III.
The design of Digital Educational Escape Rooms in Higher Education

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1. Introduction

Digital Educational Escape Rooms (DEERs) have proliferated at universities in recent years. These encompass both DEERs set up by the universities themselves for institutional, educational or guidance purposes, as well as those created by faculty members or students themselves for didactic purposes.

In the broadest sense of the term, escape rooms can be defined as live-action and team-based games in which players face a series of challenges aimed at completing a mission or solving a mystery within a limited time (Nicholson, 2015). As soon as the mission is completed, achieving a combination of hands-on and minds-on activities (Fotaris & Mastoras, 2019), players may leave the room in which they were closed.

The engaging nature of escape rooms, coupled with the cognitive skills demanded as players uncover clues and solve puzzles, has inspired many faculty members to adapt the entertainment-based escape room model for an educational use in their disciplinary domain. Recognizing this approach as a fresh method to engage students, they've identified it as a novel means to enhance and stimulate the learning processes.

Hence, Digital Educational Escape Rooms (DEERs) represent the digital adaptation of traditional escape rooms initially crafted for entertainment or replicated within school and universities for educational use. DEERs, like that presented in this volume (see subsequent chapters), can be designed to orient students willing to explore university spaces and services through a virtual tour before visiting it physically. However, this transformation is not merely a replication of a physical escape room; instead, it necessitates adopting a different perspective, due to the digital dimension, along the design of gaming elements like structure, narrative development, and puzzle construction. These elements, as emphasized by Veldkamp et

al. (2020), must significantly align with the learning or guidance goals. Furthermore, this harmonization requires intertwining game mechanics with pedagogical methodologies, demanding a design approach that is not only informed by pedagogy but also infused with fundamental game design principles.

The aim of this contribution is to describe an approach for designing DEERs according to a pedagogical perspective.

2. Scholarship on DEERs effectiveness

Emerging research into DEERs delves into the attributes, uses, and impacts of these immersive learning settings. These encompass physical and digital formats, trialed across diverse subject areas and within formal as well as informal learning settings. When exploring its influence on skill development, literature substantiates the efficacy of this approach in bolstering collaborative teamwork, fostering task persistence, and encouraging learners to approach problems from diverse viewpoints (Fotaris & Mastoras, 2019). Engaging with DEERs encourages learners to take an active role, fostering the cultivation of 21st-century skills like critical thinking (Adams et al., 2018), problem-solving (Veldkamp et al., 2021), and creativity (Foster and Warwick, 2018). This interactive participation, frequently involving group play, enables learners to collaboratively build knowledge as they navigate through a sequence of tasks. These tasks serve as scaffolds for learning, offering students a dynamic and thrilling experience (Makri et al., 2021). Several studies offer empirical evidence highlighting the positive effects of DEERs on students' motivation and their immersive gaming experiences (Fotaris & Mastoras, 2019; Vidergor, 2021).

However, limited evidence has been presented regarding the efficacy of DEERs in enhancing domain-specific skills and achieving mastery of knowledge. Only a handful of studies have investigated learning outcomes by comparing pre- and post-intervention knowledge acquisition (Makri et al., 2019; Berthod et al., 2020; Caldas et al., 2019). Lathwesen & Belova (2021) identified in these investigations the necessity for conducting multiple post-tests at various intervals and the imperative requirement for additional research delineating the specific components within escape rooms that impact student academic performance. Likewise, Taraldsen et al. (2022) advocate for extended inquiry into the utilization of DEERs and their outcomes, emphasizing the necessity for employing more complex re-

search methodologies. This underscores the imperative to define and validate a set of design principles through empirical evidence. Additionally, Veldkamp et al. (2020) assert, based on their literature review, a paucity of research exists regarding the pedagogical underpinnings of DEERs. Given this context, the current study aims to address the highlighted gap in existing research, concentrating on design principles derived from the integration of game theory and pedagogical perspectives. It introduces a cohesive design approach essential for faculty to effectively merge game-based and pedagogical principles. The study outlines key design criteria necessary for DEER development, establishing connections between gaming elements and educational components.

Prior to delving into these design criteria aimed at crafting effective DEERs, an overview of the primary learning design models utilized in DEERs development is needed. This aims to emphasize the necessity of formulating new design models that more significantly consider pedagogical principles and approaches.

