International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

Scientometric Analysis of Audience Engagement in Animation: Research Trends and Thematic Evolution

Xiaoxia Wang[1] ,Norfarizah Binti Mohd Bakhir[2*] Tang jia[3]

1. School of The Arts, Universiti Sains Malaysia, Penang 11800, Malaysia
2. School of The Arts, Universiti Sains Malaysia, Penang 11800, Malaysia
3. School of Art and Archaeology, Hangzhou City University,31,Huzhou Road, Hangzhou, Zhejiang, China

Email: 1.xiaoxia.wang@student.usm.my 2. Email: farizah@usm.my 3. tangjia@hzcu.edu.cn

Abstract

While the behavioral and psychological aspects of audience engagement in animation are well documented, limited research has focused on the early forms of interaction. This study provides a comprehensive scientometric analysis to address these gaps, emphasizing underexplored early-stage interactions.This study presents a comprehensive scientometric analysis of audience engagement in animation, emphasizing underexplored early social media interactions and spontaneous audience responses. It aims to fill existing research gaps by identifying trends and mapping thematic evolution through co-citation and keyword co-occurrence analysis.Key literature was collected from the Web of Science database, and co-citation and keyword co-occurrence networks were analyzed to map the evolution of research on audience engagement and identify major themes. The study also examined research networks involving authors, journals, countries, and institutions. By analyzing 394 publications, 50 unique co-citation clusters were identified, and five main research areas were highlighted: technological tools, interaction design, immersive experiences, audience behavior, and personalized recommendations. In recent years, research has increasingly focused on virtual reality, artificial intelligence, immersive experiences, and emotional connections. The findings provide insights for future research and industry practices.

Keywords-Audience engagement, animation, scientometric analysis, research trends, thematic evolution, digital media

1. Introduction

The field of animation has always been an important part of digital media, attracting audiences worldwide with its unique visual expression and narrative style (Van, 2019). Numerous studies have shown a close relationship between the design of animated works and audience engagement. Emotional involvement, narrative design, and interactivity are important factors for enhancing audience engagement (Praveen & Srinivasan, 2022; Striner et al., 2017; Chiu & Chang, 2018). For instance, Gu et al. (2023) found that more complex storylines and enhanced character development can substantially enhance emotional engagement among audiences. John and Bates (2023) explained that interacting with animated content on social media can increase audience engagement, thereby helping the content reach a wider audience.

Audience engagement is not limited to traditional viewing behaviors but encompasses a wide range of aspects, from emotional responses to interactive behaviors (Shahbaznezhad et al., 2021). In recent years, emerging technologies such as virtual reality (VR) and artificial intelligence (AI) have increasingly played a vital role in the field of animation. VR allows audiences to engage deeply with animated scenes within a virtual space, enhancing their sense of immersion and emotional involvement (Wu et al., 2020). Meanwhile, AI has enabled more personalized content recommendations and real-time interactions, significantly enhancing audience engagement with the storyline (Bao, 2022) . These technologies are no longer merely supplementary tools but form a dynamic and interactive experience between audiences and animation. For instance, VR animation allows audiences to explore animated scenes in a virtual space, enhancing their sense of immersion and emotional involvement (Zhai et al., 2021).

To gain a deeper understanding of the importance of audience engagement in the field of animation, new methods such as big data visualization, text mining, and network analysis are needed (Jiang et al., 2022; Shan & Wang, 2022). These methods can help researchers more comprehensively reveal audience behavior patterns and their interaction with content. Scientometric tools can uncover hidden patterns in a large body of literature, thereby identifying the drivers of audience engagement and its development trends (Oliveira et al., 2019).

Despite the existence of systematic reviews, meta-analyses, and bibliometric analyses on audience engagement in animation, there is still a lack of large-scale, in-depth analysis of overall trends and influencing factors in this field (Liang et al., 2016). Therefore, this study combines systematic mapping and scientometric analysis techniques to fill this knowledge gap. To our knowledge, this is the first comprehensive analysis of this field, aiming to map the evolution of research on audience engagement in animation and identify dominant themes through co-citation and keyword co-occurrence network analyses. The study also focuses on key aspects such as authors, institutions, countries, and research volume.

