Article

Digital Escape Rooms as Innovative Pedagogical Tools in Education: A Systematic Literature Review

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Abstract: This paper aims to present a systematic literature review on state-of-the-art Educational Escape Rooms (EERs) with the use of digital technologies. More specifically, the focus of the study is to present the current developments and trends concerning Digital Educational Escape Rooms (DEERs) and investigate how they foster learning outcomes for online learners. Additionally, the present study provides insights into the design process of such technology enhanced EERs. This review is attributed to identifying and covering research gaps since the current literature has focused on the pedagogical aspects of Escape Rooms (ERs) in education, but no studies seem to have been conducted in regard to the pedagogical implications of Digital Escape Rooms (DERs) in educational environments. Based on the exhaustive literature review, an agenda for future research is promised and the implications for designing innovative ER approaches have been highlighted. The anatomy of the fundamental components of conducting systematic literature reviews was followed. The results of the review could be addressed to multidisciplinary teams related to education, game researchers, educational researchers, faculty members, scholars, instructors, and protagonists of educational systems to encourage them to thoroughly study the core elements of DEERs and how they can be applied in virtual educational contexts to facilitate students' learning achievements.

Keywords: escape rooms; educational escape rooms; digital escape rooms; systematic literature review; technology enhanced learning; digital technologies; gamification; game-based learning; motivation; engagement

1. Introduction

In the present day, the threat posed by the COVID-19 pandemic has increased globally and affected all levels of our lives. Conventional education has been temporarily suspended and online emergency education has been adopted at all educational levels. Online lectures and tutorials, videos, and online conferences are common educational tools for educating and raising awareness about certain subjects. However, such didactic methods usually require participants to distantly watch and listen as passive learners without any interactivity [1]. In this context, there has been a shift in the educational paradigm from in-person to learner-led virtual ER environments [2] (the terms digital ERs and virtual ERs will be used interchangeably in our review and will serve as synonyms). Research has shown that millennials prefer informal learning experiences, such as ERs, due to their flexibility and because such activities engage and heighten students' interests [3].

In recent years, EERs have become a promising scientific field and have raised great interest in researchers and educators in terms of new Game-Based Learning (GBL) approaches to break out from the traditional classroom and affect various specialties and educational contexts. Most ERs have been created for recreational purposes. However, the use of ERs in education reflects their constantly increasing rate, because schools need to operate with different paradigms in the learning process. The first generation of ERs focused on difficult logic puzzles, whereas ERs have now evolved into fully immersive

environments with high-quality props and effects [4]. This means that participants in a game transfer from their real-life context into the game context and are lured into a story or a particular problem. ERs for education are problem-based and time-constrained pedagogical activities requiring active and collaborative participants, a setting that teachers want to achieve in their classrooms for the promotion of students' learning [5].

Both creating and using ER breakout activities can be deemed as instructional strategies that can enliven classroom learning experiences and lead to more learner-focused strategies. They are learner-centered activities in which a team of players cooperatively discover clues, solve puzzles, and complete tasks to progress through the challenge to achieve a specific goal [6]. Such game-based methodologies are rapidly increasing in terms of their applicability, especially in higher educational institutions. In these adventure games, players work collaboratively, usually in a team of four to six members, to solve puzzles using hints, clues, and strategy to escape from a locked room.

In today's educational landscape, ER scenarios are promising trends and can be integrated into many academic disciplines, such as healthcare [7–9], STEM subjects [10], computer science [11], chemical engineering [12], pharmacy [13], physics [14], mathematics [15], radiology [16], biology [17] and many others. The protagonists of EERs are usually secondary or higher education students, tutors, professionals, designers, and researchers. In particular, EERs have also been marginally implemented in entrepreneurship education, since there is a lack of evaluated design elements to guide the creation of EERs in this context, which hampers their wider adoption [18].

Designers aim to create ERs to achieve an active learning environment which is said to maximize students' motivation and/or engagement and enhances learning while using or developing team-building and communication skills [19,20]. The actors who are involved during the gameplay appreciate the diversity of problem-solving puzzles, the discovery learning nature and the need for collaboration among peers. Despite their advantages, EERs also face numerous challenges. In a systematic literature review conducted by [21], the limitations and challenges of implementation of EERs in the classroom were found to include: restrictions in terms of budget, classroom availability, and a lack of time to prepare classes.

In recent years, research has focused on the use of these games in educational environments due to the extensive opportunities they offer to support the learning process [19]. EERs include both ERs for educational purposes and can also be found outside of formal education, for example, in museums and libraries [22,23]. The focus of the present literature review is on formal educational environments.

From an educational perspective, EERs are linked to the methodology of gamification, as EERs are based on a game structure and design. Gamification in education rose to popularity in the early 2010s, and has been given a definition by [24] as "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems", implicitly concentrating on its core virtues: the ability to enhance learning and stimulate the motivation and engagement of students. In fact, it is a technique that proposes different dynamics concerning game elements and game design in educational environments to stimulate and create interactions with students, allowing them to develop curricular, cognitive, and social competences [25]. The core idea of gamification leads to the logic that the game elements' motivational strength can be transferred into educational contexts [26].

Since ERs are considered to be alternative, innovative, and gamification-based educational methodologies, they should be designed with great consideration and follow the proper pedagogical theories to encourage the achievement of further learning when the players are disconnected from the virtual environment. These educational tools can be gradually implemented in both physical and online classrooms as well. As suggested by [11], apart from being a great form of entertainment, ERs have attracted the interest of instructors as well, because of their ability to provoke the cultivation of valuable skills such as teamwork, leadership skills, creative thinking, and communication.

Even though many studies have been conducted concerning ERs, their use, and their impact on students' learning, no scientific research has been carried out to explore the application and effects of digital ERs in the educational environment. In this study, we adopt the definition suggested by [27] for digital ERs. These researchers argue that "DER is an innovative teaching approach incorporating digital materials with reality" (p. 2). Examining the use of digital ERs in empirical research will help identify the future implications of digital ERs for educational purposes. This is important since DERs could provide an exciting and engaging addition to teaching innovations in educational courses or programs. Yet, we have found no comprehensive review of research on the use of DERs as didactic tools in educational settings. The design of EERs with the use of digital technologies is still a very young field. It is likely that various DEER initiatives are never published, and as such, the reported number is likely to be off from or underreport the true value in terms of the availability of initiatives.

To achieve this goal, a systematic literature review of empirical articles was carried out following published guidelines [28] for conducting systematic literature reviews. The scope of the literature review is to group and present the current trends and developments of DEERs and their application in all educational levels. We studied a plethora of educational issues, concerning methods and evaluation tools used to study DEERs, educational elements, design characteristics, and the impact of DEERs in the development of cognitive, behavioral, and affective skills. We intend to encourage DEER developers to use a thoughtful, methodical, iterative process to ensure quality, educational capacity, and a positive learner experience.

2. Theoretical Background

2.1. Conceptualizing the Concepts of Educational Escape Rooms and Digital Escape Rooms

In recent years, there has been a global renaissance of interest in flexible and life-wide forms of education. The use of games as a pedagogical method has been gaining momentum [29]. ERs represent a form of game, involving innovative learner-focused activities. ERs first appeared in Japan in 2007 and have spread rapidly, mainly since 2012, to many countries in Asia, Europe, and the U.S.A. These games have incorporated technology, thus, providing virtual reality experiences and their utilization has expanded to places beyond entertainment, such as education. ERs are a type of game involving lifelong challenges, using puzzles, which are to be solved by a team in a limited amount of time [30] and are accessible to many age groups and educational environments. They are usually themed-based and sometimes driven by a narrative where gamers are engaged in a role play.

ERs require teamwork, communication, initiative skills, as well as higher-order skills, such as critical thinking, attention to detail, and rational thinking to apply a wide range of knowledge and the appropriate methods under time pressure [31,32]. The main benefits of such games are that they promote collaboration, develop problem-solving strategies, critical thinking, and creativity [33]. They are said to favor neither gender. Indeed, it has been emphasized that the most successful teams are those composed of players with diverse experiences, skills, knowledge of the environment, and physical abilities [30].

Even though an EER does not at first sight differ from a recreational ER, there are many core differences between them. The authors of [5] present the main differences between ERs for recreational and for educational purposes. The most obvious difference is that the EER puzzles, enigmas, and solutions are developed for a specific target group and concern specific well-defined learning goals and objectives, whereas recreational ERs intend to attract a broad audience and primarily focus on entertainment purposes. Additionally, from a pedagogical point of view, in the entertainment industry players collaborate to solve problems. EERs are based on social constructivism, according to which, learners are interactively involved in team-based and collaborative activities to construct knowledge. Moreover, recreational ERs take place in one or more connected, permanent room and teams usually play one after another. On the contrary, in educational settings,

since classrooms are used for different courses, tutors have a limited amount of time to set up and clarify activities and all teams play at the same time. Concerning the designed materials, recreational ERs vary in relation to preparation time and budget, whereas EERs designers do have restricted preparation times or limited budgets for developing sustainable materials. Designing educational puzzles is a challenging experience, since easy puzzles can become boring, while ones that are too difficult can cause frustration and high drop-out rates. Another important difference is that in the entertainment industry, game masters usually guide players from an adjacent room. In educational environments, such space is usually not available and teachers guide teams within the same room. Therefore, the challenge is to balance between the teachers' supervision and the learners' autonomy in learning. Finally, a recreational ER is designed for one team with a limited number of players, while EER activities are organized and intended for a whole class or course, reaching hundreds of students.

However, EERs are becoming increasingly popular, especially with professional development programs, as a way of involving players in the learning environment and engaging them in collaboration, while developing other social skills [34]. Current research has confirmed that millennials prefer informal learning experiences, such as EERs, due to their flexibility and because their activities generally engage and heighten their interests [35]. The ER genre has been given several names, as detected in the academic literature, including: escape game, puzzle room, live escape, live action game, adventure room, adventure game, escape box, exit game, breakout game, breakout room, and numerous others.

