

EXPLORING 22 YEARS OF RESEARCH ON MOBILE EDUCATIONAL GAMES: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Background and Purpose: Digital educational technologies have optimised educational methods while enabling the integration of education and games. Whereas previous studies have explored the modules of educational games design, development and evaluation separately, a comprehensive study is still lacking. Therefore, this study uses bibliometrics to provide an in-depth analysis of the full flow of mobile educational games research over the past 22 years, including identifying core authors, analysing key organisations, exploring key countries/areas, and revealing research hotspots.

Methodology: In order to explore research related to the design, development and evaluation of mobile educational games between 2003 and 2024, this study searched 1,048 articles through the Web of Science (WoS) database and conducted quantitative analyses of core authors, organisations, countries/areas, and keywords using the VOSviewer software.

Findings: The bibliometric analysis shows that there are a total of 137 core authors in the field of mobile educational games. There is a high collaboration intensity between Utrecht University and University of Amsterdam. The USA, China and England are the core countries. The research themes were focused on basic education, learning effectiveness, and technological innovation, respectively.

Contributions: This research can be a comprehensive resource for researchers interested in the design, development and evaluation of mobile educational games.

Keywords: Mobile Educational Games, Design, Development, Evaluation, Bibliometric Analysis.

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1.0 INTRODUCTION

Digital games have become an important form of entertainment for billions of users worldwide. At that time, in the field of education, educational games aiming to enhance the effectiveness of education are gradually gaining prominence (Veríssimo et al., 2024). Mobile games offer innovative ways to learn complex concepts and can significantly improve students' metacognitive regulation, self-efficacy, and subject mastery dimensions (Benzon et al., 2024). Many researchers have demonstrated the value of mobile games in education as a quality teaching resource (Alp et al., 2024).

Mobile games have been extensively researched in many fields, each of which has contributed to the development of mobile games from different perspectives. For instance, in the field of Computer Science Information Systems, researchers have focused on optimising system performance in multiplayer gaming environments to enhance user experience (Li et al., 2017). In the field of Engineering Electrical Electronic, experts have developed efficient mobile game development tools to provide strong technical support for game developers. In the field of Education, mobile games have been shown to be effective in stimulating students' sense of competence, autonomy, and engagement, thus facilitating them to become self-directed learners (Cheng, 2024).

Inevitably, limitations inherent in the traditional classroom, such as the unidimensionality of teaching methods and the lack of practical opportunities, have arisen in the course of changing times. This has led to the emergence of problems such as decaying student engagement and weakened cognitive motivation (Chen & Lam, 2024). In order to address these challenges, researchers have utilised the unique characteristics of mobile educational games in terms of convenience and experience, and have innovatively proposed the integration of mobile games with instructional content to explore the extent to which their synergistic effects influence learning outcomes (Nelson & Gabbard, 2023).

Mobile educational games are not only a complement to traditional education, but a critical component of the future of education. Research has shown that mobile educational games significantly improve the academic performance of both higher and lower achieving students compared to traditional education (AlAli, 2024). Mobile educational games blend traditional teaching with modern technology, thus surpassing traditional teaching methods in optimising the learning experience. Mobile educational games build a more dynamic and inclusive learning environment, thus promoting the development of students' critical thinking and problem-solving skills (Angreza & Purwanto, 2023).

Looking back at the technological evolution of mobile educational games, the significant impact that mobile educational games have had on students, teachers, and societal levels (Li et al., 2022). Therefore, mobile educational games, as an interdisciplinary research field, deserve to be systematically sorted out and thoroughly analysed for the whole process of design, development and evaluation in this field. This study adopts a bibliometric approach to quantitatively analyse the literature within the field, with specific research objectives including:

- i. to identify core authors and their academic influence based on author collaboration network analysis.
- ii. to analyse key organisations and their collaborative relationships through organisational collaboration network analysis.
- iii. to explore countries/areas and their level of contribution by combining country/area collaboration network analysis.
- iv. to reveal research hotspots and their key contents by using keyword co-occurrence analysis.

