The impact of escape rooms as an innovative strategy to enhance professional education: A systematic review and bibliometric analysis

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Abstract

Escape Rooms have emerged as a novel approach in educational pedagogy, recognized for their potential to enhance students' thinking skills and creativity. This study undertakes a comprehensive systematic review and bibliometric analysis of escape room research in the educational sector, drawing on the Embase, Scopus, PubMed, CINAHL, Web of Science (WoS), and MEDLINE databases to chart the evolution, impact, and future trajectory of this field. As Escape Rooms become a significant trend in the era of information technology, they offer a revolutionary way to improve learning experiences. By conducting a detailed bibliometric and co-citation network analysis of 156 articles published between 2017 and 2023, carefully selected for their relevance to Escape Room research in education, this study identifies key papers that are central to

the discourse in the field. The analysis provides a thorough overview, covering publication trends, citation rates, distribution of research across various disciplines, impact of journals and authors, international collaborations, and influential works. The findings underscore the importance of Escape Rooms as an innovative teaching strategy, capable of boosting learning outcomes and student engagement. This research offers valuable insights and serves as a foundational guide for future investigations in this rapidly expanding area.

Keywords: Bibliometric analysis, Co-citation network analysis, Escape room, Professional education.

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Disclosure statement

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Introduction

An escape room is typically a physical adventure game in which participants are locked in a themed space and must solve a series of puzzles, riddles, and challenges to escape within a set time limit (Khanna et al., 2021). Players must work together, usually in groups, to search for clues, decipher codes, manipulate objects, and uncover hidden compartments or passages (Zeng, He, & Pan, 2021). Scholars have identified that escape rooms usually use a specific storyline or scenario to set a theme, such as haunted houses, prison breaks, spy missions, or treasure hunts (Eukel, Frenzel, & Cernusca, 2017). The puzzles and challenges were designed to test the participants' problem-solving skills, teamwork, creativity, and physical abilities (Ang et al., 2020). The ultimate goal is to unlock the final door or solve the final puzzle that leads to the exit, allowing the players to "escape."

Scholars have noted that escape rooms have gained popularity worldwide as a form of entertainment and team-building (Botturi & Babazadeh, 2020). A well-designed escape room that incorporates elements of storytelling and theatricality to enhance the overall atmosphere can provide an immersive and interactive experience for players (Podlog et al., 2020). A combination of time pressure and the need for effective communication and collaboration among participants adds excitement and challenge to the experience. As new technologies continue to be developed, escape room designers are constantly exploring new ways to incorporate innovations that help provide an engaging, interactive, and immersive experience for participants (Au, 2022).

Escape rooms can thus be designed to incorporate educational elements for a fun

and valuable learning experience; some scholars have already begun to explore their value within educational contexts. For example, Hopper (2019) described escape rooms that are set in historical periods or around specific events . These require learners to use their knowledge of history and social studies to solve puzzles associated with that time. By engaging with these historical contexts, participants can gain a deeper understanding of the subject matter and develop their research and analytical skills. In addition, Sowell (2020) noted that escape rooms can incorporate themes around language, art, and literature by basing the puzzles and challenges on famous books, poems, or literary genres. By analyzing texts, deciphering codes, and solving wordplay puzzles to progress in the room, participants simultaneously draw on their prior knowledge and build reading comprehension, critical thinking, and literary analysis skills. Another example is described by Veldkamp et al. (2020), who developed escape rooms specifically designed to explore themes in science, technology, engineering, and mathematics. These puzzles and challenges can involve scientific principles, logical problems, engineering concepts, or mathematical equations, and can provide hands-on, experiential learning opportunities that encourage critical thinking and problem-solving skills.

Morrell and Ball (2020) integrated escape rooms into healthcare education to promote problem-solving and collaborative skills. By working together in teams, participants can learn how to communicate effectively, delegate tasks, and leverage one another's strengths. These skills are applicable in various educational disciplines and real-life situations. Morrell and Eukel (2021) developed a cardiac escape room for undergraduate students to enhance their critical thinking and clinical reasoning skills while fostering teamwork, communication, active learning, and engagement with the subject matter. Their findings demonstrated that escape room activities have the

potential to be an innovative and effective teaching method. Thus, educational escape rooms can be tailored to specific age groups and learning objectives to offer dynamic and interactive learning environments that engage students in hands-on activities, promote practical participation, and enhance their knowledge retention.

This study provides an in-depth assessment of the citation patterns of articles pertaining to escape rooms using bibliometric analysis. Bibliometric parameters, including publication and citation counts, have become indispensable for evaluating academic productivity and research impact (Wang et al., 2022). Among these parameters, the h-index is noteworthy because it identifies the author's most influential papers based on the citation count (Cant, Ryan, & Kardong-Edgren, 2022). The application of bibliometrics in education research has recently gained momentum and has provided valuable insights into notable works, as evidenced by author citations, authorship trends, and journal impact (Wang et al., 2022). These methods are increasingly used to examine various features of scientific research and to rank academic institutions globally. Currently, there is a lack of published bibliometric studies that specifically investigate the role of escape rooms in education. Therefore, this gap is addressed with this bibliographic study, which aims to conduct a comprehensive bibliographic analysis to identify the most cited articles, significant citation patterns, and authorship trends in escape room.

Methods

This study adopts a strategy similar to that described by Wang et al. (2022) in their systematic review and review and bibliometric analysis of published studies on education simulations. Blažun, Kokol, and Vošner (2015) also employ a similar analytic strategy in the field of medicine. We examined the most frequently cited studies in

escape room research to gain insight into their use in the field of education. The analysis encompasses various citation- and publication-related metrics and follows the established bibliometric procedures described by Cant et al. (2022).

Type of study

This systematic literature review, bibliographic study type, investigates the development and impact of escape room research in the field of education, with the following questions:

(1) How has the distribution of published escape room articles changed over time?

(2) What are the top ten most cited escape room studies in education?

(3) How are escape room studies distributed across different educational disciplines?

