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Mapping the intellectual structure of mobile gaming in education: insights from bibliometric methods

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ABSTRACT

Mobile gaming in education encompasses using games on mobile devices to achieve educational goals, offering an interactive platform that can make learning more engaging and accessible. This study addresses the gap in understanding how mobile gaming can enhance educational outcomes by mapping the intellectual landscape of mobile gaming research in education through bibliometric methods. The problem is the growing need to adapt educational tools to students' digital preferences, balancing engagement with academic rigor. A total of 247 articles were identified from the Web of Science (WoS) database. Through co-citation and co-occurrence analyses, the study identifies influential research themes and emerging trends, such as gamification, serious games, and augmented reality. The findings demonstrate that mobile gaming fosters engagement in promoting motivation and supporting problem-solving skills in educational contexts. However, it also highlights the importance of aligning mobile gaming with curriculum objectives and ensuring instructor readiness, supporting sustainable development goal 4: quality education, which aims to improve inclusive and equitable learning outcomes. It identifies emerging trends, including serious games, technology acceptance models, and the use of augmented reality in educational settings. This study provides a significant impact for educators and researchers seeking to incorporate mobile gaming into educational settings actively. The study suggests a balanced approach to mobile gaming, ensuring its introduction enhances educational goals while minimizing the potential for distraction, fostering innovation in line with sustainable development goal 9: industry, innovation, and infrastructure.

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1. INTRODUCTION

Mobile gaming has emerged as a powerful tool in education, utilizing the appeal of games to enhance learning. In the context of education, mobile gaming involves the use of game-based applications on mobile devices to teach academic concepts. This approach utilizes students' knowledge of interactive media

to promote motivation and engagement. Studies have demonstrated that incorporating elements such as reward systems, challenges, and competition makes learning more dynamic, helping students stay actively involved [1]. A notable example is puzzle-based games [2], which have been shown to enhance student engagement and critical thinking skills [3]. Furthermore, mobile games offer immediate feedback, allowing learners to correct mistakes without fearing failure and fostering risk-taking and problem-solving. This highlights the significance of striking a balance when integrating gaming into education, allowing students to reap cognitive and social benefits without compromising their focus on studies [4].

However, integrating mobile games into educational contexts comes with challenges. Educators must ensure that games are aligned with curriculum objectives and that they facilitate learning without becoming a distraction [5]. Additionally, teachers require adequate training to incorporate mobile gaming effectively, select the right games, assess progress, and evaluate learning outcomes [6]. Despite these challenges, with proper planning and support, mobile gaming can transform modern education by promoting lifelong learning, critical thinking, and active participation [7]. The potential of mobile gaming in education has sparked considerable debate. While some research emphasizes its benefits, particularly for cognitive development and engagement, others caution about its overuse. Studies have shown that excessive gaming can negatively affect academic performance, with university students who spend excessive time on games experiencing a decline in their grades [8], [9]. This points to the need for moderation and careful integration into educational settings.

Conversely, research has also highlighted how certain types of games, particularly action and shooter games, can improve cognitive functions such as attention, spatial reasoning, and multitasking [10]. For instance, players of these games have demonstrated enhanced object-tracking abilities, which could benefit academic tasks requiring complex problem-solving and task management [11]. This suggests that while gaming holds promise, it must be balanced to ensure positive educational outcomes. This study seeks to fill a gap in the literature by conducting a comprehensive bibliometric analysis of research on mobile gaming in education. The study aims to provide insights into the current state and future directions of mobile gaming as an educational tool by analyzing trends, themes, and key research areas. This research is significant because it offers a systematic overview of the field, helping educators and researchers understand the evolving role of mobile games in learning environments through the following research questions:

i) What are the most influential articles and authors on mobile gaming in education based on citation patterns?
ii) What are the most frequently used keywords on mobile gaming in education research to indicate the field's focus?