2.0 METHODOLOGY

In recent years, the scope of bibliometrics research has expanded to encompass a number of technological directions in education, such as mobile learning, e-learning, intelligent learning, instructional design, learning analytics, and artificial intelligence (Akgun & Atici, 2023).

The term “bibliometrics” was first coined by Alan Pritchard in 1969, and today bibliometric analysis has become a key tool for assessing the current state of research (Kumar, 2025; Masic, 2022). Bibliometric analysis is a research tool for measuring, tracking and analysing academic literature through quantitative methods (Roemer & Borchardt, 2015; Rojas-Sánchez et al., 2023).

Bibliometric analysis helps researchers draw research conclusions from aggregated literature by analysing data on citations, collaborations and writing. By analysing this data together, researchers are able to reveal structures, social networks and research hotspots within the field (Zupic & Čater, 2015).

Bibliometric analysis enables quantitative observation of macro trends in the research area (Mirhashemi et al., 2022). Therefore, this study presents a visual representation of the research dynamics within the field of mobile educational games by identifying the scope of research in the field, and by using the VOSviewer software to co-occur with authors, organisations, countries/areas, and keyword collaboration networks (Figure 1).

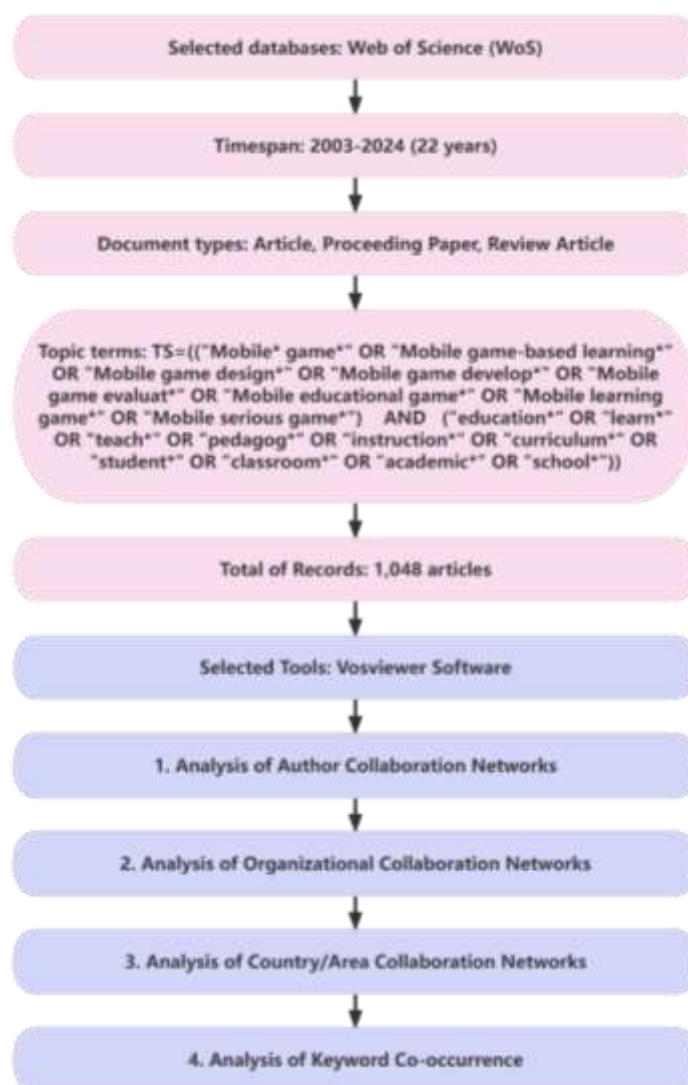


Figure 1: Research procedure

2.1 Data Sources and Search Strategies

Bibliometric analysis usually relies on mainstream databases such as Web of Science (WoS) and Scopus as data sources. WoS was the only tool that supported citation analysis until the advent of Scopus in 2004 (Mongeon & Paul-Hus, 2016). WoS has data going back to 1900, whereas Scopus has only partial data going back to 1960 and complete data only from 1996. WoS has higher quality and consistency of data, and is especially more accurate in calculating citation metrics. The WoS database only includes high-quality journals, so the average citation frequency of papers in its database is higher than that of Scopus (Vieira & Gomes, 2009). Therefore, this study used Web of Science as a search database to provide high-quality and internationalised data to support the bibliometric analysis of the design, development and evaluation of mobile educational games.

Initially, the study utilised the advanced search function of the WoS Core Collection database to conduct a literature search around the core theme of “Mobile educational game”. After analysing the highly cited literature in the field of mobile educational game, relevant keywords were identified. During the search process, the search scope was limited to the “Topic” field, covering the title, abstract and keywords of the articles to ensure that relevant publications were fully captured. The final dataset was filtered through the use of phrase searches, Boolean logical operators (e.g., AND, OR), and truncation (asterisk *) to avoid missing important research literature.