(4) What is the distribution of citation counts for different journals, and is there a correlation between the number of citations received by escape room articles and citation rates?

(5) Who are the leading authors and countries contributing to escape room research in education?

(6) What international collaborations have been occurring in terms of co-authorship and co-word network analysis among authors in escape room research?

Search terms and keywords

This study utilized the keywords ("escape room " OR "educational games" OR "escape") and (education OR learning,) and the search period spanned from January 1, 2017, to June 15, 2023.

Inclusion and exclusion criteria

The inclusion criteria were original articles published in English and peer-reviewed articles. Studies such as theses and dissertations, non-peer-reviewed articles, articles not relevant to interprofessional care education, editorials, and proceedings were

excluded.

Extracted process

A preliminary data extraction form was developed using the PRISMA process with six databases: Embase, Scopus, PubMed, CINAHL, Web of Science (WoS), and MEDLINE to capture the most recent developments in the field.

Variables extracted

The extracted variables included the year and journal of publication, author, article topic, article type, research type, study design, and article focus area. Publication-related metrics were extracted from the journal websites. To minimize potential bias, all relevant search results were downloaded from databases .txt format for further analysis. Of the 205 studies retrieved, 156 were classified as articles and analyzed for the purposes of the research work (Figure 1).

By following these steps, the study ensured a thorough and systematic synthesis of data from the included studies, providing a comprehensive overview of recent advancements in escape room research within the field of education.

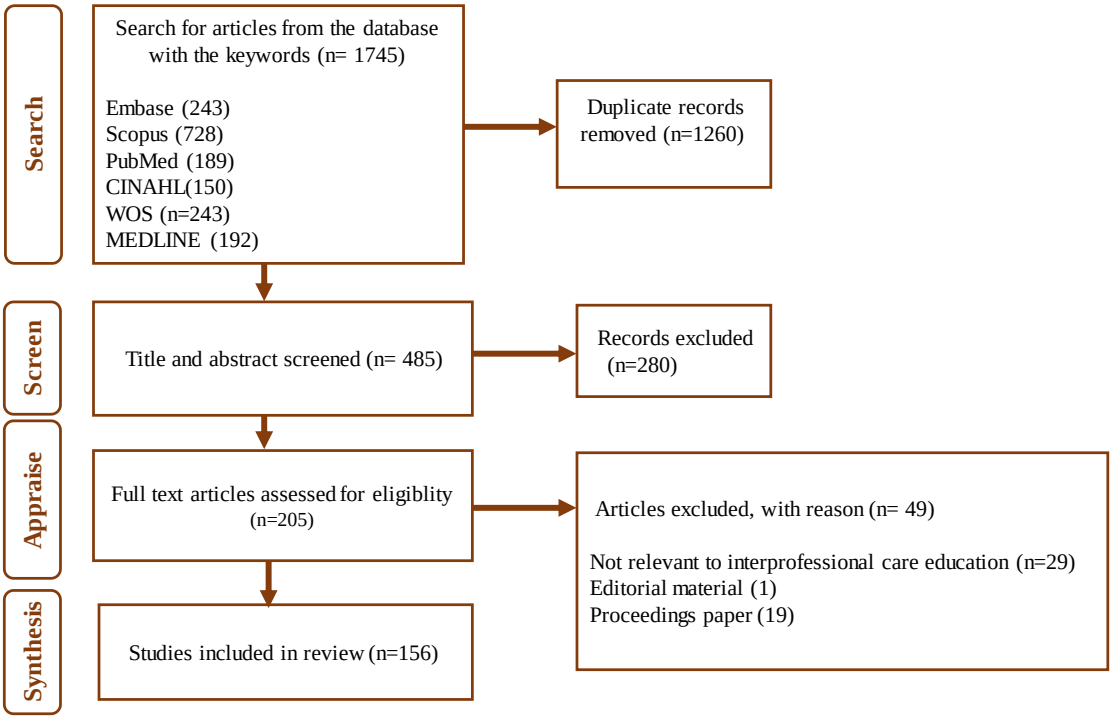

Fig. 1. The PRISMA process.

Results

The 156 articles on escape rooms were analyzed and categorized based on their publication years, which ranged from 2017 to 2023 (Figure 2). No publications were found prior to 2017; the first documented educational application of escape rooms can be traced back to Kolar (2017), who explored published papers on visitors' experiences of highly rated escape rooms using netnographic research and automated bibliometric analysis with VOSviewer version 1.6.17. The paper provided insights into the authenticity of novel attractions, as well as group dynamics around concepts of fun and flow.

Over the analyzed period, there was a noticeable rise in the number of publications from 2019 onwards, although this trend was interrupted by a relatively small decline in 2021. The overall number of publications has been steadily increasing over the past seven years, with the highest number of escape room articles published in 2022. This trajectory indicates a growing interest among scholars in employing escape rooms as educational tools within their curricula and research. This rise also aligns with trends in technology-driven research publications more broadly.

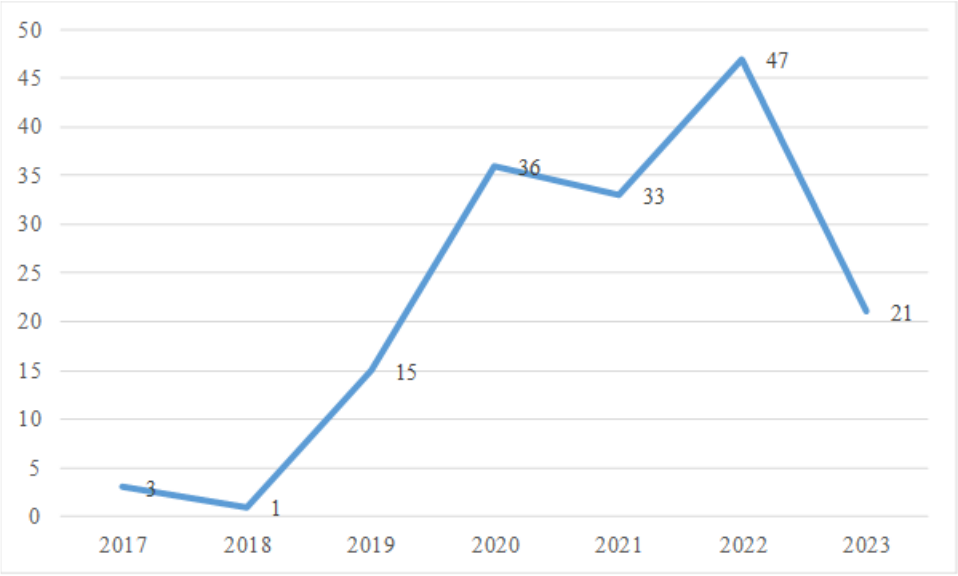

Fig. 2. Number of studies focusing on escape rooms in education per year since

2017.

