

Building Digital Educational Escape Rooms: A Modular Toolkit With Low-code Authoring Approach

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Abstract: Digital Educational Escape Rooms (DEERs) represent a compelling form of game-based learning that situates collaborative problem-solving at its core. Grounded in constructivist and collaborative learning principles, DEERs require teams to negotiate meaning, coordinate actions, and apply prior knowledge under time pressure, conditions that promote deeper cognitive engagement and knowledge consolidation. The game environment provides intrinsic motivation through narrative immersion and immediate feedback, while cooperative mechanics cultivate communication and shared responsibility. Systematic reviews confirm that DEERs foster teamwork, communication, and critical thinking, yet adoption remains limited because creating pedagogically sound DEERs demands both instructional design expertise and substantial technical skill. Existing authoring tools either sacrifice expressiveness for usability or require programming knowledge, leaving a significant gap for non-technical educators seeking to design rich, interactive learning experiences aligned with curricular goals. This work in progress paper presents the DEER-Wizard, a low-code authoring approach that guides educators through a multi-step configuration covering puzzle structure, narrative flow, and learning objectives. Each step is grounded in established DEER design principles, including narrative framing, interdependent puzzles, adaptive hint strategies, and structured debriefing, ensuring that pedagogical alignment is built into the authoring process rather than treated as an afterthought. A connected DEER-Generator converts the completed configuration into a playable game. The Wizard builds on the DEER-Toolkit embedded in a 2D multiplayer dungeon crawler with cooperative play and xAPI-based learning analytics that support formative assessment. Together, Wizard and Toolkit enable non-technical educators to design pedagogically aligned DEERs without programming expertise, directly addressing the power-usability dilemma identified in authoring tool research. The DEER-Wizard is a conceptual design with a prototype implementation in progress. A planned mixed-methods evaluation will examine usability for educators and learning outcomes for students in authentic higher education settings. The Wizard, the Toolkit, and the generated Escape Room Games are and will continue to be released as open-source software and open educational resources.

Keywords: Digital educational escape room (DEER), Game-based learning, Narrative-centered learning

1. Introduction

Game-Based Learning (GBL) embeds learning objectives into the structure of a game or playful activity to foster engagement and retention. Digital Educational Escape Rooms (DEERs) form a distinct GBL category: teams solve interconnected puzzles within a limited timeframe (Nicholson, 2015), with learning outcomes woven into the puzzle structure (Nicholson, 2018). DEERs are inherently cooperative; empirical work confirms increased motivation, collaboration, and deeper cognitive engagement compared with conventional activities (Makri et al., 2021; Veldkamp et al., 2020).

Effective DEER design requires more than attractive puzzles. Preconditions include narrative immersion (Veldkamp et al., 2022), alignment between puzzles and learning objectives (Fotaris and Mastoras, 2022), adaptive hint strategies (Santamaría Urbieto and López-Pernas, 2024), cooperative mechanics with genuine interdependence, and structured debriefing (Nicholson, 2018). Pedagogical frameworks such as EscapED (Clarke et al., 2017) and Room2Educ8 (Fotaris and Mastoras, 2022) operationalize these conditions for educators but deliberately stop at the design level.

At the technical level, DEER authoring tools face the power-usability dilemma identified in serious-game authoring research: tools that are easy to use tend to be expressively weak, and tools that are expressively rich tend to require technical skill (Laurent et al., 2022). On the easy side of that dilemma, Genially (Pornsakulpaisal et al., 2023) and Google Forms let educators build escape-room activities through form-based editors, but in typical use produce browser-based click-throughs closer to themed quizzes than to a navigable game world. Escapp (López-Pernas et al., 2021) adds progress control and analytics, yet likewise targets text-and-image

puzzles on a web page rather than a real game environment. eAdventure (Torrente et al., 2010) shows that richer authoring is possible in the serious-games space, but is tied to the point-and-click adventure format and not designed for cooperative escape-room structures. On the expressive side, custom 2D or 3D engines such as Unity and immersive VR variants (Makri et al., 2021) produce real games but require programming and asset production.