3. Learning design models

There are three distinct learning design models that are commonly adopted for the development of DEERs: the EscapED framework (Clarck et al., 2017), the Six-phases approach (Eukel & Morrell, 2021) and the Star Model ((Botturi & Babazadeh, 2020).

3.1 *The EscapED framework*

The EscapED framework, pioneered by Clarck and colleagues (2017), stands as a widely recognized reference among educators and instructors aiming to craft traditional or digital educational escape rooms. Comprising six dimensions – Participants, Objectives, Theme, Puzzles, Equipment, and Evaluation – this model serves as a comprehensive guide (Grande-de Prado et al., 2020) adaptable to various educational settings.

The initial phase of this framework emphasizes a thorough consideration of participants, urging developers to conduct a comprehensive needs analysis targeting the game experience. Within the Participants stage, developers are guided through five key areas: User Type assessment, Time allocation for the experience, Difficulty scaling tailored to diverse player

levels, Mode selection (cooperation-based or competitive-based), and Scale determining the number of participants. This stage aims to establish a foundational understanding of user types engaging with the game, providing a strategic direction for subsequent development phases.

The second phase in the escapED framework involves crafting the learning objectives for the educational escape room that, if established early in the design process, ensures purposeful game development, allowing themes and puzzles to align and enhance these objectives seamlessly. This objective-oriented step is segmented into four key considerations for developers: defining learning objectives or behavioral change objectives that integrate into the game's theme and structure, determining the disciplinary focus (single or multi-disciplinary), leveraging interactive games for soft skills development like communication and leadership, and incorporating problem-solving challenges to engage diverse learner types. This stage lays the groundwork for clearly defined game objectives and aids in devising an evaluation strategy in later design phases.

The third stage within the escapED framework directs developers to carefully contemplate the overarching theme of the experience, aiming to create a captivating and immersive game environment tailored to the intended players. This step emphasizes crafting strong themes and narratives to ensure player engagement within the constrained interaction time typical of escape room games. It involves considering player motivations, game stories, and thematic elements like decorations, props, lighting, music, puzzles, and clues aligned with the chosen theme. The Theme phase encompasses four core considerations: Escape Mode or Mystery Mode, crafting a compelling narrative, and deciding whether the game stands alone or is part of a larger, nested experience. This stage prompts developers to structure the game's composition and narrative effectively, fostering player identification with the experience and cultivating personal motivations to complete the game.

The fourth phase of the escapED framework directs developers to craft the puzzles and activities that constitute the players' interactions within the game. This step emphasizes aligning puzzle design with information derived from preceding framework steps, particularly Participants and Objectives. It entails several key elements: designing puzzles and riddles tailored to enhance the learning objectives and overall theme, providing clear instructions and rules for a seamless player experience, and ensuring the availability of clues without disrupting player immersion. Crucially, this step emphasizes the alignment of puzzles with previously established objectives, facilitating

easier validation and assessment of goal achievement.

In the fifth phase of the escapED framework, developers focus on the logistical elements and resources essential to support the game experience. For DEERs, these components are digital and necessitate designing a digital environment that mirrors the selected theme and developing technological props essential for the puzzles to function.

In the final step of the escapED framework, developers focus on evaluating the game experience, closely tied to the objectives set in the second step. This phase encompasses various key elements: testing and iterating the game, reflecting on player experiences, formal evaluation of learning objectives, adjusting based on player feedback, and creating a checklist to ensure game components are in order for subsequent play-throughs. This step serves to gather data and assess the project's efficacy in knowledge transfer while providing insights for further game development. While the EscapED framework delineates a linear, sequential learning design process, it lacks substantial integration of key pedagogical principles, despite its apparent comprehensiveness. This absence raises considerations for the incorporation of robust pedagogical references within its structure, that in any case appears the most complete among the existing design approaches.

3.2 *The Six-phases approach*

Eukel & Morrell (2021) propose a systematic and iterative six-phase approach for crafting DEERs, emphasizing a methodical process aimed at ensuring both quality and an engaging learner experience. The cyclic design process involves sequential stages of design, piloting, evaluation, redesign, re-evaluation, and repetition.