Top ten cited studies

The ten studies selected for further analysis and discussion are considered landmark works due to their high citation counts. The number of citations of these studies range from 39 to 139 (Table 1). Various research designs are represented: two focus on escape room modalities in nursing, three examine their application in chemical education, and the remaining five cover pharmacology, radiology resident education, interprofessional education, and computer programming.

One of the most cited articles, titled “Educational gaming for pharmacy students - design and evaluation of a diabetes-themed escape room” (Eukel et al., 2017), presented a pre-test and post-test approach to measuring changes in students’ knowledge of diabetes after escape room activities. The results indicate demonstrably improved knowledge of diabetes mellitus disease management among students, and received positive student feedback. Another highly ranked study by Gómez-Urquiza et al. (2019) explored the impact of using a nursing escape room as a teaching game for students. This study had a rapid rise in citations within three years of its publication, which indicates a significant interest in this topic. A study by Kinio et al. (2019), ranked third, used a vascular surgery-themed escape room to enhance medical students’ engagement with the competencies required of medical specialists in Canada. The fourth-ranked study by Brown et al. (2019) assessed nursing students’ experiences of escape rooms as a simulation teaching strategy. Results were positive, and pointed to improved learning, task delegation skills, and teamwork among participants. The fifth-ranked study by López-Pernas et al. (2019) endorsed the use of escape rooms in higher education and highlighted their positive impacts on student engagement and learning compared with traditional computer laboratory sessions. These top ten cited studies

provide a range of information about the use of escape rooms in education and emphasize their benefits for students, faculty, and researchers.

Table 1. The ten most highly cited studies on escape rooms in education.

Rank	Author (year)	Title	Education category	h-index (first author, Scopus)	Source	Times cited (all databases)
1	Eukel, Frenzel, & Cernusca (2017)	Educational gaming for pharmacy students - design and evaluation of a diabetes-themed escape room	Pharmacy education	14	*American Journal of Pharmaceutical Education*	139
2	Gómez-Urquiza et al. (2019)	The impact on nursing students' opinions and motivation of using a nursing escape room as a teaching game: A descriptive study	Nursing education	23	*Nurse Education Today*	119
3	Kinio et al. (2019)	Break out of the classroom: the use of escape rooms as an alternative teaching strategy in surgical education	Medical education	4	*Journal of Surgical Education*	105
4	Brown et al. (2019)	An escape room as a simulation teaching strategy		2	*Clinical Simulation in Nursing*	77
5	López-Pernas et al. (2019)	Examining the use of an educational escape room for teaching programming in a higher education setting	Programming education	12	*IEEE Access*	66
6	Peleg et al. (2019)	A Lab-based chemical escape room: educational, mobile, and fun!	Chemical education	7	*Journal of Chemical Education*	41
7	Vergne et al. (2020)	Escape the (remote) classroom: an online escape room for remote learning	Chemical education	17	*Journal of Chemical Education*	38
8	Ferreiro-González et al. (2019)	Escape classroom: Can you solve a crime using the analytical process?	Chemical education	21	*Journal of Chemical Education*	38
9	Jambhekar et al. (2020)	Benefits of an escape room as a novel educational activity for radiology residents	Radiology resident education	14	*Academic Radiology*	38
10	Friedrich et al. (2019)	Escaping the professional silo: an escape room implemented in an interprofessional education curriculum	Interprofessional education	2	*Journal of Interprofessional Care*	39

Distribution of studies by field

A significant proportion of the highly cited studies in this field related to education in scientific disciplines, accounting for 33.33% (n = 52) of citations, followed by nursing at 23.08% (n = 36; Figure 3). Chemistry multidisciplinary studies comprised

13.46% (n = 21) of the citations, while educational research studies accounted for 11.54% (n = 18). These bibliometric findings highlight the wide distribution of research on escape rooms within the field of education in scientific disciplines. For example, Haimovich et al. (2022) developed a virtual chemistry escape room, an immersive activity that spanned 90 minutes and involved the completion of nine puzzles, supplemented by a 45-minute follow-up session. Similarly, Magreñán et al. (2023) used an online digital escape room to teach mathematics in the first year of an engineering program and assessed students' responses to the activity.