ER games, usually seen as thematic games, are perceived as "games in which players, acting as a team, are trapped in a room and have to solve a series of problems, called enigmas, to achieve a goal, usually to escape the room, within an hour" [36]. It is perceived to be a metaphorically "locked" classroom, used for collaborative purposes between peers in specific educational contexts. Reference [11] define EERS as "rooms that include part of the course materials within their puzzles in such a way that students are required to master these materials to solve the puzzles and succeed in the escape room" (p. 31723). ERs also refer to simulations of the real world. The definition of [13] is moving in this direction. ERs are simulated scenarios where individuals or groups work together to solve a series of puzzles to "escape" the scenario in a time-framed setting. They may help to evaluate the ability of teams to work towards a common goal and provide an opportunity for both an individual and team-focused reflection of learning [13].

Although adopting EER games may yield potential learning benefits for students, the design and development of them for specific learning contexts is a time-consuming task [14]. In the 21st century, the concept of gaming, due to the rapid explosion of technology, took on major significance with the rise of the digital revolution [37]. More specifically, the beginning of the digital revolution made digital technologies—such as games and simulations—mature. This has resulted in their efficient use in education [29]. Digital elements (e.g., quick response—QR codes, applications, virtual reality, augmented reality, embedded screens, speakers, etc.) can supplement the physical components in an EER by offering adaptability. It seems to be important to best integrate digital elements so that they do not take away from the benefits of physical EER elements and contribute to the prospective learning outcomes. The scope of digital EERs should be the challenges of such games, which are intended to provide a sustainable learning experience for learners, allowing them to develop certain skills and competences—cognitive skills, collaboration, engagement and so forth—at every level. Additionally, DEER designers should be aware of setting up boundaries, emphasizing the teaching methodology and educational parameters, while creating meaningful puzzles during the design process, so as to provide fruitful educational experiences for learners.

In this sense, digital EERs can be adopted and can lead to cost-savings and flexible learning experiences in virtual learning environments. Digital EERs are immersive, engaging, dynamic, active-oriented, online learning experiences, not unlike ER games. Fully digital ERs are developed due to their cost-effectiveness, accessibility, and ease of use [38].

They use a combination of free web-based applications to simulate a series of locks to be opened, puzzles to be solved and escapades to be carried out [39]. These games belong to a broader category of ERs but differ from the rest due to the live interaction they provide with the environment [30]. DEERs are an innovative way to bring technology and critical thinking to the online classroom, and their benefits are manifold. Among others, the commitment to a learning environment is achieved, and interaction through collaboration helps students develop social skills. Reference [40] claims that educational games utilize the main principles of serious games, to create and add the element of playfulness to modern technologies. In this way, game designers have the opportunity to create meaningful educational content, and thus, maximize the acquisition of new information. These researchers also suggest that educational games are a viable alternative to existing computer learning technologies that can encourage and lead digital citizens to the acquisition of knowledge. In some educational cases, hybrid EERs are being designed to combine not only digital but also analog elements [36], thus, merging the individual and collaborative learning experience [41].

When developing a learning-oriented DEER there are four issues to take into consideration:

- Learning objectives: These objectives aim to process the topic and evaluate the student's learning experience and achievements, as well as find out, accordingly, which indicators of change must be improved.
- Single or multidisciplinary theme: Single domain or multiple disciplines presented as part of the game experience.
- Soft Skills: Interactive action games that can help develop soft skills such as communication and teamwork.
- Troubleshooting: Developing troubleshooting challenges to make the game experience interesting for players (p. 25, [42]).

An extremely popular ER genre is thematic interactive games, in which gamers are locked into a room and act collaboratively to solve riddles and puzzles to escape from the room within a set time limit. Reference [43] claims that DRs offer exposure to technology and a high level of thinking and collaboration among peers.

In general, EERs have inspired experiences in schools and universities with multiple scenarios and have received attention as a potential avenue to facilitate team-based research. In such games, teams of individuals work together under time pressure and think critically to crack codes, discover items, and solve puzzles, riddles, enigmas, and challenges that ultimately let them free themselves from a "locked" room and achieve a predetermined goal. Developmental considerations include many aspects, such as the location and size of an ER, financial issues, theme development, and other significant characteristics, namely the development of puzzles and challenges, prototyping efforts, and the incorporation of hints [44].

2.2. Categorization of Puzzles

All problems, challenges, or activities within an ER are called puzzles. To advance and fully experience an ER, the team must complete the puzzles within the playroom. These puzzles may vary in form and style, which is the responsibility of the game designer. Since ERs are inherently team-based games, the puzzles tend to ensure that every member of a team is active and can contribute to the gaming process in a meaningful way [45]. The puzzles need to be connected to the game room theme and be thoroughly comprehensible by the players based on the information available within the room. Reference [4] divided the puzzles into three core categories: (i) cognitive puzzles that include the players' thinking skills and logic, (ii) physical puzzles that require the manipulation of artifacts to overcome a challenge, such as crawling through a laser grid, and (iii) meta-puzzles, the last puzzle in the game which is often connected to the narrative (e.g., a jigsaw). Cognitive puzzles seem to predominate, whereas meta-puzzles tend to be used as the final puzzle in ERs [4].

Reference [45] presented four ways of organizing ER puzzles: (a) In an open structure, players can solve different puzzles at the same time and all puzzles need to be solved before the last one; (b) in the sequential structure, the puzzles are presented one after another; solving a puzzle unlocks the next until the meta-puzzle is solved; (c) a path-based structure, which consists of several paths of puzzles. To solve the meta-puzzle, information from previous puzzles is needed, and (d) the pyramid structure is a complex and hybrid form of puzzle that involves combining some of the above-mentioned basic structures. Puzzles usually include ciphers, jumbles, coded messages, combination locks, rebuses, and data hunts [46]. Methodologically, according to [47], an excellent design for puzzles that supports storytelling and the narrative should follow some basic principles, as summarized below:

- A puzzle consists of many elements and at least one of these elements from each puzzle must lead to the actual participation of the player.
- The resources used to solve the puzzles can come from the world in which the game takes place.
- The strategies required to solve the puzzles could add something to the narrative of the game.
- The solution may be part of the mission for which the players work.
- The existence of the puzzle in the game must make sense concerning the type of game, the setting, and the narration.

2.3. DEER Games' Learning Outcomes

In recent years, EERs have become increasingly popular educational activities with the ultimate aim of engaging students in learning environments, encouraging collaboration, cultivating soft skills of the 21st century, and their intellectual development [34]. Utilizing EERs, where students are challenged to solve problems and enigmas, leads to the promotion of exploratory learning and achieves the development of certain skills [48], as well as immersing students in the learning process [8]. In parallel, by using these tools for educational purposes, students are transformed from passive receivers of knowledge into active participants in the procedure of learning [34], as they are invited to explore new data, accept new challenges, and solve problematic conditions and mysteries.

EERs have also been suggested to be an ideal path for students to gain procedural knowledge, as they require players to act immediately, within time constraints (usually 60 min), search for evidence, and discover the solution to a problem. Additionally, the current literature states that ERs based on GBL are considered a contemporary format of knowledge transfer, due to their inclusion of easy and playful approaches towards different topics [49]. In educational contexts, the adoption of ERs as problem-solving games could provide a simulation of the real world in which students practice and develop skills and perceptions [50]. The ER concept involves a common pedagogical goal, together with a need for collaboration between teams to solve challenges and achieve that goal in time. In education, social constructivists advocate that learners construct new knowledge in social interactions with each other. Based on social constructivism, teachers implement ERs to stimulate collaborative or team-based learning [21]. A suggested criterion for designing well-constructed EERs is to ensure active participation within teams.

Features of many learning theories may be depicted in an ER activity. More specifically, elements of both social constructivism and behaviorism may be recognized to some extent [51,52]. Social constructivism since players construct their knowledge based on real-time experiences within certain tasks in the ER [51,53], and behaviorism because positive behavior is reinforced through the use of ERs [52]. Moreover, due to the nature of it being a "live-action team-based game", ERs are primarily recognized to be educational tools which coincide with features associated with a socio-cultural approach to learning [51,52]. Socio-cultural learning theory emphasizes the influence of social settings that frame the gamers' social interactions developed between the participants. In other words, ER activities are used for teaching and learning purposes and are deemed to be examples of how educators

and designers can facilitate students to communicate, cooperate, be critical thinkers, and thus, active learners.

3. Research Questions

The central aim of the present literature review is, ultimately, to stimulate academic discussion about digital ERs and their use in educational contexts, as addressed in many disciplines, since an identified gap in the literature has been acknowledged. The analysis and synthesis of the review aims to answer the following research questions (RQ):

- RQ1: What methods and assessment tools have been used to investigate the application of DER games in educational environments?
- RQ2: What are the common educational traits in the use of DERs in education?
- RQ3: What are the common design and development traits in the use of DERs in education?
- RQ4: To what extent are the learning objectives of DER games harmonized with the learning outcomes?

As regards RQ1, the methodological approaches used in the reviewed studies and the assessment tools utilized to collect the data were included in our systematic review. Concerning educational traits in the use of DERs in education (RQ2), we studied three domains, namely target groups/educational levels and discipline areas, learning goals, and tutors' role in the game process. As for the design practices of DERs in education (RQ3), we concentrated on four design aspects, namely team size, time frame, games/puzzles, and their structure, and use of digital technologies. The three educational aspects and the four design and development aspects were used as sensitizing concepts, as described by [54]. Sensitizing concepts are guides throughout the research process and provide a general sense of reference for the researchers [55]; they are starting points for further inquiry, functioning as the lens of researchers, through which to view the study and extract data in relation to these concepts. Finally, concerning RQ4, learning outcomes were categorized in conjunction with cognitive skills (transfer, cognitive load, knowledge acquisition), behavioral skills (behavior patterns, attitudes, 21st-century skills, digital literacy), and affective skills (motivation, engagement, satisfaction). Prior research has found empirical evidence that GBL has positive effects on cognitive/perceptual, behavioral, and affective domains [56]. Moreover, the application of games can foster the development of crucial skills of the 21st century, such as teamwork, problem-solving, innovation, management, programming, communication, and valuable intellectual skills (analytical and complex thinking, creativity, critical thinking, etc.) [29].