The design stage should align with needs assessments, incorporate contextual relevance, establish measurable objectives, and prioritize learner-centeredness. These rooms typically employ a simple game loop: presenting challenges, prompting solutions, and rewarding successful completion (such as escaping within a time limit). Puzzles can vary in type and structure. Educators must factor in educational objectives, available resources, and game goals, ensuring each puzzle serves educational and learner needs, enhancing communication, teamwork, skill application, and content understanding. Employing a systematic, flexible, and iterative design approach is pivotal for achieving effectiveness in these educational settings.

Before implementing escape rooms in an educational setting, educators should conduct pilot sessions involving a small cohort, including students who have completed the course, faculty members, or practitioners within the field of interest. Piloting enables the identification of potential human errors in game design and helps uncover any confusion among participants regarding specific tasks, ensuring the success of students engaging with the escape room. It's advisable for educators to take notes during these sessions, observing group participation to gather valuable insights.

In the evaluation stage, pilot results offer educators an opportunity to address concerns before fully implementing the escape room activity. It helps in clarifying tasks, ensuring appropriate timing of the learning experience, and determining the right number of clues necessary for the event. Following the pilot, educators should engage in an informal debrief with participants, seeking their input and feelings about the experience. Subsequently, designers should review qualitative feedback gathered from participants, focusing on aspects such as gaming logistics, preparation time for educators, task completion duration, team dynamics, unexpected challenges, and aligning gaming tasks with educational objectives to enhance learning outcomes.

During the redesign phase, educators should prioritize making necessary adjustments before implementing the escape room activity with student groups. It's crucial to concentrate on insights derived from the pilot, emphasizing educational interventions that enhance learning outcomes. Furthermore, educators are advised to develop tools to measure both knowledge gains and student perceptions.

The ongoing evaluation of the escape room (re-evaluation stage) involves assessing learning outcomes by comparing beyond-classroom learning, quiz or exam scores, and pre/post knowledge assessments. It also includes examining student perceptions through perception scale results across different groups and timeframes. Additionally, educators explore unintended learning, such as improvements in communication or collaboration. Qualitative feedback is gathered through focus groups, including top and bottom performing teams, to ensure diverse perspectives. Faculty involvement in these groups adds an additional layer of assessment, capturing comments and team dynamics from an external perspective.

This model's strength lies in its emphasis on constructing the DEER and continually refining it through iterative design. This approach aims to continuously enhance the DEER to cater to learner needs and foster deep learning. Another advantage is its design flexibility, facilitating easier mo-

difications and refinements to suit learner requirements. However, despite some embedded educational considerations within the design process, this model appears to lack a strong pedagogical foundation.

3.3 *The STAR model approach*

The Star Model proposes a non-linear and interdependent structure encompassing five game elements and four context elements, arranged in two layers, aiming to guide educators in Educational Escape Room as well as DEER design. The model emphasizes five core game elements, with four derived from conventional entertainment ERs and the fifth element integrating the learning aspect.

The first of these elements, the Narrative, serves as the game's central story, providing a thematic foundation crucial for immersive and engaging experiences. It assigns an active role to players, defining the ER mode or type, and is fundamental for fostering meaningful play, where challenges are purposefully integrated into the larger narrative, granting significance to players' actions.

The Game-Flow outlines the sequence of a player's experience within an escape room, usually featuring distinct phases like introduction, exploration, puzzle-solving, and culmination. Escape rooms can adopt various activity structures, either sequential, parallel, or more intricate patterns. Groupings become integral within the game flow, allowing for competitive or collaborative interactions. Ensuring active participation among all members within groups remains crucial.

Puzzles constitute the core challenges within an escape room, serving as tools for the experience. These puzzles come in different types – cognitive, physical, and metapuzzles – each requiring unique skills and often tied to the narrative. Clarity in puzzle presentation and providing clear feedback on solutions, along with specific hint guidelines, form part of effective puzzle design.

An escape room is realized through coordinated equipment, including the room space, narrative-generating items (like videos or props), and elements facilitating gameplay mechanics (crosswords, locks, technological tools). These components contribute to the immersive and interactive nature of the experience.

The Learning Process element within an Educational Escape Room (EER) constitutes the primary purpose of its existence. It encompasses tar-

geted learning outcomes, interdisciplinary competencies, and soft skills. This involves specifying what learners should achieve and how learning should occur - whether content is embedded in the background story or if specific competencies are developed through puzzle-solving.