2. METHOD

Web of Science (WoS) is known for its strict indexing and broad citation data across disciplines [12]. WoS offers access to highly cited journals and supports global research networks, making it essential for tracking trends in educational technology. Tools like VOSviewer help analyze WoS data. They allow researchers to explore topic clusters and collaboration patterns in mobile gaming in education [13]. The data retrieval was performed on September 11, 2024. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart in Figure 1 outlines the process of identifying, screening, and including studies for bibliometric analysis of mobile gaming in education. Initially, 575 studies were identified from the WoS database based on keywords ("mobile gam*" and "educat*"). After applying inclusion and exclusion criteria, such as the time period (2014-2023), document types (article or review article), and language (English), the list was narrowed down to 247 studies. A full-text review was then conducted on these 247 studies, which were included for further analysis, ensuring a focused and relevant selection.

The bibliometric analysis is a key method for understanding patterns in academic research. It uses statistical tools to examine publications, citations, and keywords. This helps researchers find influential studies, top authors, and leading institutions in specific areas [14]. In mobile gaming research, bibliometric analysis is especially valuable. It shows how this field has grown, reveals trends, and highlights new areas in the intersection of gaming and education. This approach guides future research [15]. Two main types of bibliometric analysis are co-citation and co-word (or co-occurrence) analysis. Co-citation analysis studies how often two documents are cited together. This helps to identify major research themes, influential studies, and key topics within mobile game-based learning (GBL) [13], [16]. Co-word analysis, on the other hand, examines how often certain keywords appear together. This allows researchers to spot central themes and new trends in mobile gaming for education [12], [17]. By tracking these trends, co-word analysis provides a view of potential future research areas.

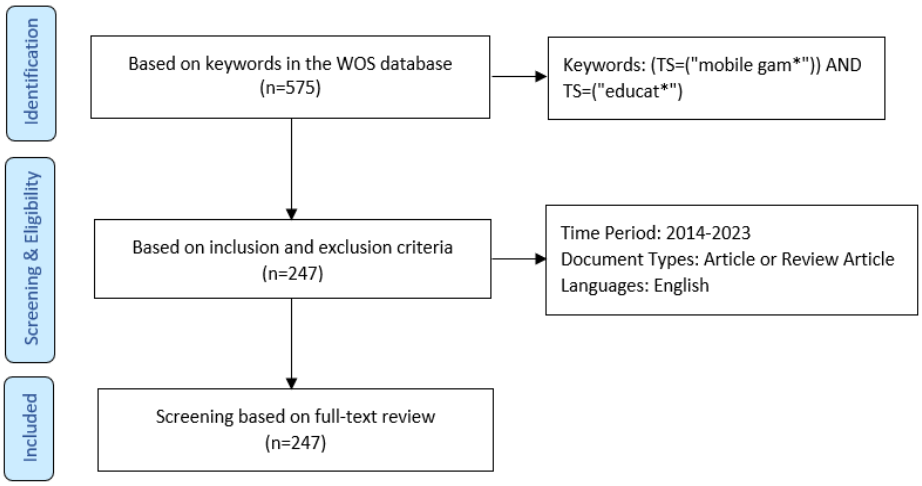

Figure 1. PRISMA flowchart

3. RESULTS

3.1. Co-citation analysis

The co-citation analysis of the top five articles on mobile gaming in education, as depicted in Table 1, underscores the most influential works that have shaped this field. Co-citation analysis delves into the frequency with which two articles are cited together, revealing their shared importance within the research community. The identified articles are pivotal to discussions on GBL, digital literacy, and the motivational elements of mobile and serious games.

The article most commonly cited is by Huizenga *et al*. [18], with 28 citations and a total link strength of 121. This research delves into mobile GBL in secondary education, specifically exploring the impact of mobile city games on student engagement, motivation, and learning outcomes. The high frequency of co-citations indicates the widespread acknowledgment of mobile gaming as a valuable instrument for stimulating students and improving learning.

Next in line is Connolly *et al*. [19] article, which has been cited 23 times and has a total link strength of 95. This systematic review assesses the empirical evidence on computer and serious games, providing a comprehensive examination of their educational applications. The frequent co-citations of this review underscore the significant role that literature reviews play in influencing current research and offering crucial insights into the educational potential of games.