The DEER-Wizard presented in this paper targets the unoccupied middle of the power-usability space: a tool that non-technical educators can use directly, and that produces an actual 2D multiplayer video game rather than a browser form. It builds on the authors' DEER-Toolkit (Matutat et al., 2026), a game framework for 2D multiplayer dungeon crawlers that provides DEER-specific components: an adaptive hint system, cooperative play for two to six, interaction primitives including code locks for entering riddle solutions and item combination, and xAPI-based learning analytics. The Toolkit resolves the execution layer, but creating new DEERs with it still requires familiarity with its internal components and programming knowledge. The Wizard closes this remaining authoring gap. While the primary target context is higher education, the Wizard and Toolkit do not impose domain restrictions and can be applied in other educational or training settings.

This paper's specific contribution is therefore the DEER-Wizard and its connected DEER-Generator: a low-code authoring approach that enables non-technical educators to design and generate complete, pedagogically aligned DEERs built on the DEER-Toolkit without any programming knowledge.

2. DEER-Wizard

The DEER-Wizard is a setup-style authoring tool that guides educators through a multi-step configuration process without requiring programming or game-design knowledge. Defaults at every step let users delegate any decision where they have no preference.

Step 1: Pre-Configuration. The user sets global parameters such as the number of players, target duration, and the visual style of the game. The Toolkit provides an asset library of spritesheets for game elements, characters, and level tiles; educators can alternatively upload their own assets to match a specific narrative (for example, a ward for nursing or a laboratory for science). Learning targets are also defined at this stage.

Step 2: Preparation. The user uploads external resources such as images or texts related to the educational content of the game. These resources will be used in Step 3 to define and configure the individual riddles.

Step 3: Riddle Configuration. The user creates and configures the riddles across three layers. The metadata layer captures duration, difficulty, and the corresponding learning target. The resource layer links uploaded materials needed to solve the riddle and supports varied game situations without manual level configuration. The task layer defines what players do in the game, such as collecting items or entering a pin code, and stores the solution. Optional hints and story events can reinforce guidance and narrative progression.

Step 4: Game Structure. The user defines the structure of the game: the order of the riddles, their dependencies, and how many solution paths exist. Dependencies between riddles support logical AND, OR, and XOR operators, enabling parallel tracks, branches, and gatekeeper riddles. The Wizard represents this as a directed graph in which each node is a riddle and each edge encodes a dependency.

Figure 1 summarizes the DEER-Wizard mockup and its relation to the DEER-Toolkit runtime across four views: runtime screenshot, game flow editor, riddle overview, and riddle configuration. The Wizard views show how educators structure the game, inspect riddles, and configure individual riddle properties. The runtime screenshot contextualizes the generated target environment and is not part of the Wizard interface.