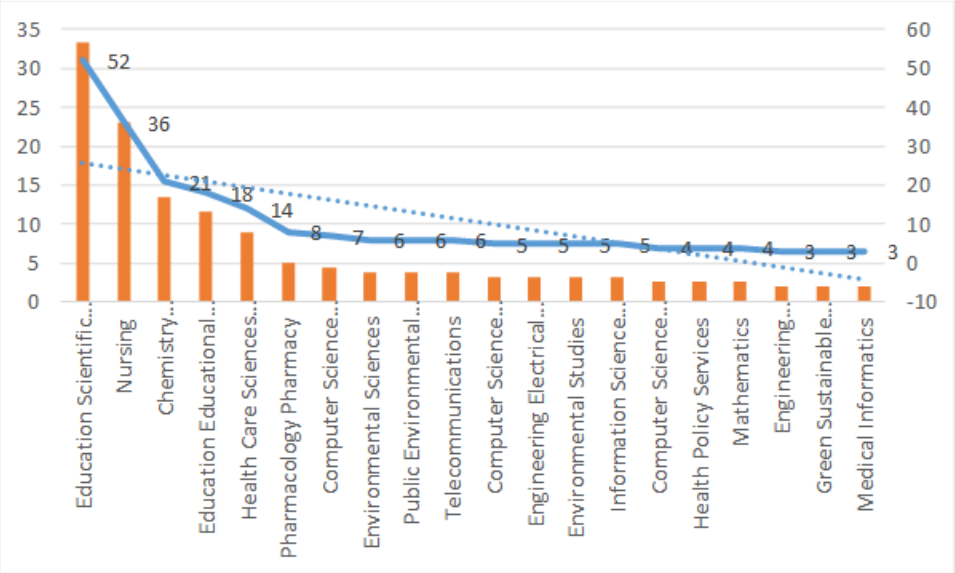

Fig. 3. Distribution of escape room studies in education by field.

Citation count of journals

Table 2 presents the citations accumulated from a comprehensive selection of articles on escape rooms published in 79 academic journals. The median citation rate was 5.0, with a mean of 22.1. It is generally expected that articles accumulate citations over time as they progress through a life cycle of several years following publication (Cant et al., 2022). The study's analysis revealed a statistically significant moderate inverse correlation (Pearson correlation coefficient = 0.887, $p \leq .001$) between the number of citations and the volume of documents published. This finding indicates that

a higher publication output tends to garner a greater number of citations, pointing to a positive relationship between publication and citation rates.

Notably, no significant correlation was found between impact factor (IF) and the volume of documents published (Pearson correlation coefficient = −0.11, p = 0.923), nor between IF and the number of citations garnered in subsequent articles (Pearson correlation coefficient = 0.55, p = 0.632). These findings suggest that papers published earlier do not necessarily accumulate a higher number of citations, and that citation rate was not influenced by the IF of journals. The study's analysis identified the following top five most cited journals: *Journal of Chemical Education* (IF = 3.208 in 2021), *Nurse Education Today* (IF = 3.906 in 2021), *American Journal of Pharmaceutical Education* (IF = 2.876 in 2021), *Journal of Nursing Education* (IF = 2.381 in 2021), and *IEEE Access* (IF = 3.476 in 2021). Higher citation rates observed in the fields of higher education, healthcare, chemistry multidisciplinary studies, and education in scientific disciplines may be due to their being more established, with a greater number of journals offering citation opportunities.

Table 2. Rankings of journals publishing articles on escape rooms in education.

Source	Documents	Citations	Total Link Strength	2021 Impact Factor
Journal of Chemical Education	16	290	59	3.208
Nurse Education Today	10	156	89	3.906
American Journal of Pharmaceutical Education	5	145	7	2.876
Journal of Nursing Education	10	116	55	2.381
IEEE Access	5	112	59	3.476
Journal of Surgical Education	1	101	46	3.524
Clinical Simulation in Nursing	4	93	42	2.856
Medical Teacher	5	51	32	4.277
International Journal of Environmental Research and Public Health	3	46	26	4.614
Journal of Interprofessional Care	3	46	21	2.663
Academic Radiology	1	37	21	5.482
Mathematics	3	35	22	2.592
Sustainability	3	32	28	3.889
Thinking Skills and Creativity	1	31	11	3.652
Computers & Education	2	27	14	11.182
Clinical And Experimental Dermatology	1	24	11	4.481
British Journal of Educational Technology	2	22	13	5.268

Source	Documents	Citations	Total Link Strength	2021 Impact Factor
BMC Medical Education	5	20	19	3.263
Heliyon	2	20	15	3.776
International Journal of Contemporary Hospitality Management	1	20	2	9.321
Journal of Oncology Pharmacy Practice	2	19	4	1.416
Education for Chemical Engineers	2	18	15	3.2
Library Quarterly	1	18	1	1.239
Environmental Education Research	1	17	4	3.725
Natural Hazards Review	1	16	3	4.2
Insights into Imaging	1	12	8	5.036
European Journal of Dental Education	1	10	5	2.528
Scandinavian Journal of Hospitality and Tourism	1	10	0	4.694
Biochemistry and Molecular Biology Education	1	9	2	1.369
ACM Journal on Computing and Cultural Heritage	1	8	1	2.047
Journal of Professional Nursing	2	8	14	2.272
Nurse Educator	1	8	8	2.791
Reference Services Review	1	8	4	0.933
American Journal of Nursing	1	7	5	2.577
Clinical Nurse Specialist	1	7	4	1.143
Journal of Mathematics	1	7	0	1.555
Western Journal of Emergency Medicine	1	7	7	3.988
Chemie in Unserer Zeit	2	6	2	0.518
JMIR Serious Games	3	6	13	3.364
Behaviour & Information Technology	1	5	3	3.32
Journal of Continuing Education in Nursing	4	5	9	1.071
Journal of Nursing Care Quality	1	5	3	1.728
Virtual Reality	1	5	0	4.697
Academic Medicine	1	4	1	8.034
Chest	1	4	9	11.393
Interactive Learning Environments	2	4	19	4.965
ACM Transactions on Applied Perception	1	3	0	1.676
IEEE Transactions on Games	1	3	2	1.237
It Professional	1	3	9	2.59
Educacion Xx1	1	2	3	3.077
Frontiers in Psychology	1	2	1	4.232
Health Information and Libraries Journal	1	2	4	3.55
Journal of Science Education and Technology	1	2	9	3.419
Psychology Research and Behavior Management	1	2	6	3.974
Computer Applications in Engineering Education	1	1	3	2.109
Trames-Journal of the Humanities and Social Sciences	1	1	1	0.467
Advances in Physiology Education	2	0	2	2.396
American Journal of Health-System Pharmacy	1	0	1	2.98
American Journal of Medical Quality	1	0	0	1.2
Applied Sciences-Basel	2	0	3	2.838
Children-Basel	1	0	14	2.835
Education and Information Technologies	2	0	5	3.666
Endocrinologia Diabetes Y Nutricion	1	0	3	1.833
Geriatric Nursing	1	0	0	2.525
Innovations in Education and Teaching International	1	0	8	2.027
Interacting with Computers	1	0	1	1.623
International Journal of Low-Carbon Technologies	1	0	0	3.071