Garris *et al.* [20] secured the third position with 17 citations and a total link strength of 63. Their article introduces a model that elucidates the impact of games on motivation and learning, emphasizing the psychological processes that underpin the effectiveness of games in educational contexts. The substantial number of co-citations underscores the enduring significance of motivation theory in GBL, establishing this work as essential for researchers investigating engagement and immersion in educational environments.

Table 1. Co-citations (top 5 articles)

Rank	Authors	Title	Citations	Total link strength
1	Huizenga *et al*. [18]	Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game	28	121
2	Connolly *et al*. [19]	A systematic literature review of empirical evidence on computer games and serious games	23	95
3	Garris *et al*. [20]	Games, motivation, and learning: a research and practice model	17	63
4	Hamari *et al*. [21]	Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning	16	50
5	Qian and Clark [22]	Game-based learning and 21st century skills: a review of recent research	12	42

3.1.1. Co-citation by clusters

A graphical visualization using VOSviewer demonstrates the relationships and organization of authors and research themes in the literature [23]. The co-citation analysis of mobile gaming in education, illustrated in Figure 2, reveals five distinct clusters, each corresponding to a specific research focus. Among

the 10,497 cited references, 56 articles with at least six citations were chosen for the co-citation analysis. Table 2 provides an overview of these clusters and proposes labels based on key publications.

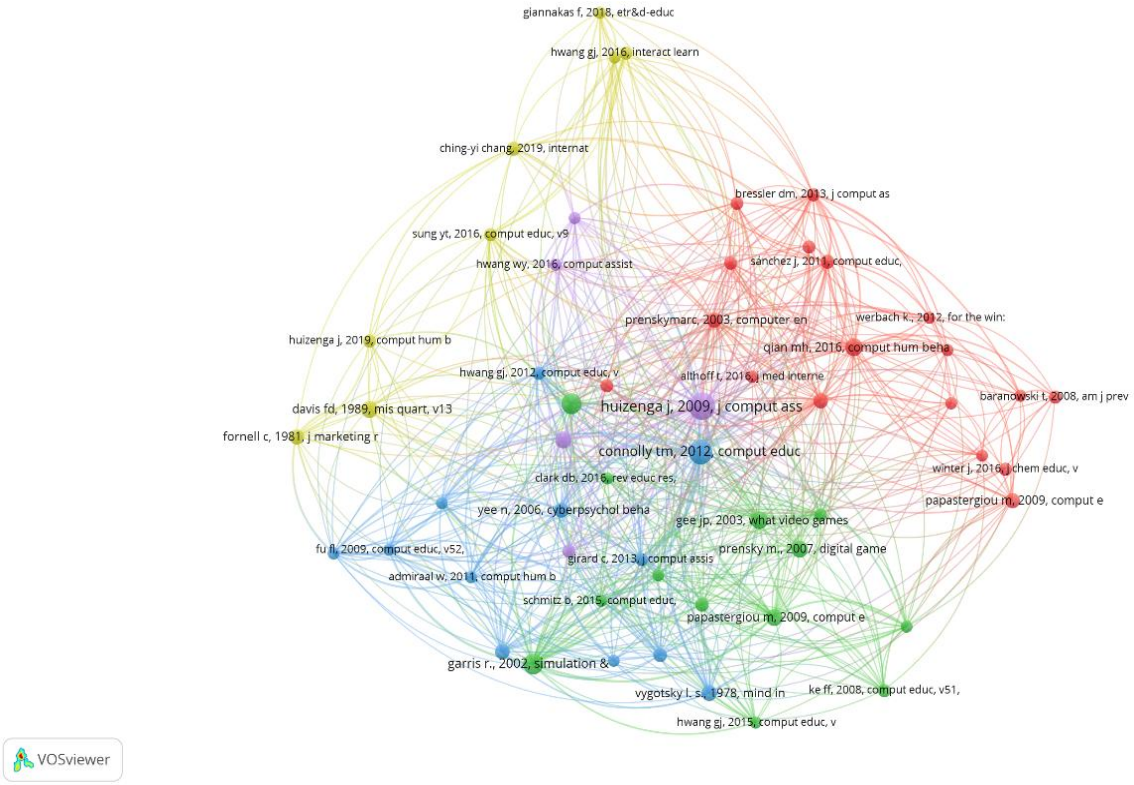

Figure 2. Co-citation analysis (VOSviewer visualization)

Cluster 1 (red), known as "GBL and gamification," is dedicated to exploring the use of digital games and gamification in the field of education. It features notable works such as Qian and Clark [22] review of the impact of GBL on 21st-century skills, and Prensky [24] influential piece on digital GBL. This cluster primarily focuses on how GBL and gamification techniques can enhance student motivation and learning outcomes, showcasing the educational potential of games.