In our attempt to answer the research questions raised, a systematic literature review of the scientific research in this field was carried out by applying specific inclusion criteria. Among the analyzed bibliography, a multitude of research studies can be found. If we narrow the search to digital ERs used for educational purposes, the number of papers is considerably more limited, due to the novelty of such field. However, with the large amount of data analyzed, this research on the use of DEERs offers an analysis which could become fertile ground for further research.

4. Research Method

Following the work of [28]—PRISMA model (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), a systematic literature review of scientific articles published between 2006 and 2021 was conducted using the Google Scholar, and Scopus databases. The studied time period was limited to these years because our intention was to demonstrate the huge boom in the use of DERs in education especially in the years 2019 and 2020. This review comprised the following five steps: (1) search strategy, (2) selection, (3) quality assessment, (4) data extraction and (5) data synthesis (see Figure 1).
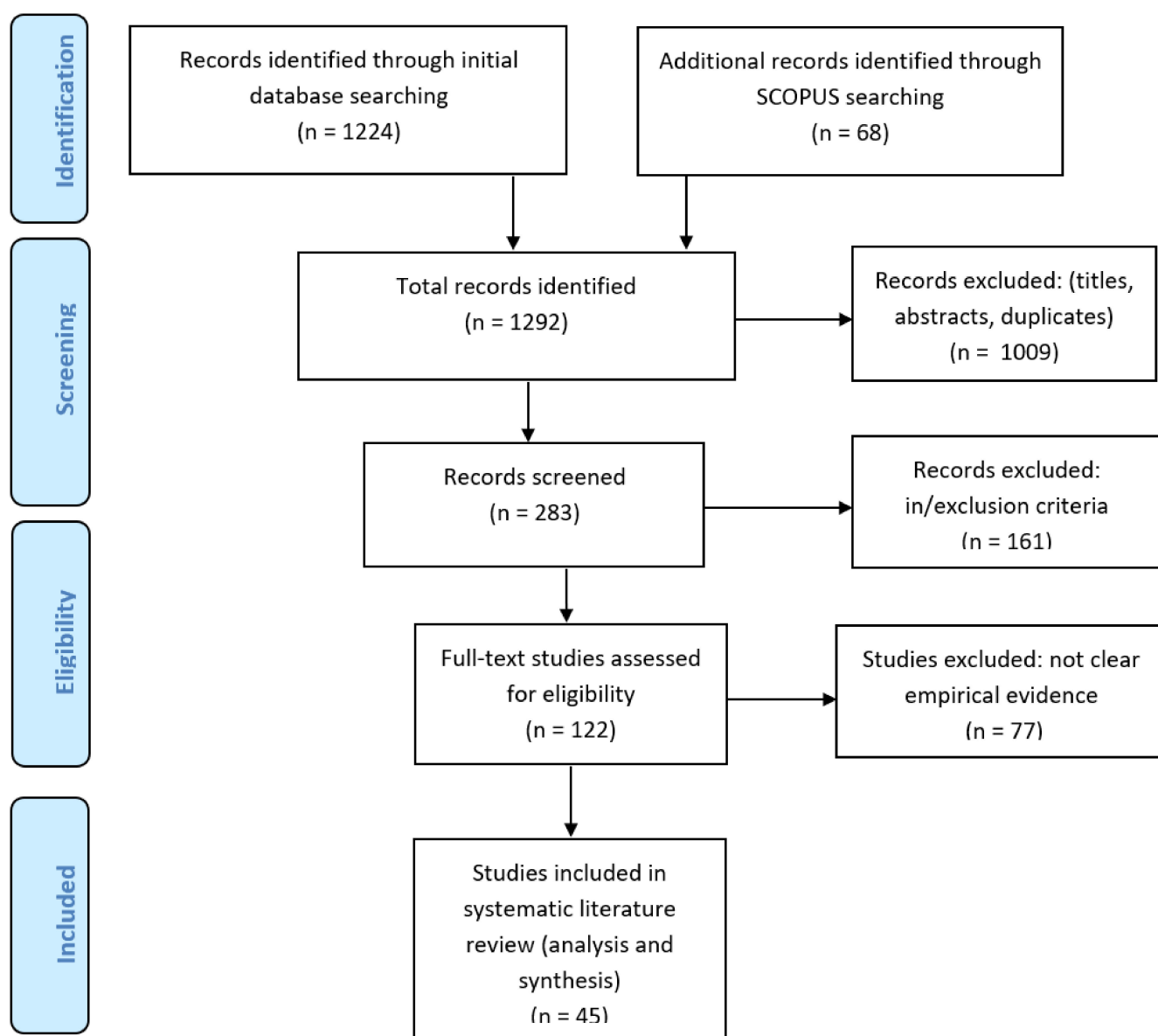
Figure 1. Flow diagram illustrating the literature review selection process.

In the first phase, we searched for the term "escape room", using search engines, such as Google, to obtain an overall impression of the relevant synonyms for this concept and keywords related to the application of ERs with the use of digital technologies for educational purposes (see Table 1).

Table 1. Core concepts and synonyms.

Core Concepts	Synonyms
Escape Rooms	Escape games, gaming rooms, breakout rooms, breakout games, breakout boxes, serious escape games, real escape games, educational escape rooms, educational escape games, exit games, puzzle rooms, adventure rooms
Digital ERs	Virtual ERs, online ERs
Educational Level	Primary education, secondary education, K-12 education, high school, middle school, intermediate school, higher education, further education, graduate school education, university education, tertiary-level education, vocational education

We considered setting up exclusion criteria to be of extreme importance, as this adds to the transparency and reproducibility of the selection results. We looked at each of the documents we came across in detail and excluded those that did not provide relevant information to our research, since the study of ERs means that there are some studies that either fall outside the scope of our discussion or are related to other fields except education (e.g., tourism). Additionally, we excluded studies that did not mention the design of the DEERs that was adopted in the educational process. Finally, the studies that were listed in other databases and those that only included opinions about the use of DEERs were excluded from our work. Through such an initiative preliminary phase, we found out that the concept of ERs seems to be understandable and well defined [47]. Additionally, it was found that some authors used the term "breakout rooms" as a synonym for ERs and narrower terms such as "escape games", "serious escape games", "breakout boxes", "breakout games", "exit games", "puzzle rooms", "gaming rooms", and "adventure rooms". In our search for articles, the two terms "ERs" and "escape games" were distinguished in the majority of searches and used the other terms mentioned above. Then, databases SCOPUS and Google Scholar were searched, with the search string ("escape rooms" OR "escape games" OR "digital escape rooms" OR "breakout rooms" OR "breakout games" OR "virtual escape rooms" OR "virtual escape games" OR "online escape rooms", OR "online escape games") AND ("education*"), identifying, respectively, 1224 (Google Scholar) and 68 (SCOPUS) records (see Figure 1). All SCOPUS records also showed up in the Google Scholar search.

In the second step, the three co-authors independently screened the remaining 1292 publications' titles, abstracts, and duplicates. A total of 1009 articles were excluded and the remaining 283 studies were scoped for further information. As we intended to synthesize practices on DEERs for teams in online settings, the exclusion criteria were: (i) DEERs for one participant and (ii) EERs intended for use only in physical educational settings. Inclusion criteria were: (a) only peer-reviewed articles, conference papers, or book chapters were included, (b) completely digital EERs, since these games differ in gameplay, puzzles, game design, and settings, (c) hybrid EERs (physical and analog elements) were included, (d) the accessibility of the publications written in English, (e) an experimental study or quasi-experimental design on the development and evaluation of a digital EER, (f) only empirical studies (quantitative, qualitative or mixed methods) were included, (g) articles published between 2006 to 2021, and (h) studies conducted in educational contexts (e.g., primary, secondary, higher, vocational education). A total of 161 studies did not include digital educational elements and did not fit our checklist of predetermined inclusion and exclusion criteria, and so these were also excluded. The full-text versions for eligibility were 122 and were carefully and thoroughly reviewed in relevance to the clearness of their empirical evidence.

A thematic analysis procedure was followed during this process (Figure 1). Each researcher kept separate notes and read each study multiple times to properly comprehend its content, research methods, procedures and main findings displayed. Afterwards, all the derived information was compared and discussed until a consensus was reached. From the 122 articles, 77 studies did not include any clear empirical evidence about the use of DEERs and were removed too.

In the third step, the quality of the dataset was assessed in light of the research questions. For all research questions, on specific educational issues and design aspects of the games and learning outcomes in line with the learning goals, all studies meeting the inclusion criteria were included. It is important to stress, that for research questions concerning learning outcomes, only peer-reviewed articles with assessed learning outcomes, for example, pre-and/or post-tests evaluation, were included. An exception is the study conducted by [57] which was also included, despite not having yet performed evaluation tests, since it addressed digital electronics and refers to vocational education and training. This final data set consisted of 45 documents, which were further analyzed to provide aggregated data findings concerning the research questions of the review.

It is worth mentioning that the categorization of [45] for puzzle structures and the puzzle taxonomy of [4] were used to classify the puzzle organization in the reviewed studies.

5. Results

5.1. Dataset Characteristics

Of the 45 articles selected for the systematic literature review, only one study was published in 2006 (2.2%), one study in 2012 (2.2%), one study in 2016 (2.2%), seven studies in 2017 (15.5%), seven studies in 2018 (15.5%), twelve studies in 2019 (26.6%), fifteen studies in 2020 (33.3%) and one study in 2021 (2.2%). However, there seems to have been an increased proliferation of the use of digital EERs as the years passed. All of the publications were published in scientific journals, international conferences, and book chapters (see Table A1 in Appendix A).