Source	Documents	Citations	Total Link Strength	2021 Impact Factor
International Journal of Social Robotics	1	0	0	3.802
Jnp- The Journal for Nurse Practitioners	1	0	5	0.826
Journal of Genetic Counseling	1	0	1	2.717
Journal of Information Science	1	0	0	2.462
Journal of the American Geriatrics Society	1	0	0	7.538
Journal of the Medical Library Association	1	0	4	2.323
Journal of the Serbian Chemical Society	1	0	6	1.1
Medicine	2	0	9	1.817
Moravian Geographical Reports	1	0	1	2.311
Perspectives on Medical Education	1	0	4	4.113
Review of Managerial Science	1	0	0	5.435
Romanian Reports in Physics	1	0	3	2.085

Authorship analysis

Among the 156 articles on escape rooms in education, 504 first authors were identified. Two Spanish researchers, Aldo Gordillo and Sonsoles López-Pernas, emerged as distinguished authors, having led six highly cited papers and contributed to several others. Additionally, Enrique Barra published five papers on escape rooms between 2017 and 2023. Three other authors, Juan Quemada, Guadalupe Molina-Torres, and Carmen Ropero-Padilla, each led four papers. The first author citation metric serves as a valuable benchmark for faculty evaluation and helps identify prominent authors within specific fields. An example is Heidi N. Eukel, who published three articles on escape rooms in education, accumulating a total of 184 citations (Figure 4).

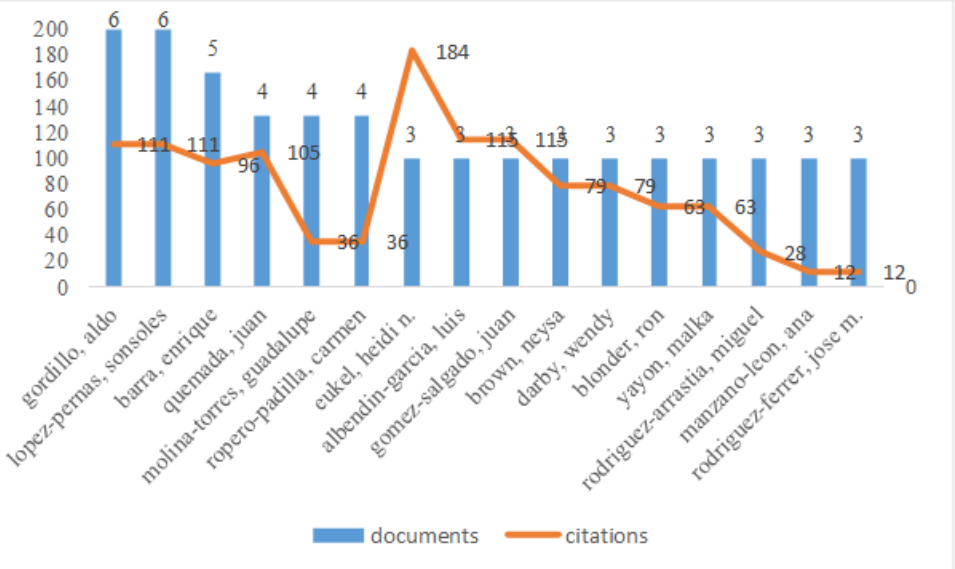

Fig. 4. The distribution of published articles and citation rates among authors.

Various indices were used, including h-index, g-index, and i10 index, to quantify and evaluate performance in academic authorship. The h-index, which is widely recognized, reflects an author's impact. For instance, an h-index of 2 indicates that the author has three papers, each of which has been cited twice. In this study, the h-indexes of the top 16 first authors who had published more than three papers ranged from 2 to 20, with the highest h-index belonging to the most cited paper (Table 3). The relationship between the citation rate and volume of published documents was also examined using SPSS version 22.0 (IBM, Armonk, NY, USA) and Pearson's correlation coefficient; the results revealed no significant correlation (Pearson correlation coefficient = 0.238, $p = 0.374$). Similarly, no significant correlation was found between citation rate and h-index (Pearson correlation coefficient = 0.446, $p = 0.083$). These findings suggest that h-index tends to increase throughout a researcher's career as citations accumulate with each publication. Therefore, authors who remained active in their field over time were more likely to achieve higher impact metrics. Considering that the impact metrics of a potential co-author can be beneficial for scholars, when it comes to seeking research partners for collaborative projects, it is possible to enhance the overall quality and impact of collaborative endeavors by working with co-authors with high metrics.

Table 3. Ranking of authors of escape room research in education.

Author	Documents	Citations	Total link strength	h-index
Gordillo, Aldo	6	111	358	12
Lopez-Pernas, Sonsoles	6	111	358	12
Barra, Enrique	5	96	292	12
Quemada, Juan	4	105	276	12
Molina-Torres, Guadalupe	4	36	204	8
Ropero-Padilla, Carmen	4	36	204	6
Eukel, Heidi N.	3	184	92	14

Albendin-Garcia, Luis	3	115	253	20
Gomez-Salgado, Juan	3	115	253	20
Brown, Neysa	3	79	156	2
Darby, Wendy	3	79	156	3
Blonder, Ron	3	63	146	18
Yayon, Malka	3	63	146	7
Rodriguez-Arrastia, Miguel	3	28	174	8
Manzano-Leon, Ana	3	12	90	6
Rodriguez-Ferrer, Jose M.	3	12	90	13

International collaboration analysis

The highly cited studies in the research analysis were produced by authors from 33 different countries. Table 4 shows the distribution of the 156 studies according to the country of the lead author. A significant proportion of the studies (64 out of 156) were led by authors in the USA, followed by Spain and England. The diversity of countries represented is encouraging, because it indicates substantial international involvement in the exploration of escape rooms in educational practice and research.