The data retrieval strategy is as follows: TS=((“Mobile* game*” OR “Mobile game-based learning*” OR “Mobile game design*” OR “Mobile game develop*” OR “Mobile game evaluat*” OR “Mobile educational game*” OR “Mobile learning game*” OR “Mobile serious game*”) AND (“education*” OR “learn*” OR “teach*” OR “pedagog*” OR “instruction*” OR “curriculum*” OR “student*” OR “classroom*” OR “academic*” OR “school*”))

The timeframe of this study is set to be from 2003 to 2024, a total of 22 years, with the aim of comprehensively analysing the evolution of research in the field of Mobile educational game. The year 2003 was chosen as the starting point because it marks the earliest literature on the field in the WoS database, providing a complete basis for time-series analyses in subsequent studies. Furthermore, to ensure data quality, only Article, Proceeding Paper, Review Article were included, excluding Book Chapters, Early Access, Correction, Book Review, Meeting Abstract, Editorial Material, News Item, Retracted Publication, Retraction.

In addition, only research literature written in English was selected because English is the dominant language of international academic communication, facilitating cross-country comparisons and international impact assessments. After screening, a total of 1,048 documents were obtained for the period 2003-2024, sufficient to support the subsequent analyses. These documents were downloaded in a “Tab delimited file” format, containing the full records, and imported into VOSviewer software for analysis.

2.2 Tool Selection and Data Analysis

Currently, there is a wide variety of Scientific knowledge map tools developed globally, and some of the more commonly used ones include VOSviewer, CiteSpace, Bibexcel, HistCite, SciMAT, Gephi, and CRExplorer. Compared with other visualisation tools, VOSviewer is more prominent in handling large-scale data and mapping (Dai et al., 2023). VOSviewer is a bibliometric analysis tool developed by Leiden University, the Netherlands, which is mainly used to construct and visualise scientific knowledge graphs. It helps researchers to reveal the structure, hotspots and trends in the research field by analysing author collaborations, keyword co-occurrences, citation relationships, etc. (Arruda et al., 2022).

Scientific knowledge mapping is the use of scientific mapping tools to generate a comprehensive overview of the knowledge structure of a particular field of study by acquiring

bibliographic records in that field (Chen & Song, 2019). VOSviewer provides cluster analysis and timeline analysis functions that enable the mapping of scientific knowledge to show the evolution of a research topic (Cheng et al., 2021).

Collaboration network analysis is the use of social network analysis to map real entities and their relationships to nodes and connecting edges in a network, so as to visualise the associations between collaborators, core groups and their patterns of collaboration (Hu et al., 2020). VOSviewer supports co-authorship analysis of authors, organisations, and countries/areas, which helps researchers to understand the collaborative patterns in the field (Liu et al., 2025).