The studies, nearly all single case studies, are presented in various forms of documents: peer-reviewed articles ($n = 32$), conference papers ($n = 11$), and book chapters ($n = 2$). The majority of studies were carried out in European countries ($n = 23$), with fewer having been carried out in the U.S.A. ($n = 12$). The remainder were carried out in Asian countries ($n = 10$). The developed DEERs were tested and evaluated by various numbers of participants/players (from $n = 2$ to $n = 332$).

5.2. Methods and Assessment Tools

This section assesses the methodological approaches utilized in the studies included in this literature review and the assessment tools used to collect the data. The studies included in the present review reveal that research on the use of DERs in education is dominated by an emphasis on research structure and exhibited a great variation in the methodological fundamentals. The majority of studies ($n = 34$) referred to the experiences gained from designing and using a DER and included the use of some sort of either quantitative and/or qualitative instrument tools to collect feedback from the participants after the gaming activity [58–60]. Some articles ($n = 6$) based their conclusions only on informal feedback from students and staff [61,62]. Other studies strictly utilized a qualitative approach ($n = 12$) or used a quantitative approach ($n = 4$) that relied on post-test questionnaires [63,64]. Some studies ($n = 4$) used pre-and post-test surveys of content acquisition of knowledge and motivation [32,59], whereas others ($n = 19$) combined questionnaires with a qualitative feedback debriefing after the participants had completed the ER activity [20,65].

Other articles added informal observational impressions to the body of assessment feedback as derived from instructor designers [66,67]. This is considered valuable information, especially if a researcher seeks to find out more information about the game and how such a pedagogical tool is evaluated by the participants themselves. However, the value of the educational research community is limited.

We also found examples of strictly qualitative approaches [68,69]. Some of the articles relied on anonymous feedback [42], observation forms and group debates [70], feedback from reports about the digital platform used for the application of the game [62], or post-test interviews [71]. Data were also derived from a qualitative questionnaire answered by players after they had completed the ER activity [72]. Moreover, case-study methodologies were identified, since their purpose is to design DEERs for integrating them into different curricula, in which students are strongly engaged in GBL activities [11,61,73,74]. Additionally, an action research methodology was noticed [75] with one of the researchers in the tutors' role.

Moreover, there seem to be studies that include strong methodological approaches, either formal or informal, for triangulation reasons. The majority of studies were found to use quantitative and mixed-method approaches ($n = 30$). The mixed result studies are significant as they provide a better comprehension of their findings by triangulating results and thereby improving the validity of their conclusions [76]. For example, [73] utilized video recordings, teachers' notes, peers' feedback, and worksheets, learning anecdote records, individual interviews, and focus-group interviews for evaluating the DEER. Ref-

erence [71] used observation notes, questionnaires, video recordings, audio recordings, post-game interviews, and players' notes for the assessment of DEER games.

5.3. Common Educational Traits in the Use of Digital Eers

5.3.1. Target Groups/Educational Level/Discipline Areas

According to the data collected, most of the target groups are participants from higher education (n = 23) or secondary education (n = 7). The number of articles which focused on primary education was lower and not a considerable amount (n = 5). Additionally, studies were found that addressed both higher education and professional development programs (n = 2), one study for secondary education and vocational education, one study for primary and secondary education, one for further education, and one for general education. It is noticeable that four studies do not mention the educational level of participants (see Table 2).

Table 2. Educational contexts.

Types of Educational Settings	Number of Studies
Primary education	5
Secondary education	7
Higher education (pre-graduate, undergraduate, graduate, and post-graduate)	23
Further education	1
General education	1
Mixed *	4
NS **	4
Total	45

* The players were from different levels of education or a mix of students and professionals within a field. ** Not stated. The studies do not refer to a specific group of players, school type, or educational level.

Most of the studies were developed for formal education (n = 34) in various disciplines, while the remaining eleven studies did not mention content areas. Many studies (n = 13) were developed for various science, technology, engineering, and mathematics (STEM) concepts, educational robotics, technology, and marketing and digital electronics. Additionally, the data show that eight studies were related to natural sciences, such as biology, chemistry, physics, and astronomy, and eight were related to health concept disciplines (medicine, nursery, pharmacy). Moreover, one study covered the field of educational sciences, another one was related to the field of library sciences and three studies covered content from several disciplines. Surprisingly, in the rest of the studies, the discipline area was not mentioned. All these findings are summarized below (see Table 3).

Table 3. Subject areas.

Subject Area	Number of Studies
STEM subjects *	13
Health care subjects **	8
Natural sciences ***	8
Educational sciences	1
Library sciences	1
Mixed ****	3
NS *****	11
Total	45

* Includes science, technology, engineering, mathematics, educational robotics, technology and marketing, and digital electronics. ** Includes medicine, nursery, and pharmacy. *** Includes chemistry, physics, astronomy, and biology. **** Studies referred many content areas (e.g., natural science and technology, infant education and social education). ***** Not stated. Articles examined the use of DEERs as an educational method in general.

5.3.2. Learning Goals

The reviewed research describes learning objectives in different levels after the scrutinized examination. The learning goals describe (i) cognitive or perpetual skills—e.g., acquisition of knowledge and content-related skills, (ii) behavioral/social skills and 21st-century skills, and (iii) affective skills—motivation, engagement, and satisfaction. For most of the DEERs, the learning goals are a combination of content knowledge goals and related skills, such as digital competencies. Among others, the DEERs are integrated into curricula, programs, or courses to enhance or improve learning [37,77], to increase content knowledge [67], to promote effective learning [27], to understand concepts [48,75] and to demonstrate students' knowledge and skills [78]. Less often, ERs are used to introduce (*n* = 7), extend, or integrate (*n* = 3) content knowledge and skills.

Addressing learning goals from a behavioral or social aspect, the majority of studies involve practicing or developing team-building [20], communication/interaction skills [60,63], problem-solving [67], creativity [79] and 21st-century skills [65]. Concerning learning goals about affective skills, most studies refer to the development of motivational skills and engagement in the learning process [46,80,81]. Furthermore, we identified DEERs whose aim was to change attitudes [32], and to provide professional development [82] and training to educational professionals [70]. If compared to medical DEERs, STEM games describe more social skills, such as collaboration and cooperation, problem-solving skills, and skills of the 21st century, such as team-building and creativity. For STEM DEERs, the rationale for communication and team-building is their role in collaborative and team-based environments to foster a deeper understanding of related content [42,83]. In medical and natural science DEERs, the learning goals seem to be more cognitive and affective-oriented.

5.3.3. Educator's Role

The role of tutors, instructors, and designers of DEERs is considered of utmost importance, especially in online collaborative learning environments. More specifically, tutors adopt a dynamic and motivating role in group-work, promoting collaboration between online players [84]. Additionally, the instructors' role is crucial in a game-based pedagogical arena to make sure that the GBL methodology is correctly applied for the learning goals of the ER to be entirely achieved.

Instructors do have a certain role at the introduction of the ER game, during, and after gameplay. In the introduction, participants are introduced to ER rules, such as the use of mobile phones or tablets, the role of collaboration, and less often, the learning goals. Movies, emails, audiotapes, or information sheets were also used instead of oral instructions [20], as well as video sharing to provide instructions and useful guidelines to players on how to participate in the game [19,81]. Additionally, in the study of [50], tutors took on the role of instructors who introduce the materials, the gaming tools, and the procedure of the ER to the participants. In another study, the tutor took on the role of the game master, who provides instructions before starting the game [85].

In the reviewed studies, teachers seem to take on multi-dimensional roles, such as pedagogical, social, technical, and managerial roles. During the gameplay activity, multiple roles of instructors and designers can be identified: (a) monitoring, (b) moderating, (c) guiding, (d) facilitating, (e) providing hints, (f) encouraging, and (g) debriefing. It is remarkable that, in the included studies, the adopted role varies from one aspect to all the above-mentioned aspects. The monitoring role is thoroughly mentioned in the reviewed literature. In eight studies, the role of monitoring was clearly stated. The faculty usually monitored the team's progress for ensuring safety and confirming that all rules were followed. The monitoring process usually took place within the same game room, in contrast to in recreational ERs [45]. In four studies, faculty usually monitored players in the game room [20,66,80,86], and in four studies players were monitored from an adjacent room [19,37,59,77]. The reason for monitoring from an adjacent room is to keep players immersed during the game process, an important factor in game theories for engaging players. However, no study was found in which participants were shown to have felt less

immersed when instructors were physically present in the same room. Students admitted frustrating feelings in case of early guidance [80] or due to time pressure or not properly understanding the given instructions [86].

Moreover, the guiding role of staff members is excessively outlined in the sense of tutors as game masters. Such a role is described by [45], who admits that tutors should only intervene in the game process when it is necessary. In the present review, the nature of guidance is also presented; giving instructions [19,75] and acting as coordinators [85], providing design guidelines and training sessions [71], checking if techniques or skills are correctly performed [59,66], answering questions about rules [20], encouraging students to work as a team [68], and keeping track of teams [64]. Additionally, the facilitator's role is stressed in several studies, especially in terms of providing hints [59,65]. The nature of hints is described in some studies; for example, either a team is given a restricted number of hints [59]—the first hints are free, but if more hints are needed, a time penalty is provided [20,66] or players could earn a hint by completing a small knowledge test, which requires time [11]. Players have the opportunity to receive hints personally or by pre-set hint cards. Concerning pre-set hint cards, there is a need for designers to know exactly what participants need at which moment [59]. The motivations for using hint cards have not been clearly described in the studies, but it is assumed that the hint cards are used to prevent disorganization of participants' immersion, which is a vital element in EER games.

In addition to all these components, tutors observe the whole game during its process and provide formative feedback, facilitating the students to solve the riddles and unlock the door of the DEER [59]. However, there seems to be a loss of direct feedback by faculty during the learning process due to the lack of proximity between staff and players. Reference [77] attributes this to time constraints. Sometimes, they also act as social facilitators and encourage groups of students to collaborate and support them in their effort to escape from the room [68,83]. Additionally, we noticed the technical function of instructors, since they appear to be eager to provide answers about the process and support game methodology [20].