Table 4. Number of studies produced by different countries.

Country	Number of papers	%
USA	64	41.026
SPAIN	39	25
ENGLAND	8	5.128
ISRAEL	7	4.487
AUSTRALIA	6	3.846
NETHERLANDS	5	3.205
CANADA	4	2.564
NORWAY	4	2.564
PEOPLES R CHINA	4	2.564
ECUADOR	3	1.923
TAIWAN	3	1.923
FINLAND	2	1.282
FRANCE	2	1.282
GERMANY	2	1.282
MALAYSIA	2	1.282
NORTH MACEDONIA	2	1.282

SINGAPORE	2	1.282
SWITZERLAND	2	1.282

Notably, there were several international authorship collaborations among the 156 studies (Figure 5). Distinct clusters were identified representing this collaborative work: the red cluster consists of collaborations by authors from the USA, Australia, Canada, and Malaysia; the green cluster represents collaborative work among authors from Spain and Ecuador; and The blue cluster includes collaborations among authors from England, the People's Republic of China, and Germany.

There is emerging evidence suggesting that international collaborations can enhance research quality by leveraging the synergies of expertise and cultural diversity, particularly for newer research institutions (Wang et al., 2022). In a study examining authorship in the USA, it was found that collaborations with authors from other countries had a positive, albeit limited, impact on citations (Cant et al., 2022; Kolar, 2017). However, the impact of collaborations on citations in the social sciences showed mixed results, regardless of whether the collaborations were international or domestic. Further investigation is therefore needed to gain a better understanding of the effects of collaborative authorship in educational research.

Overall, the study's findings were characterized by limited international collaborations and diverse domestic authorship groups, indicating that escape room research in education is still in its developmental stages. Research groups in this field seem to be formed on the basis of locality and convenience, and a team-based specialist center or centers of research excellence have yet to be established.

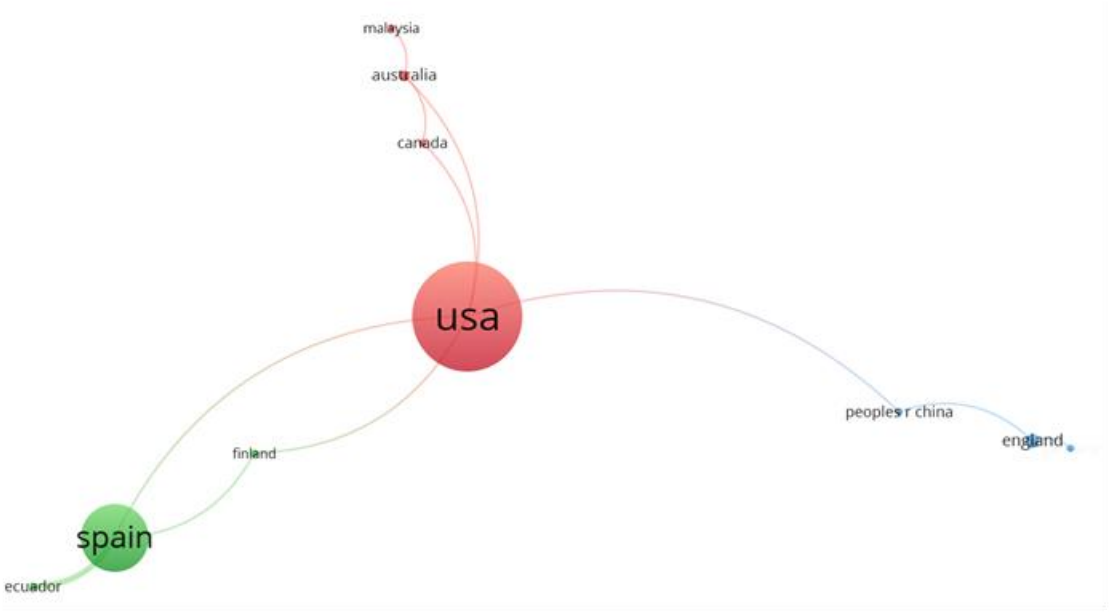

Fig. 5. Distribution of international co-authorships.

Distribution of co-citation

Citation count among co-authors is widely used as an indicator of research quality, the assumption being that frequently cited articles are of high quality (Cheng et al., 2022). Table 5 presents the co-citation networks of 17 core escape room articles, and highlights the most frequently co-referenced articles, with Gómez-Urquiza et al. (2019) being the most cited (n = 115), followed by Kinio (2019; n = 101), Brown (2019; n = 77), and Peleg (2019; n = 41). A high citation rate indicates that a paper has significantly contributed to the research field and will likely influence the design and nature of similar work in the future. In this way, the number of citations serves as a measure of the impact and recognition of a paper within the scholarly community. Highly cited papers often represent groundbreaking research, influential findings, or innovative methodologies that shape the future directions of research in a particular field. Researchers frequently refer to, and build upon, these highly cited papers to advance their own investigations, thereby contributing to a cumulative knowledge base and furthering progress in a particular research domain.

Table 5. Clusters of co-authorship of escape room articles in education.