The design of an Educational Escape Room (EER) not only involves the five game elements but also considers its contextual dimensions. Four key dimensions play a crucial role in informing the design process: players, time and space constraints, evaluation strategy and debriefing. The post-game debriefing phase completes the learning cycle, bridging the gameplay experience with the broader learning context. It involves making players aware of the learning that occurred during the game and connecting it to prior knowledge and the overall learning process.

The strengths of the STAR Model lie in its comprehensive approach, ensuring consistency and interdependence among all its elements, along with its focus on contextual elements examined within a separate, albeit interrelated, layer.

4. Key factors for DEERs design

The three aforementioned design models are instrumental in pinpointing the primary features of the intended educational escape room and structuring it based on game design principles, encompassing aspects like narrative, rewards, and challenge levels. Explicit references to pedagogical perspectives and a more robust link between game design and learning design ought to be adequately integrated into a design learning process, irrespective of the chosen design model. To establish this connection, a set of design principles should be considered to incorporate a pedagogical approach:

– Coherence among the design elements of DEERs
– Balance between gaming and learning components
– Usability of DEERs

4.1 *Coherence*

Coherence is essential for maintaining the consistency and efficacy of Digital Educational Escape Room (DEER) experiences, as highlighted by Botturi & Babazadeh (2020). It dictates that all facets within the DEER,

including puzzles, clues, narratives, structure, and challenges, must align harmoniously. For instance, if the overarching theme involves solving a mystery related to pyramids, all these elements should exhibit coherence with ancient Egyptian history and culture. If the challenge involves identifying the correct chemical formula, quiz games do not align as suitable puzzles. However, coherence extends beyond the correlation among game elements or within learning design components (such as objectives, activities, strategies, and assessment); it encompasses the interconnection between game design and learning design elements. This premise, as proposed by Veldkamp et al. (2021), asserts, for instance, that puzzles should be congruent with learning objectives. If a learning objective emphasizes the application of a concept, the corresponding puzzle should not merely consist of a drag-and-drop game but rather an interactive digital simulation necessitating decision-making skills and hands-on engagement.

Two primary aspects that illustrate the interconnection between game design and learning design are evident: the scenario and the flow. The former, the scenario chosen for the educational escape room, corresponds to the immersive experience that the player/learner encounters within the game context, drawing inspiration from real-life situations (Nicholson, 2015). The scenario resonates with the situated learning theory (Lave & Wenger, 1991), aligning with principles and mechanics of game design. This learning theory posits that learning occurs within an environment, with the escape room's scenario serving as a narrative or problem context wherein knowledge application takes place. Consequently, pedagogical insights can inform game design by adhering to the principles of situated learning.

The latter aspect, aligning gaming with pedagogy, pertains to the concept of flow. It carries a dual significance: one in gaming theory, where flow represents an optimal state of engagement for players, fostering motivation and enjoyment (Csikszentmihalyi, 1990); the other in pedagogy, where flow corresponds to Vygotsky's zone of proximal development. An equilibrium is established between the learners' skill level and the presented challenge, thereby averting potential boredom or frustration (Fotaris & Mastoras, 2019).

4.2 *Balance*

Game elements and learning elements should be given equal priority in the design process of DEERs. The risk is to give priority either to game elements such as or to pedagogical ones as in, at the expense of the other elements. If prioritizing the game over learning occurs, it results in entertaining the learners while diverting from the pursuit of the DEER's learning objectives. Conversely, prioritizing learning over the game allows learners to pursue the learning objectives but may lead to dissatisfaction or annoyance with the gaming experience. Johansson et al. (2014) present four perspectives that, if combined, are aimed at bridging this gap. The first one is utilizing heuristics to eliminate design flaws that might interrupt immersion and engagement, diverting players from achieving the game's predetermined objectives. Interrupting immersion not only hampers the concentration necessary for learning but can also demotivate learners from engaging in play.