Cluster 2 (green), known as "motivation and engagement in learning," delves into the motivational and cognitive advantages of GBL. Key papers in this area include Hamari *et al.* [21], which explores student engagement and flow in GBL, and Garris *et al.* [20], which presents a model for comprehending the impact of games on motivation and learning. The research in this cluster investigates how games capture students' attention, enrich their learning experiences, and facilitate deeper immersion.

Cluster 3 (blue), titled "serious games and learning outcomes," explores the empirical evidence that supports the educational benefits of serious games. Connolly *et al.* [19] offers a thorough review of studies on computer and serious games in educational environments. The emphasis here is on how serious games accomplish distinct learning objectives and how they stack up against conventional learning approaches.

Cluster 4 (yellow), known as "technology acceptance and mobile learning," focuses on the significance of mobile games in education and the acceptance of technology by learners. Davis [25] technology acceptance model (TAM) is a prominent point of reference in this cluster, frequently utilized to investigate how students' willingness to adopt mobile gaming technologies is influenced by their perceived ease of use and usefulness. Studies such as those conducted by Huizenga *et al.* [26] and Giannakas *et al.* [27] analyze the impact of mobile games in secondary education, taking into account factors such as immersion and learning outcomes.

Cluster 5 (purple), known as "mobile learning and immersive environments," delves into the exploration of mobile learning environments and the immersive experiences they offer. Notable works such as those by Huizenga *et al.* [18] and Schwabe and Göth [28] focus on the ways in which mobile games can engage and motivate learners within educational settings. This cluster is committed to investigating the utilization of mobile technology in creating immersive and interactive learning experiences.

Table 2. Co-citation cluster on mobile gaming and education

Cluster no and color	Cluster labels	No. of articles	Representative publications
Cluster 1 (red)	GBL and gamification	18	[22], [24], [29]–[34]
Cluster 2 (green)	Motivation and engagement in learning	13	[20], [21], [35]–[38]
Cluster 3 (blue)	Serious games and learning outcomes	12	[19], [39]–[42]
Cluster 4 (yellow)	Technology acceptance and mobile learning	8	[25]–[27], [43], [44]
Cluster 5 (purple)	Mobile learning and immersive environments	5	[18], [28], [45]

3.2. Co-occurrence analysis

The examination of the top 10 keywords in mobile gaming and education, as in Table 3 offers valuable insights into the interconnectedness of key terms within the literature. These keywords illuminate the primary themes in research related to mobile gaming and education, providing a clearer understanding of the field's focal points and connections. "Education" stands out as the most commonly used keyword, appearing 57 times with a total link strength of 223, underscoring its central role in studies on the use of games for teaching and learning. This underscores the growing emphasis on integrating GBL into educational systems.

The term "gamification" appears frequently, with 37 occurrences, indicating the growing interest in incorporating game elements, such as rewards and competition, to enhance student motivation and engagement. Following closely are "mobile game" (36 occurrences) and "mobile learning" (34 occurrences), demonstrating the rising significance of mobile technologies in delivering educational content, particularly outside of traditional classroom settings.

The phrases "GBL" and "mobile learning" are each mentioned 34 times, indicating a growing emphasis on interactive, hands-on learning experiences. The term "design" appears 28 times, underscoring the importance of creating and tailoring educational games to meet specific learning objectives. Additionally, "serious games" are referenced 27 times, highlighting the use of games for purposes beyond entertainment, such as imparting specific skills or addressing real-world challenges like health education.