The role of tutors after the game is to conduct a debriefing session, which is emphasized by [45] as a common and well-known concept to mentally process experiential learning activities and recreational ERs. Its purpose is to provide students with an opportunity to self-assess and critically reflect on the game experience [87]. In this review, a considerable number of studies ($n = 13$) mention a form of debriefing by participants, either in the form of facilitated small group discussions or in the form of formal evaluation by participants. A summarized list of the mentioned components of debriefs are presented below:

- Exchange of ideas and reflections on the experiences of the game, since designers are interested in receiving feedback on the procedure and the activity itself.
- Evaluation from participants on the learning objectives and the extent to which they have achieved.
- Discuss and focus on content course knowledge, learning outcomes of each puzzle concerning the learning goals—a vital element, and skills to be developed.
- Reflect on the impact of the game on teamwork and communication improvement.
- Ask questions from participants' points of view and verify their reasoning.
- Discuss new topics that emerged during game activity and extend content knowledge.
- Provide feedback on participants' performances and how they perceived the whole gaming process and experience.

5.4. Common Design and Development Traits in the Use of Digital EERs

5.4.1. Team Size

This refers to the number of participants in each team in the DEER. A group size of two people was identified twice. In a study carried out by [69], for part of each synchronous session, students worked in two-person teams using breakout rooms. In the other study, developers required players to work on all the puzzles, and therefore, on all

concepts and skills [11]. In most reviewed studies, the group size range is between three and six participants, because with a small group of people, instructors achieve greater participation and immersion of players during the digital game [20,66]. Additionally, the group size is examined in accordance with the required playtime. This means that groups consisting of more than six players required more playtime than those with less than six participants. Additionally, none of the groups with team sizes higher than six participants could eventually escape in time, as a result of larger teams hindering communication and organization [59].

5.4.2. Timeframe

The time needed to complete a DEER, solve the puzzles and unlock the door is limited and is determined before the beginning of the game, with players also being notified before starting. The playtime concerns the minutes spent on trying to solve the puzzles, without the introductory phase before the game and the time devoted to debriefing after the end of playing. In this review, the playtime range is between 5 and 130 min, with the majority of games lasting 45 or 60 min. It is worth noting that in one study, there was no time limitation, which allowed flexibility in exploration [74], and in another study, there were no time-restricted gaming sessions [57]. On the contrary, we identified one research study, in which developers gave participants two hours to solve the puzzles since two hours are considered a typical duration of computer lab online sessions [11]. The reason for choosing a specific time limit is rarely justified, and if explained, it depends on certain pedagogical reasons; on the length of the class, the complexity of puzzles and challenges, and the synchronous nature of online sessions [65,69].

The time devoted to playing the game does not seem to be related to specific educational levels or content areas. In science education and STEM, the median time limits are alike—45 min. Whereas in medical education, the median is 60 min. In general, participants in DEERs are urged to complete all puzzles in time. Additionally, it is noticeable that for nineteen DEERs, these data are lacking in the research. In educational settings, reaching the expected learning goals in time is deemed as a vital factor for the success of a digital game in order to prevent feelings of frustration and dropping out. In two studies, where none of the groups completed their mission, participants admitted feeling frustrated and doubted whether or not they had achieved the learning objectives [77,86]. The abovementioned studies suggest testing the puzzles to determine the time involved.

5.4.3. Type of Games, Puzzles and Their Structure

In this systematic review, we came across a plethora of studies which are characterized as fully digital since they incorporated digital-based elements in their DEER games. The overwhelming majority of the selected studies (42/45) are digital EERs and implement a variety of computer-based technologies, such as virtual reality, augmented reality, mixed reality, QR codes, 3D, etc. (see Section 5.4.4). However, a tendency was observed in the current literature, namely, developers of DEERs try to adopt more blended/hybrid EERs solutions, which involve a combination of both digital and analog components and are conceived as new teaching methods for many discipline areas. This finding is surprising and also deserves more clarity from researchers. A lot of questions have arisen, for instance: (a) what are the boundaries of EERs? (b) When do the games start and when do they end? (c) If a game uses, for example, a video to inform the players of the narrative, does it make it a DER game? Additionally, in the study of [18], QR codes were also used in the physical puzzles, so does this use make them DER games? All these issues need to be further investigated. However, digital puzzles may require players to understand, write and/or execute codes in real-time, thus, allowing for more complex challenges to test and improve skills (e.g., programming skills, digital literacy skills), whereas physical puzzles are of great help for enhancing both the immersion of the experience and student engagement in the narrative. Three studies combined online and paper-based clues that were implemented in

their courses [11,20,77]. Such studies revealed the new methodological trend in designing DERs in educational contexts and led learners to a multitudinous hybrid experience.

The game-flow of puzzles has been an element that has often preoccupied researchers. According to [45], the organization of puzzles—open or linear structure, sequential structure, path-based structure, and hybrid structure—has been identified. In the present review, a lack of reference to the structure of designing the DEERs was found. Only one-third of the reviewed studies, namely twelve (26.6%) out of the forty-five studies, mentioned the structure of their design. Among them, three studies formed a linear sequence in their puzzles, according to which, team members solved a single puzzle upon successful completion of a task, which then led them to the next puzzle [37,46,71]. The linear structure of puzzles is preferred by DEER developers since their design requires a team of players to perform a series of collaborative activities [71] or can be aimed at developing anthropocentric interactions and team-building skills [37]. The other eight teams of researchers preferred a predefined sequence and based their choices on designing DEER puzzles on a sequential path-design, according to which, solving one puzzle unlocks the next until the final puzzle can be solved [11,19,58,59,74,79,81,85]. The sequential path seems to be the most common schema for ERs, according to [45], and mainly applies when a large number of teams collaborate to solve the puzzles. In the study of [20], the activity was somewhat linear, meaning that the clue derived from solving one puzzle or problem, led directly to another one in a semi-defined sequence. The choice for this puzzle structure is intentional, according to the researcher; "First, the instructional nature of the hiring process required a defined sequence. Second, the linearity reduced variability in "paths", which made it easier for the instructors to manage and the participants to progress through the entire game" (p. 45).

The description of the puzzles in the present review indicated that some puzzles were based on puzzles commonly used in recreational ERs, such as sudokus, rebuses, crosswords, cryptograms, challenges, and riddles or hidden objects and words with hidden messages [88]. Additionally, these studies can be recognized according to the categorization of puzzles of [4] (see Section 2.2). In most of the reviewed studies, cognitive puzzles seem to predominate in DEERS, since they make use of the players' skills. For example, in a reviewed study, puzzles were designed using automatic constructions, secret codes, vaults, padlocks, hidden clues, interactive puzzles, and missions to accomplish, as well as to develop cognitive, kinetics, and social skills [89]. In another study, that aimed to develop collaborative skills by doing, puzzles included more complex activities, such as ciphers, jumbles, coded messages, combination locks, rebuses, and data hunts [46]. Other puzzles can be characterized as meta-puzzles, obviously connected to the narrative, for example, jigsaws [83] or online jigsaws [82].

5.4.4. Application of Digital Technologies

Of the 45 reviewed studies, all of them are entirely based on the digital medium and offer a digital experience to online players. In four articles, as stated before (see Section 5.3.3), digital technologies were used to monitor students' safety and progress from an adjacent room. Digital technologies serve various goals in DEERS, which depend on the educational content area of the courses incorporating DERs. The STEM education and healthcare disciplines are pioneers in implementing DEERS in their curricula. In the field of medicine, digital technologies are primarily used for structuring the game, such as unlocking new puzzles by scanning a QR code [86], and make the work of tutors easier, which is significant especially for large groups [20]. Furthermore, it is found that technologically enhanced tools are necessary for students to search and interpret medical knowledge [59]. Concerning STEM disciplines, online tools are used as part of the DEER game learning goals [11]. Similar to in healthcare education, in STEM content areas, digital technologies are utilized to structure the digital game when referring to large groups [79].

It is noteworthy that a variety of digital tools are detected in the included studies. A great deal of DEERS use virtual reality (VR) and augmented reality (AR) technological tools

for serious purposes in educational settings. VR and AR are necessary tools, especially for building social interactions between players and teamwork in ERs [63,71], as well as for cultivating interactions within a network [83]. Moreover, in many studies, we found immersive technologies, such as mixed reality (MR), which is a relatively new environment that makes it possible to enhance users' experience of physical ERs with rich digital context and can be identified both in STEM and medical education [60,90]. Smartphone technologies, 3D applications (e.g., 3D graphics), 360 videos, QR codes, Google Forms, social media platforms, virtual cameras, video conferencing, video tutorials, robotics, mobile devices, and tablets are some of the digital objects and elements that are incorporated into the various puzzles of the DEER activities in the selected studies. All these digital tools make learning more effective by promoting students' opportunities for online communication, social interaction, and cooperative gamified-oriented activities between teammates.

5.5. Evidence of Impact and Outcomes for DEERs

5.5.1. Development of Cognitive Skills

Since no scientific evidence concerning DER learning outcomes in educational surroundings were found, it is crucial to analyze the effects of ERs in digital educational environments and harmonize them to learning goals. The included studies emphasized the application of DEERs and their effects on the cognitive domain, related to knowledge acquisition, understanding knowledge, enhancing knowledge and active learning, cognitive load, and transfer. Evaluation of the DEERs' learning performance was conducted through post-test surveys and feedback sessions, namely online questionnaires, interviews, group discussions, observations, debriefing, and test scores. Only seven studies measured the achievements on the learning goals utilizing a pre-and post-knowledge test and one study made use of a pre-test assessment.