The second one lies in emphasizing pedagogical research as a foundational aspect essential for designing games beyond mere entertainment. This emphasis ensures that games serve a dual purpose by not only engaging users but also aligning with educational objectives. By leveraging pedagogical research, game designers can create experiences that integrate effective and meaningful learning strategies, optimizing the educational value of games beyond mere amusement. This approach acknowledges the potential of DEERs as powerful educational tools, capable of delivering substantial learning outcomes while maintaining an engaging user experience. The third perspective is advocating for supplementary activities that contextualize and enhance the predefined objectives of gameplay. The DEER experience can be preceded by preparatory activities introducing the thematic focus and followed by a session where faculty members engage students in reflecting on the knowledge acquired during the game experience. The fourth perspective entails the introduction of «meaningful learning», closely associated with «meaningful play» (Salen and Zimmerman, 2004; Clark et al., 2023), aimed at harmonizing the prioritization of game elements and pedagogical elements. This means that, since designers possess a spectrum of options when it comes to theoretical approaches, it's crucial to harness a theoretically sound approach that builds upon existing knowledge of the core academic concepts within the game being designed. Clark et al., building on the idea of Vygotsky (1962) that "the formation of concepts emerges from the child's own everyday life experience", focus

on the inclusion within the game of features that allow users to leverage embodied everyday experiences that emphasize the students' learning in their context while exploring scientific big ideas. Drawing from Vygotsky's notion (1962) that «concept formation arises from a child's everyday life experiences», Clark et al. concentrate on integrating in the game features that enable learners to utilize embodied everyday experiences, emphasizing students' contextual learning while exploring significant scientific concepts.

4.3 *Usability*

Usability refers to the precise execution of technological elements within educational escape rooms, ensuring ease and intuitiveness for users to navigate, comprehend tasks, and execute all necessary actions to overcome challenges. From a technological perspective, usability (Chang and Johnson, 2021) is characterized by:

- Learnability: It's essential for designers to facilitate easy learning and navigation within the system, allowing users to comprehend tasks effortlessly.
- Efficiency: Consideration of operational efficiency is crucial in system design, enabling users to operate the interface effectively and complete tasks expediently.
- Memorability: The system's user-friendliness should allow users to operate based on memory, even after initial exposure to the interface.
- Error Rate: A good system or interface should aim for a low error rate, reducing user barriers and ensuring a smoother and more inclusive experience (see Chapter 5 in this book).
- Satisfaction: Users should derive a pleasurable experience while operating the system or interface, enhancing their acceptance and engagement.
- Effectiveness: Evaluating whether users can accomplish preset goals using the system is pivotal, determining the overall success and utility of the interface.

Additionally to technological aspects, the usability of DEERs should also consider other pertinent factors. Designers ought to contemplate representations of game environments and players, aiming to dismantle stereotypes associated with game participants. This involves transcending the

dominance of white and male figures in game design and participation by offering diverse and multiple representations of individuals involved (Clark et al., 2023).

A further aspect concerns the accessibility of the challenge (ibid.), that should accommodate a wide range of students with their different skills and characteristics. Designers should adopt a low floor/high ceiling approach (Papert, 1980), providing an easy entry point (a low floor) for novices, while offering opportunities for more advanced learners to delve deeper, reaching a high ceiling of complexity within the same learning environment.

5. Conclusion

This chapter has explored the characteristics of the most important DEER design models, along with an analysis of the implications arising from the connection between game theory and pedagogy. The design of DEERs requires not only technological skills, but also a deep knowledge of both game design elements and learning design principles and the ability to combine these two sides (Repetto et al., 2023). Faculty members aspiring to create and explore escape rooms with their students must adeptly intertwine seemingly disparate principles and harmonize them. This synchronization is a key to craft learning environments that are not just effective educationally but also inherently and greatly motivating for HE students. The incorporation of pedagogical soundness holds substantial significance within the DEER (Digital Escape Room) design process. It serves as a manifestation of the designer's cognizance regarding the educational considerations underpinning the choices made. This entails a deliberate interconnection between gaming elements and pedagogical principles, thereby affording an expert perspective to discern the fundamental pedagogical framework and direction. Furthermore, the designer's aptitude for creativity is indispensable in crafting DEERs, necessitating a generative and iterative approach. This aptitude ensures the originality and innovativeness of various constituent elements comprising the DEER, encompassing the structural configuration, the narrative employed to convey the subject matter and associated challenges, the integration of diverse puzzle types, as well as the methods entailed in acquiring and assembling keys and codes essential for successful escape scenarios.

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