Yellow-green cluster	Citations	Green cluster	Citations	Blue cluster	Citations	Purple cluster	Citations
Gomez-Urquiza (2019)	115	Kinio (2019)	101	Brown (2019)	77	Peleg (2019)	41
Lopez-Pernas (2019)	65	Jambhekar (2020)	37	Friedrich (2019)	38	Ferreiro-Gonzalez (2019)	38
Lopez-Belmonte (2020)	36	Huang (2020)	31	Connelly (2018)	36	Vergne (2020)	38
		Vidergor (2021)	27	Roman (2020)	25	Vergne (2019)	34
						Ang (2020)	31
						Watermeier (2019)	28

Figure 6 depicts the four strongest co-citation connections among the 17 core articles examined. Larger circles signify articles that were co-cited more than ten times. Links between the nodes in the network represent the strength of the co-citation relationships. For instance, the papers by Gómez-Urquiza (2019), Lopez-Pernas (2019), and Lopez-Belmonte (2020) were co-cited in the yellow-green cluster, with Gómez-Urquiza et al. (2019) accumulating the highest number of citations (n = 115). These three papers focused on using escape rooms in game-based learning to enhance university students' academic performance. The second most cited paper (n = 101) was Kinio et al. (2019), in a co-citation cluster with Jambhekar et al. (2020), Huang et al. (2020), and Vidergor (2021), all of which explored the use of escape rooms in training and teaching. Kinio et al. (2019) examined the effectiveness and implications of using escape rooms as a teaching strategy in surgical education; Huang et al. (2020) investigated the impact of digital escape rooms infused with science teaching on learning performance, motivation, and problem-solving ability in elementary school students; Jambhekar et al. (2020) discussed the benefits of using escape rooms as a novel educational activity for radiology residents; and Vidergor (2021) investigated the effects of digital escape rooms on "gameful" experience, collaboration, and motivation

among elementary school students. These four articles all explored the application of escape rooms as an innovative teaching strategy in various educational contexts. By analyzing these co-citation relationships using VOSviewer version 1.6.17, researchers can easily locate interconnections between papers and identify recent issues in the field.

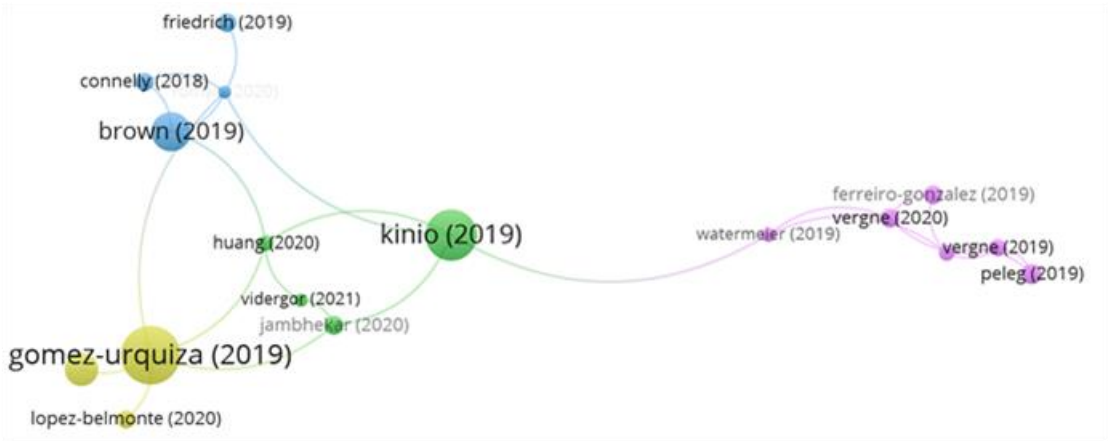

Fig. 6. Co-citation distribution of escape room articles in education.

Hot topics with co-word network analysis

According to Lin et al. (2022), co-word analysis assumes that keywords provided by authors in academic publications accurately describe the research content. Using this method, the co-occurrence of keywords indicates primary areas of interest in a research topic. The two keywords of interest appearing together in the same study suggest a bibliometric relationship between the corresponding topics. In this study, only co-occurring links that exceeded the average strength were considered influential keywords.

To determine the co-occurrence relationships among keywords, a co-occurrence matrix was created. The 591 keywords identified in the study were arranged in rows and columns, with each cell representing the frequency of co-occurrence of two specific keywords (Figure 7). The more frequently two keywords are used together by researchers, the more likely they are to represent similar concepts in the context of

scaffolding research. After obtaining the co-occurrence matrix, VOSviewer version 1.6.17 was employed to visualize the structure of the keyword co-occurrences. The top five most frequently occurring keywords were “escape room” (f = 70), “gamification” (f = 39), “education” (f = 28), “game” (f = 24), and “students” (f = 21).

Four distinct clusters of co-occurring keywords were identified (Figure 7). Co-words in the blue cluster included “lab,” “collaborative/cooperative learning,” and “humor/puzzles/games.” In the purple cluster, co-words were “escape room,” “gamification,” “game-based learning,” and “simulation.” Co-words in the green cluster included “education,” “games,” and “students.” Lastly, co-occurring keywords in the yellow cluster were “game” and “motivation.” Co-word network analysis revealed a significant and timely interest in the design and impact of gamification on student learning outcomes, which has great potential to inspire and guide future scholars in their research.