Research hotspot identification refers to the identification of core research themes or cutting-edge issues in a field that are currently receiving widespread attention by analysing keywords, themes or citation relationships in the literature. VOSviewer is able to quickly identify research hotspots and core themes in a field through keyword co-occurrence analysis (Zupic & Čater, 2015).

3.0 RESULTS

The use of VOSviewer to visualise and analyse national and international research literature allows for a quick grasp of current research hotspots and future research trends (van Eck & Waltman, 2010). The power of VOSviewer makes it a key tool for this study, helping researchers to gain an in-depth understanding of the research dynamics in the field of mobile educational games design, development and evaluation.

3.1 Analysis of Author Collaboration Networks

In total, 3,237 authors were analysed, and 137 eligible authors were screened from the 3,237 authors using 3 articles as the threshold for the minimum number of author publications. Within the network of 137 items, some items did not form connections and existed independently. To ensure network completeness, all items were included in the visual analyses. Clusters identified different research clusters in the author collaboration network; Links indicated collaborative relationships between authors; and the size of the Node size was positively correlated with the author's publication volume (Figure 2).

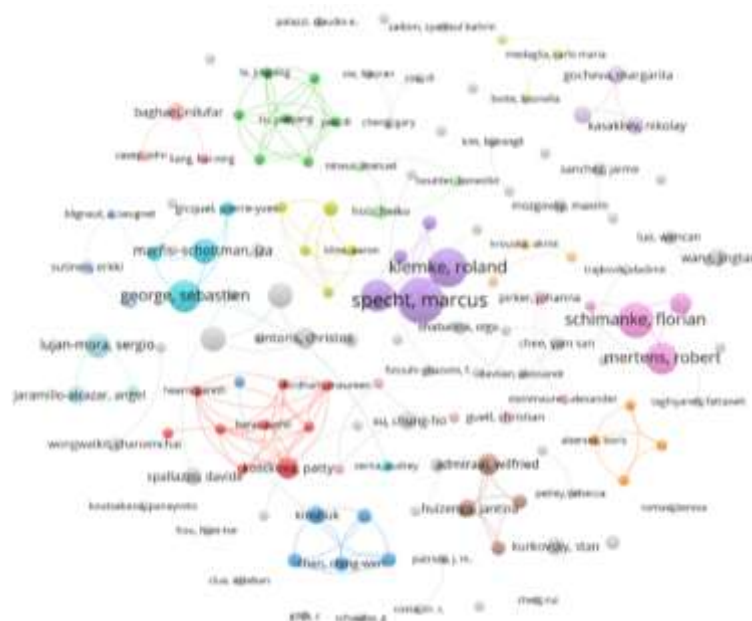


Figure 2: Author collaboration network using VOSviewer

As shown in Figure 2, a total of 58 clusters are formed, of which 36 clusters form connections. For example, Cluster 1 (red) includes Arjyal Abriti, Baral Sushil, Boscor Andrei, Fordham Maureen, Hearn Gareth, Kayastha Rachya, Kostkova Patty, Molnar Andreea, Mueller Sonja; Cluster 2 (green) includes Bi Jingping, Deng Hao, Su Yueyang, Tao Jianrong, Wu Runze, Yao Di, Zhao Shiwei; Cluster 3 (dark blue) includes 6 items; Cluster 4 (dark yellow) includes 5 item, and Cluster 5 (dark purple) includes 5 items.

The top authors and their number of publications are Specht Marcus (13 articles), Klemke Roland (11 articles), Schimanke Florian (10 articles), Schmitz Birgit (9 articles), Mertens Robert (9 articles), George Sebastien (9 articles), Marfisi-Schottman Iza (7 articles), Avouris Nikolaos (7 articles), Yiannoutsou Nikoleta (7 articles), and Lujan-Mora Sergio (7 articles).

