts, identify bugs, and implement necessary fixes. | O6 |
| 6 | **Name**: Reboot NeoSim.<br>**Description**: With all systems restored, the final step requires integrating all components into a cohesive, functional 3D simulation. Players must ensure that all mechanics work together before executing the final system reboot. | O7 |

## 5. Support

Access to documentation and tutorials for independent problem-solving.

## 6. Participant assessment

The escape room will be offered to students as an optional graded activity. Grading will be based on the following factors:
- Completion of puzzles within the time limit.
- Functionality and polish of the final 3D scene.
- Demonstrated understanding of Unity and C# scripting.
- Peer and self-evaluation of teamwork and learning progress.

# The escape of Victor Lustig

## 1. Context

- **Educational level**: Tertiary education.
- **Knowledge area**: E-safety, digital literacy.
- **Topics:** Password security and authentication, phishing and online scams, mobile device security, cyber hygiene, and misinformation.
- **Learning objectives (LOs):**
  O1. Identify secure authentication methods and the importance of strong passwords.
  O2. Recognize phishing attempts and online fraud techniques.
  O3. Recognize security risks in mobile applications.
  O4. Assess online information critically.
  O5. Identify cybersecurity best practices in real-world digital scenarios.
  O6. Develop basic digital skills.

## 2. Main characteristics

- **Format and delivery mode**: Virtual, remote (and asynchronous).
- **Participation mode and team size**: Individual.
- **Duration:** 1 hour.
- **Resources required:** A computer with Internet connection and a web browser.
- **Accessibility:** Remote and asynchronous participation. Virtual resources compliant with WCAG (Web Content Accessibility Guidelines). Subtitles available for video and audio files.

## 3. Description

In this educational escape room, participants assume the role of an elite detective assigned to capture Victor Lustig, a notorious con artist known for orchestrating elaborate scams. His latest scheme involves the sale of fraudulent bracelets that falsely claim to cure COVID-19. The scam has gained widespread traction due to the proliferation of health-related misinformation on social media and instant messaging platforms, and it has affected thousands of individuals.

The National Police and the National Intelligence Center have been monitoring Victor Lustig and have discovered that he intends to flee the country on the same day the investigation begins. Given the urgency of the situation, the authorities have assigned the case to their most skilled detective: the participant. The investigation leads the participant to an apartment where Victor Lustig had been residing. Upon arrival, the space appears to be deserted, but various clues indicate that he left in a hurry. To track his next move, the participant must thoroughly examine the apartment, uncover hidden evidence, figure out security codes, and determine Victor Lustig's intended destination. Will the participant be able to discover this destination in time to prevent the escape of Victor Lustig?

Throughout the escape room, which is composed of 7 puzzles arranged in sequence, the participant will engage with digital literacy concepts, including responsible use of technology, and the identification of fake news, online scams, and cybersecurity threats.

# 4. Puzzles

| No. | Name and Description | LOs |
|---|---|---|
| 1 | **Name**: Enter the office.<br>**Description**: The participant must enter a code to open a door and access a room, which turns out to be an office. The code is the date of birth of Victor Lustig, which is marked on a calendar hanging on the wall. | O1, O5, O6. |
| 2 | **Name**: Access the computer.<br>**Description**: The participant must break into a computer to continue the investigation. One of the notes on the office's desk contains the password required to access the computer, while the rest of the notes provide information about fake news and cybersecurity. | O1, O4, O5, O6. |
| 3 | **Name**: Access the email inbox.<br>**Description**: The participant must access the email inbox of Victor Lustig. The password of this inbox is the same as the computer's password, as he uses the same password for most of his devices and services. The email address can be found in a file on the computer. With this information, the participant can gain access to the email inbox of Victor Lustig. | O1, O5, O6. |
| 4 | **Name**: Open the smartphone backup.<br>**Description**: One of the emails the participant can read after accessing the email inbox of Victor Lustig contains a backup of his smartphone protected by a password. To solve this puzzle, the participant must guess this password by identifying phishing emails from different banks. | O2, O4, O5, O6. |
| 5 | **Name**: Unlock the smartphone.<br>**Description**: In his haste, Victor Lustig forgot his smartphone in the apartment. To solve this puzzle, the participant must unlock this smartphone using the correct pattern. The participant can figure out this pattern by listening to audio files contained in the smartphone backup previously found. | O1, O5, O6. |
| 6 | **Name**: Uninstall the dangerous application.<br>**Description**: The participant must identify and uninstall a dangerous application from the smartphone to make it work, as it is almost unresponsive. To successfully carry out this task, the participant must review the permissions granted to the installed applications. | O3, O5, O6. |
| 7 | **Name**: Guess the destination town.<br>**Description**: The participant must guess the town where Victor Lustig intends to escape. This location can be determined by examining a plane ticket found in the "Downloads" folder of the smartphone and performing a search using a web search engine such as Google or Bing. | O5, O6. |

## 5. Support

This escape room is designed to be conducted remotely and asynchronously without supervision. However, it offers automated hints. The participant may request hints at any time, with the limitation of receiving no more than one hint every 5 minutes. Each puzzle has multiple hints available, which are given in increasing order of helpfulness. The last hint of each puzzle provides the solution to the participant.

Moreover, the escape room features an AI-powered agent designed to support participants throughout the experience. This agent can provide contextual help, answer questions about the puzzles, and offer guidance based on the participant's progress.

## 6. Participant assessment

The escape room will be offered to the participants of a MOOC (Massive Open Online Course) as a mandatory graded activity, whose score will have a weight of 10% in the final grade of the MOOC. Participants will earn 0.8 points for completing all the puzzles of the escape room, regardless of the time spent. Additionally, those who complete the activity within 1 hour (i.e., before the time runs out) will earn 0.2 additional points.

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