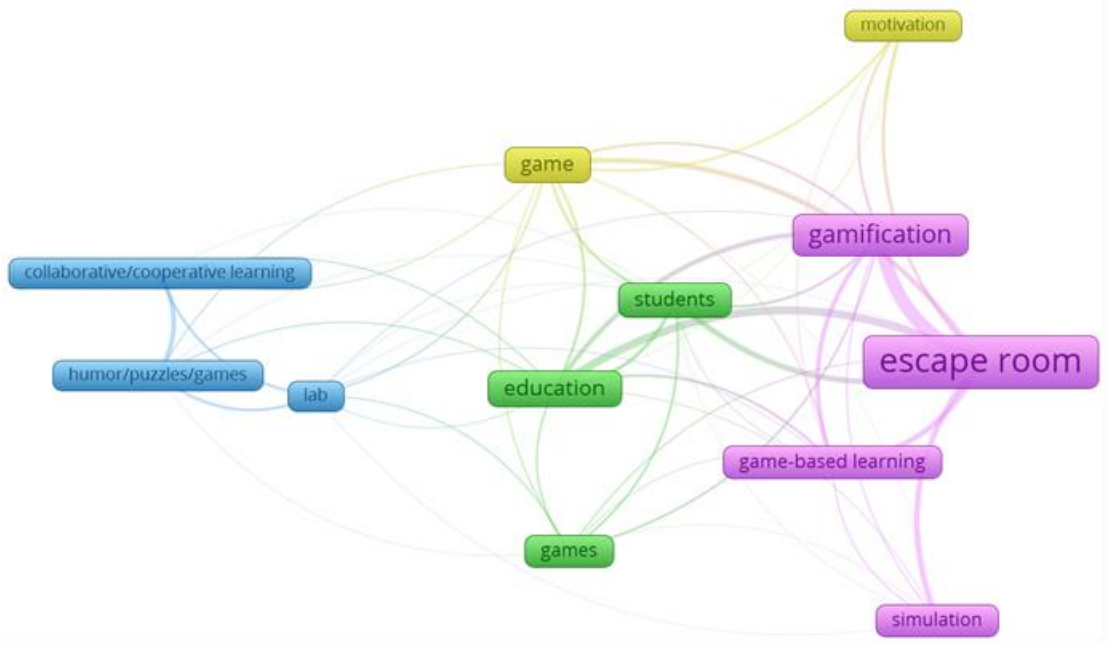

Fig. 7. Keyword co-occurrence in escape room articles in education.

Discussion

Several key findings emerged from the study's bibliometric analysis of escape room research in education. The analysis—covering 156 articles published between 2017 and 2023 and examining their publication date, citation count, field of study, journal, authorship, and international collaborations—revealed a steady rise in the number of escape room articles over the seven-year period, which indicates a growing interest among scholars and researchers in using escape rooms as an educational strategy. Analyzing the top ten cited studies provided valuable insights into the effectiveness and application of escape rooms in various educational contexts, such as nursing, pharmacology, and programming.

This study highlighted the wide range of research on escape rooms within the field of education in scientific disciplines. There was also significant representation in the fields of nursing, chemistry multidisciplinary studies, and educational research. These findings suggest that escape rooms have fascinated researchers, and are increasingly being applied across a wide range of educational disciplines. Notably, the citation count analysis revealed that the number of citations garnered by escape room-related studies showed a moderate inverse correlation with the volume of documents published; this suggests that higher publication output tends to attract more citations. Interestingly, the IF of journals did not significantly influence the citation rates of escape room articles.

The authorship analysis identified leading authors in the field, such as Aldo Gordillo and Sonsoles López-Pernas, both of whom have contributed significantly to escape room research. The h-indexes of these authors showed that citations tend to accumulate with each publication, indicating that the impact of researchers' work increases over time. Collaborations were identified among authors from different countries, indicating a degree of international expertise and cultural diversity in escape

room research. Through a co-word network analysis of hot topics, the terms “escape room,” “gamification,” “game-based learning,” and “simulation” were identified as emerging major trends for future research. Morrell et al. proposed a similar kind of game-based learning via the simulation of a cardiac escape room for improving undergraduate nursing students’ learning results (2021).

Overall, the findings suggest that the use of escape rooms in education is an evolving research area with a growing body of literature. The analysis provides insights into the most cited studies, the distribution of studies in different fields, journal citation rates, leading authors, and international collaborations. Taken together, these findings can guide researchers, educators, and policymakers in understanding the current landscape and potential future directions of escape room research in education.

Limitations

Because this study relied solely on data from six databases—Embase, Scopus, PubMed, CINAHL, WoS, and MEDLINE—it excluded any relevant studies not indexed in the databases and could represent only a partial understanding of the field. Given the limited coverage of the six databases, including other databases and resources when retrieving literature, it could provide more comprehensive results as well as a more detailed perspective on this growing field of interest. In addition, this study focused on a specific type of publication (articles), potentially excluding other relevant forms of study such as reviews, commentaries, and conference papers. This may have limited the breadth of understanding achieved, because other types of literature might contain important perspectives and findings in the field. The timeframe of the study, which spanned the seven-year period from 2017 to 2023, might also have excluded earlier relevant research, particularly regarding the origins and evolution of interest in

the topic; extending the timeframe to earlier years would provide a more comprehensive picture of research in the field.

Although bibliometric methods were used to analyze and evaluate citation and publication metrics, these indicators alone may not fully reflect the quality and impact of the research. Other factors, such as the rigor of the research methods, innovation, and practical application, may better determine the significance of studies. Relying solely on bibliometric indicators may not, therefore, allow a comprehensive assessment of the quality of research. Finally, limiting analysis to articles published in English might exclude relevant studies published in other languages. Including studies produced in other languages in future research would almost certainly provide a more diverse, inclusive, and comprehensive understanding of the field globally.

Conclusion

Research on the use of escape rooms in nursing education is a growing field, but it remains underrepresented in terms of citation rates, indicating the need for more impactful and sustained research endeavors. This study sought to identify the most influential contributors to this field by analyzing the leading authors, research articles, and journals, providing insights into who and what are shaping this domain. Through an extensive bibliometric analysis of the most-cited articles, we evaluated the h-index impact scores of first authors and other key metrics, contributing to a clearer picture of the intellectual landscape of escape room research in nursing education.

One notable observation is the significant geographic diversity among the highly cited authors, who represent 33 different countries. However, despite this broad international presence, there remains a lack of substantial international collaboration within the most influential studies. This gap suggests a missed opportunity for building on diverse educational practices, perspectives, and resources across borders, which

could help enrich the development and integration of escape rooms into nursing education curricula. To bridge this gap, establishing an International Center of Research Excellence for escape room-based learning could facilitate global partnerships, create shared research agendas, and enhance cross-national synergy to address this collaboration deficiency.

Furthermore, it is crucial for scholars, educators, and policymakers to appreciate both the potential and the limitations of bibliometric analysis in shaping research directions and priorities. Such analyses not only highlight influential contributors and research trends but can also guide research funding and policy decisions, serving as a tool for evaluating faculty productivity, assessing the quality of research outputs, and ultimately supporting the growth of emerging educational innovations like escape room methodologies in nursing. By promoting more informed research strategies and collaborations, this field can evolve into a more robust and impactful area of study that effectively supports healthcare education worldwide.

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