The top 3 authors for Total link strength are Specht Marcus, Klemke Roland and Kostkova Patty in that order. According to Price's Law, the minimum number of core authors to publish in a given field is (Price, 1963):

$$m = 0.749 \times \sqrt{n_{max}}$$

m is the minimum number of publications by core authors in the field. n_{max} is the number of articles by the most prolific authors in the field. In this study, $n_{max} = 13$ and $m \approx 2.70$, so authors with three or more publications are positioned as core authors in the field, with a total of 137 core authors (Zhu & Ma, 2020).

The author collaboration network shows that there are 137 core authors in the field of mobile educational games. The red cluster with Kostkova Patty as the core author is the most active subgroup in the field. Specht Marcus is not only the author with the highest output in the field, but also the author with the highest total link strength, implying that this author has a high influence in the field.

3.2 Analysis of Organisational Collaboration Networks

In total, 1,179 organisations were analysed, and 45 compliant organisations were screened out of the 1,179, using 5 articles as the threshold for an organisation's minimum number of publications. Within the network of 45 items, some items did not form connections but existed independently. In order to get a full picture of the structure of the whole network, isolated nodes were chosen to be included. The focus was on analysing the different research groups in the organisations' collaborative network; the collaborative links between organisations and the volume of the organisations' article output (Figure 3).

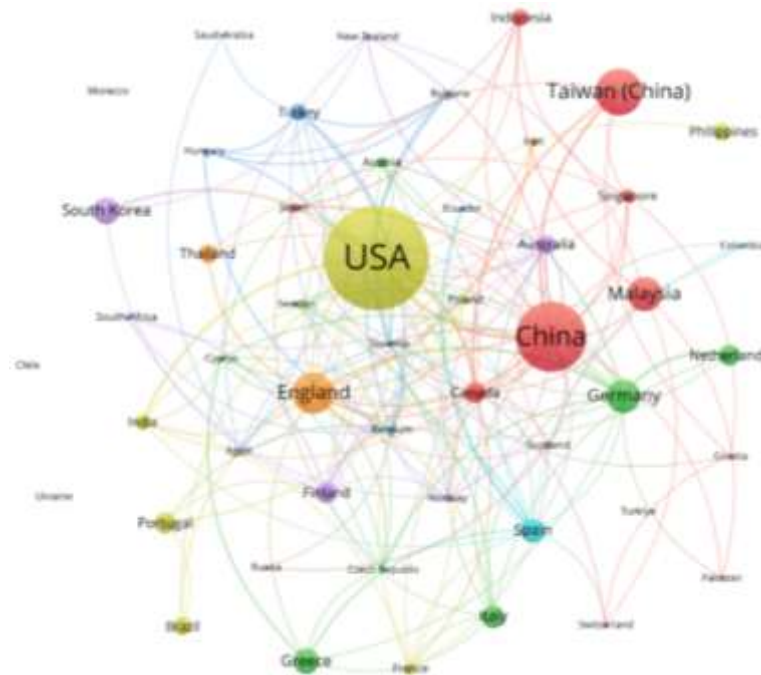


Figure 4: Country/area cooperation networks using VOSviewer

As shown in Figure 4, a total of 12 clusters are formed, of which 8 clusters form connections. For example, Cluster 1 (red) includes Canada, China, Croatia, Indonesia, Japan, Malaysia, Pakistan, Singapore, Switzerland, Taiwan (China). Cluster 2 (green) includes Austria, Cyprus, Czech Republic, Germany, Greece, Italy, Netherlands, Sweden. Cluster 3 (dark blue) includes Belgium, Bulgaria, Egypt, Hungary, Saudi Arabia, Slovenia, Turkey.

The top countries/areas and their numbers of publications are the USA (156 articles), China (104 articles), Taiwan (China) (70 articles), England (61 articles), Malaysia (51 articles), Germany (50 articles), South Korea (40 articles), Greece (38 articles), Spain (36 articles) and Italy (34 articles). The top 3 countries in terms of total link strength are the USA, China and England.