From the 20 studies which investigated the learning results of the students, the participants ranged from a vast majority to all perceived DEERs as effective tools [37] that assisted them in achieving the learning objectives and/or consented to their implementation in the curriculum. Only one study reported that DEER is not suitable for teaching higher-level concepts, since it is time-consuming and can run for a small number of individuals [77]. These findings are extremely significant as they indicate the positive impact DEERs can have on the learning performance of students. The integration of DEERs into the curriculum is in line with pedagogical learning strategies, such as GBL, problem-based learning, collaborative learning, and active learning that are recruited for facilitating and enhancing learning outcomes, since several studies increased academic results by integrating such strategies [46,74,82,91].

A correlation between increased engagement, motivation, and learning results were identified [68,74,83]. All studies that measured both learning and motivational outcomes and reported increased academic performance also noted improved motivation, positive behaviors, and feelings, or significantly influenced learning-related attitudes, such as learners' engagement. As a consequence, our results show a strong relationship between improved motivational and engagement outcomes and significant learning achievements. Interestingly, in one study, participant engagement (n = 124) and perceived learning outcomes in DEERs were closely related [11].

In the reviewed studies, it was portrayed that students sufficiently understood the meanings and properties of many subjects and reported positive learning outcomes. More specifically, the active acquisition of knowledge and a deeper understanding of new concepts were related to many subjects; diabetes [59], programming [11], biology [74], electromagnets [48], astronomy [91], mathematics [32], engineering [83], and numerous other content areas. In [59], a cross-sectional pre-and post-test research design was adopted to evaluate the players' performances (n = 74). It is worth noting that a week passed between the pre-knowledge test and the DEER game. Students' mean score for the post-test (81%), was statistically higher than the mean score for the pre-test (56%).

5.5.2. Development of Behavioral Skills

The studies selected for the literature review were also focused on the use of DEER games and their important impacts on the behavior domain, concerning changes in users' behaviors and attitudes, and what is more, in the development of 21st-century skills. The selected studies evaluated these goals based on tutors' observations in the online platforms and/or students' self-perception/evaluation. The ER activities reinforced and strengthened social interactions and peer relationships, which helped to establish a great sense of belonging in the group of players. The 21st century skills enabled players to participate in online learning communities within an emerging network society [83].

Among the skills that were found in several studies, it can be claimed that they lead to the promotion of collaboration [62,63,92], cooperation [20,86], social interaction, and communication [67,93], as well as problem-solving [32,83]. Improved analytical skills, such as higher-order thinking skills [42], creativity and imagination [70,79], entrepreneurial skills [89], and self-confidence skills, especially in managing medical cases [66], were also indicated to have benefitted from applying DERs in education. Additionally, other skills such as increased team-building and group dynamics were reported to have emerged in many studies [60,78,81]. In the reviewed articles, there seems to be an obvious diversity concerning team-work and the time needed to perform a task or solve an online EER puzzle. Consequently, it can be concluded that with an appropriate design, team-work is a prerequisite to complete a DEER in time.

Given the importance of digital skills, due to the digital transformation of society, practicing and developing digital literacy skills and ICT competencies are highlighted as the intentions of educators in integrating DERs in all educational levels and contexts [70,89]). Although current research [94] and political resources [95,96] have portrayed digital skills and skills of the 21st century as key career competencies and a political priority, it is surprising that only a few articles have focused on the application of DERs in primary and secondary education [27,73,89] and teacher education [85]. It is worth noting that there are studies that addressed a great deal of 21st-century skills in their DEER design process. For example, in the research of [65], emphasis was given to the creation of key competencies and skills, such as collaboration, teamwork, digital literacy, and higher-order thinking skills.

5.5.3. Development of Affective Skills

During our investigation, of the 45 studies included in the systematic literature review, three outcomes concerning the affective domain were highlighted: engagement, motivation, and satisfaction. The included studies based their findings on students' feedback after the gameplay mainly through post-test evaluation surveys/questionnaires, interviews, group discussions, and observations. As the studies addressed different questions, postulations, and answer scales, it is impossible to aggregate the participants' answers. Some inefficient outcomes were noted and analyzed in a few articles, which reported important issues, for example, between those students who had managed to complete the tasks and puzzles encountered in the sessions and those who had not [77,80,86]. However, in most of the studies, the vast majority of participants highly appreciated the gaming activities and expressed positive views about the integration of DEERs in the curriculum [73,91]. More specifically, players felt highly satisfied with the whole experience [74] and viewed DEERs as a fun, interesting, challenging, and enjoyable gaming experience [50,88]. Additionally, they stated that DEERs would be applicable in many disciplines and are easy to use as didactic tools [48], attractive and excellent educational tools [72,79], and pleasant alternative ways for active learning [19].

Enthusiasm, curiosity, fun, a sense of enjoyment, satisfaction, and all positive emotions towards DEERs are values that are directly associated with intrinsic motivational aspects [19,32,80,90]. Although some studies did not measure the impact of DEERs on motivation [48,83], all other studies revealed a general increase in motivational outcomes, indicating the possible positive affordances such innovative tools have when incorporated into educational settings. Furthermore, extrinsic motivational factors and achievement-

based rewards, such as praise, promotion, recognition, competition, time constraints, game grading, "victory signs", leaderboards, and bonus points, as part of the game procedure to stimulate users were noticed in some studies [20,65,74,93]. While rewards should not be a panacea for completing the DEER game process, they can serve as a supplemental incentive for students. We assume that researchers interpreted the motivation for winning as an intrinsic motivation for learning. Nevertheless, both extrinsic and intrinsic motivational factors are considered part of any ER game and have a pivotal role in students' learning performance by fulfilling their needs for competence and autonomy. As a result, to acknowledge only one motivational aspect or take into consideration one without the other, will only give an incomplete consideration.

Moreover, findings of the students' evaluation indicated high levels of engagement with content in their effort to solve different challenges and enigmas in DEER game activities [61,69,85]. Based on our analysis, players' positive attitudes, motivation, and involvement are directly linked to enhancing and better understanding scientific concepts, generally improved learning outcomes, and creating meaningful learning experiences [74,75], as well as supporting the development of their skills [89]. A finding worth mentioning is that in reference [11], 84 participants were tested for gender bias. The male participants showed a high tendency towards DEER gaming, whereas the females showed a statistically significant lower inclination. However, no gender bias was detected in any of the questions in the surveys that addressed the DEER. Ultimately, integrating DEER learning activities can engage students in both synchronous and asynchronous online environments [68].

6. Discussion of the Results

Although the implementation of DERs in education is deemed as a novel trend in the scientific literature that is still academically unexplored, this work presents a systematic review of the current literature, focused on the use of such innovative didactic tools in educational settings over the past sixteen years. In the present study, there is a marginal focus on the holistic view of the application of DERs in educational environments. The scope of the literature search was limited to EERs with the use of digital technologies, addressed at different educational levels of formal education. As students were born and have grown up in the era of user-friendly and multiple-purpose digital technologies, new forms of technologically enriched EERs have been developed for educational purposes. The results seem to reveal that DEERs are innovative, promising, immersive, active, and collaborative instructional approaches that can guide and shape learning achievements more greatly than traditional educational methodologies.

Since 2017, the study of ERs has increased and spread around the academic world, incorporating technological tools and expanding into areas beyond the entertainment section, such as education. Although this scientific field is still in its infancy, the majority of articles have prioritized theoretically mapping the current situation in the use of ERs in education [21,41,97], designing ERs for pedagogical purposes [30], reporting the users' experiences in collaborative rooms—either real or virtual [98], or collecting and providing feedback data on learners' performance, the degree of content understanding and participants' perceptions for the use of the ER games in post-activity tests [14]. By identifying gaps in the literature, the aim of this paper was to review the methodological approaches and assessment tools utilized to collect the data derived from participants' responses and tutors' points of view, to present common education and design characteristics and practices in the use of DEERs, and to examine their impact on specific learning achievements in cognitive, behavioral and affective sectors.

6.1. Key Findings and Implications

The majority of reported articles used a variety of methodological approaches and data collection assessment techniques for evaluating the DEERs either from the scope of players or instructors–designers. The ever-increasing production of publications in this

field reveals the curiosity of researchers as regards ER methods in educational research. Still, little attention has been paid to the research design and methods applied in data collection, assessment tools, and the analysis of results in DEERs studies. This is comprehensible given the preliminary phase of the use of such games and the experimental design approach to the use of DEERs as pedagogical tools. The analysis showed that most studies used either quantitative or strictly qualitative methodological approaches. In some other cases, mixed-method research methodologies were adopted for triangulation reasons, thus, strengthening the validity of findings. Except for the conventional means of extracting data, some of the studies used data gathered through the DEER game applications and interactive platforms, and smart technologies. These digital applications have the potential to provide immediate and useful feedback data, in order to support researchers' findings (e.g., scores of quizzes, final assessments). Additionally, during the learners' participation in the DEER, the debriefing phase is their opportunity for further interpretation and reflection; without becoming involved in the reflection stage, the gaming experience cannot lead to effective, immersive, and long-term learning outcomes. To our surprise, only 12 of the reviewed studies included debriefing details in their DER experience, despite the value of designing debriefing sessions as an integral part of collaborative DEERS [6,99].

As such, more attention should be given by designers to the research design and methods for collecting data and addressing assessment tools, so as to evaluate the learning outcomes of players who are involved in the DEER gaming process. It is suggested that both pre-test and post-test surveys should be conducted, so as to identify what knowledge acquisition is expected and what is finally achieved. Furthermore, it would be beneficial to include different types of assessment, such as interactive peer assessment, self-critical assessments and reflective observations to assist in achieving a more holistic evaluation of the DEER from the learners' perspectives. It is considered to be of extreme importance for future designers to identify the learners' scope and views in order to avoid designing DEERs which will not lead to learners achieving the learning goals and objectives. Furthermore, through their opinions—especially if negative feelings are reported—designers may seek the opportunity to identify misconceptions, omissions or even the mistaken formulation of puzzles and review them in the next phase when deciding to design new ER puzzles.