Table 3. The 10 most frequent keywords in the co-occurrence analysis

Rank	Keyword	Occurrences	Total link strength
1	Education	57	223
2	Gamification	37	124
3	Mobile game	36	99
4	Mobile learning	34	116
5	GBL	34	114
6	Design	28	96
7	Mobile games	28	64
8	Serious games	27	93
9	Motivation	26	130
10	Engagement	23	113

3.2.1. Co-word analysis

The analysis in Figure 3 indicates that out of 1,250 keywords, 54 meet the criteria, revealing important intersections of technology, teaching strategies, and student engagement in mobile learning environments through co-word clusters, as detailed in Table 4. Cluster 1 (red), identified as "students and learning outcomes," emphasizes the key role of students, technology, and academic achievement in mobile GBL. This cluster delves into the ways in which mobile applications can have a positive influence on educational results. Terms such as "students," "mobile gaming," and "knowledge" indicate a focus on researching the impact of digital games on learners, especially younger students or children.

Cluster 2 (green), known as "gamification and motivation," highlights the utilization of gamification in mobile learning and its impact on student motivation and engagement. This cluster presents the educational opportunities presented by games that employ competitive, reward-based systems to enhance motivation, as evidenced by terms such as "mobile game," "serious game," "gamification," and "experience."

Cluster 3 (blue), titled "educational design and technology integration," emphasizes integrating education, GBL, mobile learning, and design. This cluster demonstrates a keen interest in developing educational games and the technological infrastructure to support them. The keywords "design" and "devices" indicate a focus on creating mobile platforms and devices to enrich educational experiences.

Cluster 4 (yellow), known as "health, well-being, and digital play," delves into the fusion of mobile games and health. This cluster focuses on the potential of mobile games to tackle concerns like anxiety and

offer mental health support. The terms "play" and "digital games" emphasize that mobile games serve educational purposes and contribute to promoting health and well-being. Studies in this field often explore the therapeutic advantages of mobile games.

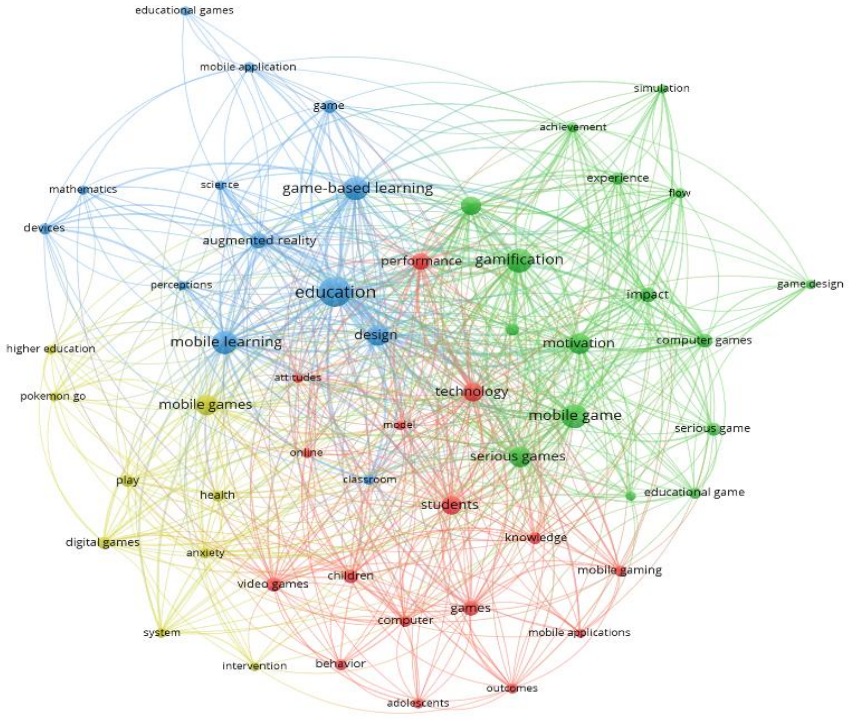

Figure 3. Co-word analysis of mobile gaming and education

Table 4. Co-word analysis of screen time and parental

Cluster no and color	Cluster label	Number of keywords	Representative keywords
1 (red)	Students and learning outcomes	16	"Students," "technology," "performance," "mobile gaming," "games," "video games," "children," "mobile applications," "knowledge"
2 (green)	Gamification and motivation	16	"Mobile game," "gamification," "motivation," "engagement," "impact," "serious game," "educational game," "experience"
3 (blue)	Educational design and technology integration	13	"Education," "game-based learning," "mobile learning," "design," "augmented reality," "game," "devices"
4 (yellow)	Health, well-being, and digital play	9	"Mobile games," "play," "digital games," "health," "anxiety," "intervention"