The country/area collaboration networks show a pattern of concentration of international cooperation in this area, with the main cooperation countries clustered in North America, the East Asian region and Europe. The cluster (red) with China as the core country is mainly from Asia, North America and Europe, showing the characteristics of cross-regional cooperation. The cluster (green) with Germany as the core country is all from Europe, showing the characteristics of regional cooperation. The cluster (dark blue) with Turkey as the core country is mainly from Europe, the Middle East and North Africa, showing the characteristics of cross-regional cooperation.

3.4 Analysis of Keyword Co-Occurrence

Initially, 2,713 author keywords were counted. After merging synonyms and deleting words not related to the topic, a total of 2,682 keywords were derived, and 41 compliant keywords were screened from the 2,682 keywords using 6 keywords as the threshold for the minimum number of keyword occurrences. Moreover, some of the items did not form connections but existed independently. In order to make the connection relationship between nodes clearer, only the nodes in the network that were connected to each other were shown, and the isolated nodes were ignored, and finally 39 keywords that meet the requirements were screened out. (Figure 5).

interaction, the principle of cultural context, the principle of adaptive learning, and the principle of context-aware learning.

The principle of collaborative interaction promotes the enhancement of collaborative problem-solving skills. Bressler et al. (2019) analysed the process of collaborative mobile phone games to improve students' collaborative problem-solving skills. Students' dialogue discourse in the game was explored through cognitive network analysis (ENA). The results of the study confirmed that collaborative mobile phone games are effective in improving collaborative problem-solving skills.

Adopting the principle of cultural context ensures that mobile educational games are effectively adapted to the cultural habits of local users. Mueller et al. (2020) designed culturally appropriate serious games to teach health information in low- and middle-income countries. The results of the study showed an increase in the level of users' comprehension and application skills, reflecting the game's ability to be effectively integrated into the local cultural context.

The principle of adopt adaptive learning to dynamically adjust game content and difficulty. Gnadlinger et al. (2024) explored the pedagogical function of serious games combined with adaptive learning in cochlear implant rehabilitation. The purpose of the study was to enhance student motivation during self-directed training. The results of the study suggest that serious games combined with adaptive learning are feasible in cochlear implant rehabilitation.

The principle of context-aware learning enhances the applicability and authenticity of learning. Ruo-Yu and Chang-Hwa (2020) studied the design of a cultural heritage mobile game based on contextual awareness. The study revealed the importance of context-aware learning in game design using railway cultural heritage as a background. The results of the study can provide a reference for the construction of future cultural mobile phone games based on context-aware design.

3.4.2 Development Techniques for Mobile Educational Games

Through the analysis of keywords such as "augmented reality", "deep learning" and "emotion", it is concluded that the current mobile educational games mainly use augmented reality (AR), deep learning, affective computing.

The application of Augmented Reality (AR) technology significantly enhanced students' practical skills. Bressler et al. (2021) utilised mobile augmented reality to engage students in science practices via mobile devices and integrate them into the real world. The results of the study showed that students' interest in science can be effectively enhanced through well-designed mobile augmented reality games.

The application of deep learning technology enables researchers to analyse users' emotions more accurately. Baghaei et al. (2024) explored game design and technology interventions for mental health. The results of the study found that analysing user behavioural data through deep learning models allowed for more accurate identification of individual characteristics and allowed for dynamic adaptation of content to provide personalised support.

The use of affective computing technology enhances user motivation and engagement. Kalantarian et al. (2020) used games to collect data on the emotional frames of children with autism during play. The conclusions of the study found significant limitations of existing commercial emotion classifiers in and provide an important reference for the application of affective computing techniques in the field of special education.