The largest representation of publications belongs to European countries, whose designers seem to show their clear preference in recommending more GBL activities in educational surroundings. The most commonly chosen target group is higher education students, whereas a smaller representation of secondary and primary education students was noticed. This finding is consistent with other recent reviews of the literature, which, however, mainly emphasized the impact of physical ERs in general in educational settings. It seems that the secondary and primary education studies lag behind higher education research [21,41]. This finding may be attributed to the fact that tertiary educational institutions usually have better resources, and the faculty members have high levels of expertise in digital technologies and are probably more research-focused compared to school teachers. It might also be attributed to the fact that in primary education, there is more focus on learning through gameplay using all the senses, and young children make less use of digital technologies. Hence, educators at universities are probably more likely to carry out high-quality research designs. Nonetheless, given the eagerness with which school teachers are constantly trained through professional development programs—especially during the COVID-19 pandemic period—and adopt ER modes in their digital classes [27,82], this representation will probably change. Thus, it is highly recommended that, in the future, more online designers should organize DEERs to be offered to school teachers to maximize their students' eagerness for learning.

Concerning the domain of the DEER application, this review indicates that most DEERs cover subjects related to the broad field of STEM Education. This technology-oriented domain is regarded as a shift and is reflected in emerging research priorities [11,19]. STEM studies are integrated into a plethora of curricula units due to their interdisciplinary nature [100]. In such fields, the use of digital tools is a key part of the learning process.

They are used to structure the game and ease the tutors' work in digital classes, which is of utmost significance, especially when faced with challenges such as large enrolment classes or courses while ensuring active participation and collaboration, along with facilitating a balance between instructors' guidance and students' autonomy level. In healthcare DEERs, digital technologies are primarily used for structuring the gameplay activities or are utilized by students to search and interpret medical information. It is considered of paramount importance for future research to more thoroughly explore DEERs and their usage in other discipline areas as well as in the subject areas of philosophy, philology, linguistics, and the arts, to provide players with an immersive playful experience. Additionally, it is suggested that DEERs' potential, affordances, benefits and boundaries should be clarified and linked with the whole spectrum of all educational levels.

As regards the learning goals of the DEERs, they describe cognitive, social, and affective skills, mostly related to motivational and engagement factors. The majority of DEERs depict a combination of perpetual skills (acquisition of knowledge, new concept understanding), and related skills, such as digital competencies or programming skills. Less often, DEERs are used to introduce, extend, or integrate content knowledge and skills. Looking at the learning goals from a behavioral aspect, most of them involve practicing or developing team-building, communication and social interaction skills, problem-solving, creativity, and 21st-century skills. These skills have been recognized as core skills for all levels of education and the workforce in research-based orientation papers [101,102] and formal policy debates [103]. This review also investigated the learning goals related to affective skills. Most studies refer to the development of motivation and engagement of learners as well as changing attitudes. STEM DEERs research describes more social skills, thus, responding to the collaborative nature of DEERs, whereas healthcare and natural science DEERs highlight more cognitive and affective-oriented skills. Consequently, it is suggested that designers and instructors should design puzzles aimed at involving all of the abovementioned domains, resulting in a high success rate for their students; success provides learners with positive learning experiences and feelings of confidence about themselves. To do so, they should create interesting and challenging puzzles, neither too easy nor too difficult, to prevent boredom or drop-out.

We also concentrated on the tutors' role in the introduction, during and after gameplay. In the introduction, players are introduced to ER rules, the materials, the gaming tools, and less often, the learning goals. Tutors take on a supervising and game master role to aid in providing clear instructions before the game starts, a finding which is consistent with other studies [10,52,104]. During the gameplay, instructors take on roles related to monitoring, moderating, guiding, facilitating, providing hints, encouraging participants, and debriefing. After the game, tutors usually debrief, give valuable feedback to participants, and discuss any themes that arose during the game session. Tutors are recommended to be the overall supervisors of the gaming process and intervene only when required, to allow learners to become more autonomous in learning. Since the debriefing process is highlighted in related research [105], it is suggested that tutors provide suitable feedback in the form of debriefing after the completion of the gaming process. In this regard, future research should be conducted to investigate the feelings of students after the debriefing process.

Although the selected studies do not always describe considerations for all choices made in relation to the design game aspects, we came across specific design traits in the application of DEERs. Team sizes ranged between three to six players, which allowed for the achievement of greater participation and immersion. Small numbers of group size are detected, due to the educational nature of such games and because large group sizes are more difficult to manage [106]. In this context, it would be preferable for designers to design puzzles addressed to less than six players to avoid being disorganized and fail in unlocking the door and escaping. The time needed to solve the puzzles and finally unlock the door and escape is determined and notified to the players before participating, and is mentioned to be in the range of 45 up to 60 min. It should be noted that time limitations are irrelevant to the educational levels or discipline areas. However, in some game scenarios, time is

considered an important factor for completing the game. For example, in medical DEERs, time-constrained activities are considered a vital design element but also a pedagogically significant factor, since peer collaboration under time pressure is a key skill for saving lives in medical professions. Researchers anticipate that the time frame can affect the learning procedure while participating in a DEER activity [81]. Therefore, designers should range the playtime after seriously considering the complexity of the riddles, or there should be no time restrictions for allowing more flexibility and deep discussion and cooperation between players.

The DEERs included in this study can be characterized as fully digital since they implement digital elements in their structure. They incorporate multiple digital applications, interactive social media platforms and smart technologies. The reasons for applying digital technologies are manifold, namely: (i) to monitor students' safety and progress from an adjacent room, (ii) to structure the DEER game, (iii) to make instructors' work easier, (iv) to cope well with large groups, (v) to help learners' search for and interpret new knowledge (in medical studies), thus, leading to great immersion. This finding complies with the research of [107], which argues that digital tools are used to support the narrative, and lead students to immersive experiences. Nonetheless, in recent years more hybrid solutions are mostly preferred by designers, since they include both digital and analog elements which target larger groups of participants. Digital puzzles require more complex skills to be taken into consideration, namely digital literacy and computer programming skills. The abovementioned digital tools enhance effective learning and promote opportunities for online communication, social interaction, and collaborative GBL activities [108]. Thus, it is useful for future designers to design more hybrid types of DEERs that use augmented reality and virtual reality technology, a type that is expected to be widely adopted in the future [21].

DEERs research has also been heavily divided in terms of the potential it can encompass as regards students' significant academic results. The achievement of learning outcomes has been related to the gaming learning goals (see Section 5.3.2). Such a paradigm is positively perceived by learners since high levels of fun/enjoyment, knowledge acquisition, active learning, cognitive load, and transfer are reported. It can be argued that by considering the prevailing learning theories, DEERs incorporate core elements from a multitude of dynamic pedagogical approaches underpinning DEERs. Collaborative learning theories and teamwork orientation were embodied in the design of DEERs since players were called upon to act as a team aimed at a common goal. The need for participants to work collaboratively to succeed in a time-pressured but enjoyable gaming setting allows them to develop multiple communication skills as well. At the heart of ERs is the social dimension in the form of cooperation between players and the network of relationships that arise [33]. Such collaborative and active learning fosters learning outcomes and leads to the deep assimilation of knowledge. Additionally, elements of GBL are integrated into DEERs since these games have existed within a time frame, certain scenarios, and concrete challenges for participants. In parallel, innovative DEERs are primarily structured following the rules based on problem-solving learning theory, as games are based on solving puzzles and problematic situations that students should process to unlock the room, escape from it, and eventually win. However, not all of the reviewed studies described theoretical considerations for all choices. Thus, other new lines of interest in research on DEERs could be found in combining them with educational methodologies and learning theories as well as the justification of all choices in relation to the studied educational aspects and the common practices.

It is crucial that, regardless of educational content and level, DERs in education are conceived as effective and auxiliary educational tools for understanding difficult concepts through the traditional way of teaching methods. What is more, DEERs are deemed as valuable educational tools that can be transferred to other campuses and institutions [72]. Indeed, in a few studies, a great transferability of DEERs into different curricula has been reported in terms of topic subjects and levels of students. Interestingly, current research has

indicated that students report high levels of engagement and motivational skills as a result of the gaming activity, leading to positive learning outcomes. This result is compatible with previous studies: that the more motivated and engaged students are, the more likely they are to achieve more significant learning results [16,109]. DEERs also assist students in understanding the value of seeing problems from different perspectives, exposing them to collaborative teamwork, strengthening social interactions and activating team-building spirit, leading to effective attitudes and behavioral outcomes. Researchers have illustrated the opportunities that DEERs provide to online learners, educators and professionals to enhance the development of analytical skills, communicational skills, 21st century skills, as well as practice problem-solving strategies in the workplace. This finding is in line with other studies in the field, which outline the positive impact of ERs in developing soft skills—critical thinking, communication, active listening, collaboration, teamwork, and shared leadership [107,110].

Researchers have also focused on affective outcomes, such as fun, enthusiasm, sense of enjoyment, curiosity, satisfaction, engagement, and motivation. A large proportion of research has emphasized these intrinsic motivational factors and students highly appreciated the gaming activity and expressed positive views about the incorporation of DEERs in academic courses. Additionally, positive attitudes and high satisfaction ratings have been portrayed, since players viewed DEERs as a challenging, pleasant, and transferrable gaming experience, which can be addressed by many scientific fields. Furthermore, multiple extrinsic motivational mechanics and achievement-based rewards can be detected, such as praise, promotion, recognition, competition, time constraints, game grading, "victory signs", leaderboards, and bonus points. Research has shown that external motivating factors can be effectively used "to engage learners when they initially view the activity as low value" and "to narrowly focus attention and to shorten time perspectives" [111] (p. 222). Although prizes and points are not deemed as the main targets of a DEER activity, however, they still represent a significant game element. It is suggested that the combination of intrinsic motives with external rewards can affect the development of skills and enhance the understanding of scientific concepts, even those that were considered difficult to understand, for example, mathematical concepts. In this way, motivational elements fulfill students' need for autonomy in absorbing new information in digital learning environments, thus, leading to positive learning results.