4. DISCUSSION

The bibliometric results provide critical insights into the transformative potential of mobile gaming in education and its implications for educational practice and policy. The analysis highlights the significant role of gamification and GBL in fostering student engagement, motivation, and cognitive development [46]. These findings underscore the need for integrating mobile games into teaching strategies to create dynamic and immersive learning experiences for educational practice. By aligning mobile games with curriculum objectives, educators can use them to reinforce academic content, particularly in subjects that require problem-solving and critical thinking. Additionally, mobile games offer personalized learning opportunities, enabling students to progress at their own pace and catering to diverse educational needs. Such adaptive environments ensure inclusivity and equity, particularly for students with varying learning abilities [47]. However, the success of these approaches depends on equipping educators with the necessary skills through targeted professional development programs. These programs should emphasize game-based pedagogy, strategies for selecting suitable games, and methods for assessing learning outcomes while mitigating potential distractions [48]. When thoughtfully implemented, mobile gaming can transform traditional classrooms into student-centered environments, encouraging active participation and lifelong learning.

From a policy perspective, the findings point to the need for a comprehensive framework supporting mobile gaming integration into educational systems. Policymakers should prioritize investments in developing and adopting mobile GBL tools that are pedagogically robust and culturally relevant. Addressing infrastructural challenges, such as ensuring equitable access to high-speed internet and mobile devices, is vital to bridging the digital divide [49]. Establishing clear standards and guidelines for mobile gaming in education can ensure alignment with curriculum goals while safeguarding data privacy and promoting accessibility [50]. Moreover, fostering collaborations between academia, industry, and government can accelerate the innovation of educational games, with policies encouraging research into their long-term impact on cognitive and emotional learning outcomes. The bibliometric analysis also emphasizes emerging technologies like augmented reality and serious games, which have the potential to reshape educational frameworks by providing immersive and context-based learning experiences. By strategically integrating these elements, policymakers can drive the adoption of innovative teaching methods that align with contemporary educational goals. Together, these efforts can position mobile gaming as a pivotal tool for achieving inclusive, equitable, and high-quality education, contributing to broader objectives like enhancing digital literacy and fostering global competency among learners.

5. CONCLUSION

The potential for further research lies in exploring specific applications of mobile gaming in diverse educational settings, such as special education, adult learning, and vocational training. The increase in citations, especially in recent years, can be attributed to the growing adoption of mobile learning strategies in educational institutions and a heightened interest in research focusing on the impact of mobile gaming on cognitive, emotional, and behavioral learning outcomes. In summary, mobile gaming in education has transitioned from a specialized study area to a well-established and influential field. The rising number of publications and substantial citation rates underscore its significance in contemporary educational discourse. As mobile gaming technologies continue to advance and integrate into educational systems, this research area is anticipated to flourish, maintaining its prominence in academic exploration.

Thus, these findings indicate that educators and curriculum designers can leverage mobile games to create more immersive and interactive learning experiences. Educators can boost student motivation, even in challenging subjects, by incorporating gamification elements—like challenges, rewards, and immediate feedback. Curriculum designers could use this research to develop frameworks integrating mobile gaming seamlessly with learning objectives. This ensures that games act as reinforcement rather than a distraction from the curriculum. Furthermore, training educators to select and implement suitable mobile games tailored to their curriculum needs will be essential for maximizing the educational potential of mobile gaming. This approach can advance contemporary pedagogy by embedding adaptive, learner-centered strategies into the classroom through technology, thus fostering engagement and improving academic performance.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Walton Wider	✓	✓			✓				✓			✓		
Cathy Mae Toquero	✓			✓	✓		✓			✓				
Karen Joy Brillo Talidong		✓		✓		✓				✓	✓			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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