3.4.3 Evaluation Methods for Mobile Educational Games

Through the co-occurrence network of keywords such as “survey”, “test”, “behaviour”, “expert” and “experimental”, it is sorted out that the current mobile educational games mainly use questionnaires, knowledge test, behavioural analyses, expert reviews, experimental designs.

The questionnaires are used to systematically collect multidimensional feedback from users on their game experience. Criollo-C et al. (2024) used two standardised questionnaire tools to assess how a mobile application can support basic cyber security teaching. The results of the study showed that the game was able to keep the users’ mental load low and motivate them to learn about cybersecurity instruction.

The knowledge tests are used to measure students’ progress in specific skill areas. Hwang et al. (2015) adopted a knowledge testing method to assess students’ performance in listening and speaking and to analyse the key factors affecting learning outcomes. The results of the study verified the ability of gamified learning activities based on mobile systems in being able to effectively improve students’ speaking skills.

Behavioural analyses are used to be able to explore learners’ behavioural characteristics in the game. Chou et al. (2021) designed and developed a mobile game for Chinese history education and assessed its impact on learners’ historical knowledge acquisition, cognitive thinking and collaborative problem-solving behaviours. The results of the study revealed an increase in learners’ historical knowledge acquisition as well as a positive impact on collaborative problem-solving behaviour.

The expert reviews are used to provide professional guidance for the optimisation of the game. Troussas et al. (2020) designed a smartphone game learning application for assessing and improving students’ knowledge of the programming language C#. The application was evaluated through expert review method and statistical hypothesis testing. The results of the study validated the effectiveness and feasibility of mobile game-based learning in higher education.

Experimental designs are used to compare the differences in learning outcomes between the use of educational games and traditional teaching methods. Schmitz et al. (2015) used a rigorous control group design and multidimensional assessment to validate the effectiveness of a mobile phone game-based learning approach. The results of the study provide preliminary evidence for the use of game-based learning approaches in behaviour change and competency development.

4.0 FUTURE RESEARCH DIRECTIONS

Current mobile educational games design, development and evaluation also face a number of challenges. Many mobile educational games are unable to dynamically adjust their content according to learners’ abilities and needs, and lack personalised design content and adjustment methods. Moreover, existing evaluation methods are more accustomed to using questionnaires and expert reviews, and lack in-depth analyses and long-term tracking of learners’ learning process and effects. In addition, mobile educational games have different needs in different cultural and social contexts, and it is more difficult for mobile educational games to meet diverse cultural needs.

Future research should pay more attention to how to better use big data technology and artificial intelligence to optimise the personalised content and dynamic adjustment methods of mobile educational games. Various assessment methods, such as behavioural analysis, are further used to evaluate and track the long-term learning effects of mobile educational games. Focus on the adaptive design of mobile educational games to ensure that mobile educational games can meet the diverse needs of different cultures and social backgrounds.

5.0 CONCLUSION

This study reports on a comprehensive bibliometric analysis of mobile educational game publications from 2003 to 2024 through WoS. The findings help researchers to fully understand the core authors, key organisations, key countries/areas, and research hotspots across the design-development-evaluation process of mobile educational games. The study includes 1,048 publications and 2,713 keywords by 3,237 authors in 1,179 organisations and 96 countries/areas.

The results of these publications show that the largest core groups of authors in the last 22 years are from Nepal and England, and the second largest core group of authors are both from China. Utrecht University and University of Amsterdam are the top ranked organisations in terms of total link strength, which not only has a high intensity of collaboration, but also a higher number of collaborations. The USA, China and England are the core countries with the largest number of articles and the highest strength of connections, suggesting that these countries dominate international co-operation in this area.

Augmented Reality and Machine Learning are the keywords with the highest and second-highest frequency of occurrence, and are the keywords with the highest and second-highest total link strength, indicating that they are the most active research directions and core research hotspots at present. Spaced Repetition and Supermemo also show high research intensity, reflecting researchers continued focus on optimising and enhancing student behaviour and learning outcomes.

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