The study of DEER games opens new horizons in the academic field since the quantity and quality of data produced can be increased, providing valuable insights into the students' learning experience. As a result, the continuous integration of digital GBL methodologies in education is a widely noticed phenomenon highlighted in the modern curricula for supporting the learning process. Still, future research should try to address issues that relate to different aspects of DEERs, such as the mechanics and elements utilized in DEERs, as well as educational strategies. Additionally, more studies must be conducted in regard to DERs in different levels of education, mainly primary and secondary education, and in various educational subjects, due to the digital revolution and the demand for implementing new technological tools to determine the extent of the impact of DERs on education. Furthermore, tutors, as designers of DEER games, can heavily influence the DER procedure in digital educational environments. Some of the reviewed studies were associated with vocational education, and the designers were eager to incorporate DER strategies in their teaching. In this sense, research on the instructors' perspectives of how they view the use of such innovative tools, could provide valuable information concerning students' learning outcomes.

Additionally, we recommend some valuable guidelines for the development of prosperous DEER games:

(i)   Adopting a game-designed framework and well-defined design criteria and key pillars. This might lead to a game that more adequately meets the learning goals, adapts to educational learners' needs, and focuses on key competencies for the target audience.

(ii)　Creating hybrid learning experiences. The combination of digital with analog elements can foster the learners' transfer from the conventional classroom context to the digital game context, thus, stimulating collaboration and team-building skills among learners.

(iii)　Using sustainable materials (materials that can be produced in required volumes without depleting non-renewable resources), with the aim to create digital sustainable EERs. In education, since budgets and time are usually restricted, designers are forced to favor reusable and multipurpose educational materials [21,35].

To conclude, the present literature review intends to contribute to the instructional design by providing clear evidence of the potential of DEER games to support teaching and learning across different discipline areas. The results may extend the roadmap for further research, offer new insights to researchers and educators, and provide tutors with effective advice and suggestions on how to implement DEERs into their educational practice.

6.2. Limitations and Future Research Agenda

Despite our efforts, this study had several limitations could have threatened the validity of our work. As only 45 studies were eligible for inclusion, more scientific research is required to thoroughly understand the scope, use, potential and boundaries of DERs in educational contexts. DEERs research has been primarily focused on STEM education, rather than other discipline areas, such as the natural sciences or sustainability education. Although an increase in the number of studies published in the literature in relation to natural and medical education has been noted (8 + 8 studies), a more significant sample of studies could provide more concrete results of the effects of DEER on students' learning performance. This sample may clarify the gaps in the literature related to the significance of pedagogical theories underpinning DEERs, the impact that DEERs have on learners' achievement and their interrelation with specific learning theories.

The present review of the research on the use of DER games for educational purposes has indicated that this research field is still in its infancy and that it is about time researchers entered a more thorough phase of research. We used multiple database searches, but potentially relevant publications could have been overlooked due to bias in selecting databases or in the search strings used for our searching. However, future studies could utilize more engines, electronic libraries, indexes, or databases in their research, such as Academic Search Premier (EBSCO) and ProQuest, to mitigate the bias in selecting databases. Furthermore, to overcome language bias—since only articles written in English were included—we could have searched for publications in other languages than English. Moreover, future researchers could further expand their investigations to include other types of publications that could provide deeper insights, such as books, PhD-theses, and conceptual papers. By omitting these publications, we are aware that we may have missed some important empirical and peer-reviewed papers on the significance and potential of DERs in education. Despite the exclusion of such types of publications aiming to increase the validity of our research, the preliminary phase of DERs in education could benefit from more in-depth information being extracted from the abovementioned resources, as proposed by [28].

Another considerable limitation in our review is that in some important research parameters were overlooked. For example, some studies did not include the characteristics and demographics of the samples utilized, such as the educational level, content areas, number of participants, etc. Such data have been found to affect DER game current practices, which also affects the generalizability of our findings. If all the necessary information was included, more valid results may have been obtained.

Additionally, we should mention that the analysis and interpretation process may challenge the trustworthiness and consistency of qualitative work. However, in every single part of this work we have attempted to explicate the whole systematic review process from the rationale of the study, the research methods, as well as the selection and analysis phase,

striving for objectivity in our decisions, interpretations, and selections and aiming to secure the trustworthiness and consistency of our work.

7. Conclusions

In the present study, we carried out a systematic literature review, the purpose of which was to depict the current state of the literature on the application of DERs games as innovative instructional tools for educational purposes. This review provides us with valuable information and insights, and in this way, enriches the current state-of-the-art applications in this field in multiple ways. Primarily, we increased our understanding of the ways DERs are applied in various educational contexts. We identified the current developments and trends in the current literature in the use of DEER games and put an emphasis on important educational and design characteristics. Additionally, we examined the impact DEERs have on students' learning outcomes in cognitive, behavioral, and affective domains. Another valuable contribution of this research is demonstration of DEERs' capability to reinforce data collection from participants in research studies by incorporating new assessment tools such as follow-up polls, formative or informal feedback, comments on the game platform, scores of quizzes, debriefing and so forth. Following the e-learning definition of [112], DEERs are also considered a suitable way for improving access to training, communication and interaction, while facilitating the adoption of new ways of understanding and developing remote learning. Finally, we provided actionable guidelines, concrete future directions and theoretical lenses for future designers and researchers to better address the challenges in the field.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available in this article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Author(s), Publication Year, Journals/Conferences/Chapters of the reviewed articles.

Author(s)	Publication Year	Journals/Conferences/Chapters
Hämäläinen, Manninen, Järvelä, and Häkkinen [71]	2006	The Internet and Higher Education
Hou and Chou [48]	2012	ICCE
Bassford Crisp, Sullivan, Bacon and Fowler [83]	2016	Research in Learning Technology
Pendit, Mahzan, Basir, Mahadzir and Musa [88]	2017	Information Technology (INCIT) International Conference, IEEE
Lin, Wang, Zhung, Wang, Wang, Li, Li, and Hou [50]	2017	Advanced Applied Informatics
Glavaš and Stašcik [32]	2017	Mathematics education as a science and a profession MATH TEACH
Eukel, Frenzel, and Cernusca [59]	2017	American Journal of Pharmaceutical Education
Borrego, Fernández, Blanes, and Robles [19]	2017	Journal of Technology and Science Education
Clarke, Peel, Arnab, Morini, Keegan, and Wood [37]	2017	International Journal of Serious Games
Warmelink, Mayer, Weber, Heijligers, Haggis, Peters, and Louwerse [60]	2017	Extended abstracts publication of the annual symposium on computer–human interaction in play
Whitton [61]	2018	Research in Learning Technology
Wise, Lowe, Hill, Barnett, and Barton [62]	2018	Journal of Information Literacy
Giang, Chevalier, Negrini, Peleg, Bonnet, Piatti, and Mondada [80]	2018	International Conference Educational Robotics

Table A1. *Cont.*

Author(s)	Publication Year	Journals/Conferences/Chapters
Marinou, Papoutsidakis, and Tseles [89]	2018	International Journal of Engineering Science Invention
Adams, Burger, Crawford, and Setter [66]	2018	Journal for Nurses in Professional Development
Williams [67]	2018	IEEE Integrated STEM Education Conference
Hermanns, Deal, Campbell, Hillhouse, Opell a, Faigle, and Campbell [86]	2018	Journal of Nursing Education and Practice
Cain [20]	2019	Pharmacy Teaching and Learning
Lien, Wang, Wang, Li, and Hou [75]	2019	8th International Congress on Advanced Applied Informatics
Mystakidis, Cachafeiro, and Hatzilygeroudis [74]	2019	10th International Conference on Information, Intelligence, Systems and Applications
Hanus, Hoover, Lim, and Miller [63]	2019	IEEE Conference on Virtual Reality and 3D User Interfaces (VR)
Karageorgiou, Mavrommati, and Fotaris [85]	2019	13th European Conference on Game-Based Learning
Mills, and King [78]	2019	The Power of Play in Higher Education
Musil, Gartner, Pesek, and Krašna [92]	2019	42nd International Convention on Information and Communication Technology, Electronics and Microelectronics
David, Arman, Chandra, and Nadia et al. [58]	2019	4th International Conference on Computer Science and Computational Intelligence
Rosenkrantz, Jensen, Sarmasoglu, Madsen, Eberhard, Ersbøll, and Dieckmann [72]	2019	Med Teach
Peleg, Yayon, Katchevich, Moria-shipony, and Blonder [81]	2019	Journal of Chemical Education
López-Pernas, Gordillo, Barra, and Guemada [11]	2019	IEEE Access
O'Brien, and Pitera [65]	2019	Journal of Educational Technology Systems
Montoro, Colón, and Moreno [70]	2020	Educational Technologies 2020 (ICEduTech 2020)
Lior [42]	2020	International Journal of Advanced Statistics and IT&C for Economics and Life Sciences
Ang, Ng, and Liew [38]	2020	Journal of Chemical Education
Estudante, and Dietrich [93]	2020	Journal of Chemical Education
Gomez [82]	2020	Journal of Technology and Teacher Education
Huang, Kuo, and Chen [27]	2020	Thinking Skills and Creativity
Xi, Dai, and Mark [90]	2020	International Journal of Modeling and Optimization
Jiménez, Arís, Magreñán Ruiz, and Orcos [78]	2020	Education Sciences
Cates, Krueger, Simpson, and Stobart-Gallagher [64]	2020	Cureus
Neumann, Alvarado-Albertorio, and Ramírez-Salgado [68]	2020	Journal of Technology and Teacher Education
Vicari [91]	2020	International Journal of Designs for Learning
Monnot, Laborie, Hébrard, and Dietrich [79]	2020	Education for Chemical Engineers
Eukel, Frenzel, Frazier, and Miller [46]	2020	Simulation and Gaming
Saltz, and Heckman [69]	2020	Online Learning Journal
Chou, Chang, and Hsieh [73]	2020	*Technology, Pedagogy and Education*
Dochtsis, Kotsifakos, and Douligeris [57]	2021	Internet of Things, Infrastructures and Mobile Applications

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