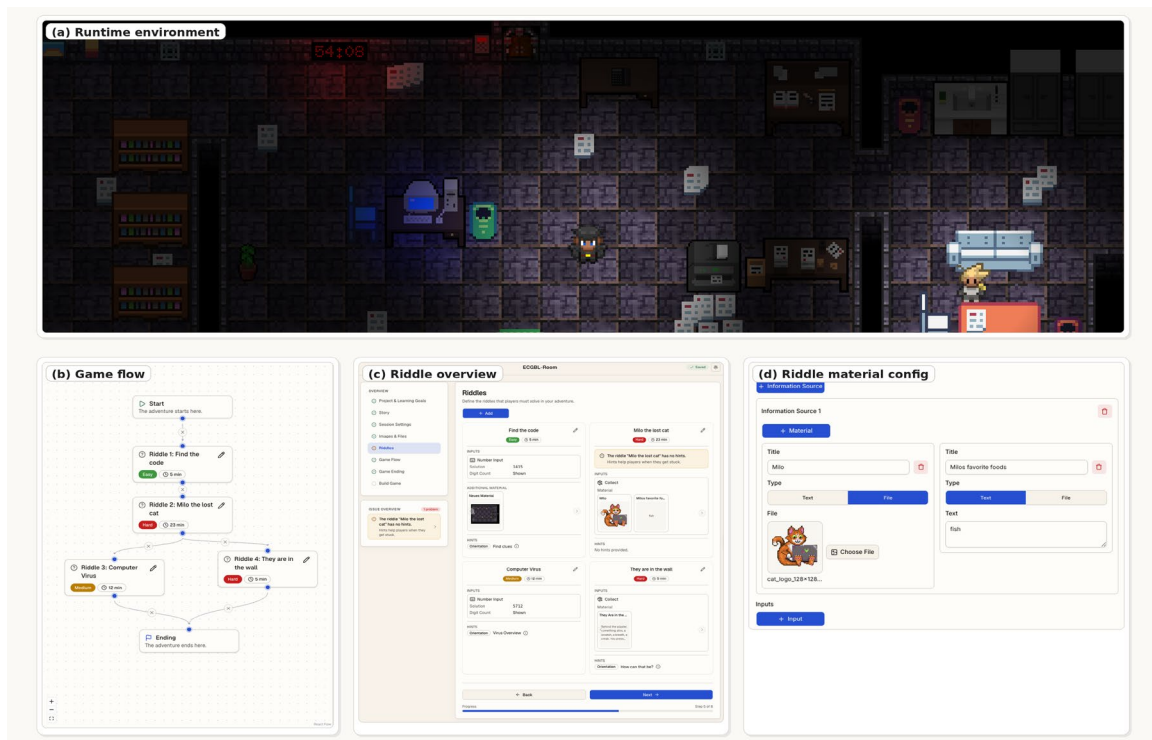


Figure 1: Overview of the DEER-Wizard mockup and its connection to the DEER-Toolkit runtime. The figure combines four views: (a) an illustrative in-game room from the DEER-Toolkit runtime, (b) the game flow editor defining the sequence and dependencies of riddles, (c) the riddle overview summarizing configured riddles and their properties, and (d) the riddle configuration view for specifying task type, riddle mechanic, mechanic skin, story events, solution-related information, and hints. The runtime screenshot is not part of the Wizard interface itself, but contextualizes the environment into which Wizard-authored configurations are instantiated

A DEER-Generator in the background consumes the DEER-Config produced by the Wizard, selects matching components from the Toolkit, and outputs a Dungeon-Config that the game loads directly. In this transformation, the riddle graph also serves as the level graph: each riddle is mapped to a room, graph edges become progression gates, and predefined room templates are populated with game elements defined by the selected mechanic skins. As a result, the authored pedagogical structure is preserved in the generated spatial layout. Internally, the graph is translated into a Petri net that drives execution and enables fine-grained state tracking for adaptive hints and xAPI-based analytics.

3. Implementation Status and Future Work

The Wizard and Generator are early prototypes with all base features implemented; no empirical evaluation has been conducted yet, so no usability or effectiveness claims are made. A formative mixed-methods study is planned with higher education educators without programming background, recruited across domains. Sessions will combine task-based authoring, think-aloud protocols, and semi-structured interviews; qualitative data will be analysed thematically. The central hypothesis is that participants can author a coherent DEER within one session. Coherence will be assessed with a rubric covering narrative consistency, puzzle dependencies, and alignment with learning objectives. Domain experts will apply the same rubric as the primary measure of pedagogical alignment, complemented by task-completion rate and time on task. Existing DEER scenarios from the literature will also be reconstructed to test Wizard expressiveness.

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Ethics Declaration: No ethical clearance was required for the work presented. The contribution is conceptual and technical and does not involve human subjects, personal data, or interventions requiring ethical approval.

AI Declaration: Generative AI tools were used to support language editing, improve clarity and conciseness. All content, interpretations, and conclusions remain the sole responsibility of the authors.

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