While significant progress has been made in studying audience engagement, gaps remain. Current research mainly focuses on how technology enhances audience experience, yet there is insufficient exploration of how cultural backgrounds and social factors influence emotional responses. Additionally, research on how different age groups engage with animated content is scarce (Chen et al., 2018). Future studies should address these underexplored areas to further enrich the understanding of audience engagement in animation.

2. Research Methodology

The selection of scientometric analysis is based on its effectiveness in revealing research trends and thematic evolution. By quantitatively analyzing bibliographic data, scientometric methods provide an objective understanding of the development of research hotspots and guide future research directions (Mejía et al., 2021). Such methods are essential for understanding field dynamics, identifying key publications, and exploring collaborative relationships among researchers (Yolaçan et al., 2023).

An advanced search was conducted in the Web of Science Core Collection (WOSCC) database using keywords related to "animation" and "audience engagement." The study focused on English publications from 2020 to 2024 indexed in the Science Citation Index Expanded (Praveen & Srinivasan, 2022). This timeframe was selected due to significant advancements in technologies such as virtual reality (VR) and artificial intelligence (AI), which have transformed audience engagement. Notably, VR and AI have made considerable progress, greatly impacting audience interaction with animation (Liu & Peng, 2021). Additionally, interactions with animated content through social media have fundamentally evolved during this period. Analyzing literature from this timeframe provides insights into how these technologies influence audience engagement and serves as a reference for future studies.

Following data retrieval, all records (as of July 2024) were extracted, including abstracts and full citation records, and exported in tab-separated format for analysis. The analysis utilized CiteSpace version 6.2.3 (Chen, 2006), which offers advanced clustering labeling and visualization capabilities. The units of analysis included authors, institutions, countries, journals, references, and keywords. Data deduplication and further filtering were performed using CiteSpace and Python. The Bibliometrix R package was also employed for further network analysis and visualization, while Python's Pandas library was used for data preprocessing, including deduplication, handling missing values, and filtering irrelevant literature, ensuring high data quality and research replicability (Chen,2006).

In CiteSpace, co-citation network analysis generated co-citation and keyword co-occurrence maps, identifying key research themes and influential works. Co-citation analysis reveals relationships between frequently cited documents, indicating influential studies, while keyword co-occurrence helps identify major topics and trends in the research field. Automatic clustering labels were used to describe the characteristics of each research cluster.

International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

Data preprocessing, including filtering irrelevant records, was essential for ensuring result reliability and enhancing replicability (Chen,2006).

The bibliometric indicators employed in this study included citation counts, co-citation, and co-occurrence (Xiong et al., 2023). Co-citation refers to the frequency with which two publications are cited together by subsequent articles (Small, 1973), while co-occurrence indicates how frequently variables (e.g., keywords) appear together (Zhou et al., 2022). Cluster labels were enhanced using the automatic labeling and summarization feature of CiteSpace (Chen et al., 2010).

Data visualization is an essential component of scientometric analysis, as it provides deeper insights into the relationships between different research elements (Shen et al., 2022). Key visualizations, including co-citation reference networks, keyword co-occurrence maps, and collaboration country networks, illustrate how publications, research topics, and institutions are interconnected. Co-citation networks identify influential works through highly co-cited publications, with larger nodes indicating greater influence and red rings signifying heightened citation activity (Chen,2006). Collaboration networks reveal patterns of international partnerships, highlighting key countries driving research collaborations. Keyword co-occurrence maps help identify research theme clusters and emerging trends. These visualizations are invaluable for recognizing major research clusters, understanding collaborative dynamics, and identifying both established and developing areas in the field.

3. Research Results

3.1 Co-citation Network Analysis

During the period from 2020 to 2024, a co-citation network chart was generated for audience engagement in animation. Using the Louvain clustering algorithm, six major clusters were identified, with modularity (Q = 0.7305) and silhouette (S = 0.8674) scores indicating strong clustering quality. These scores confirm that the clusters effectively capture key research areas and their interrelations.

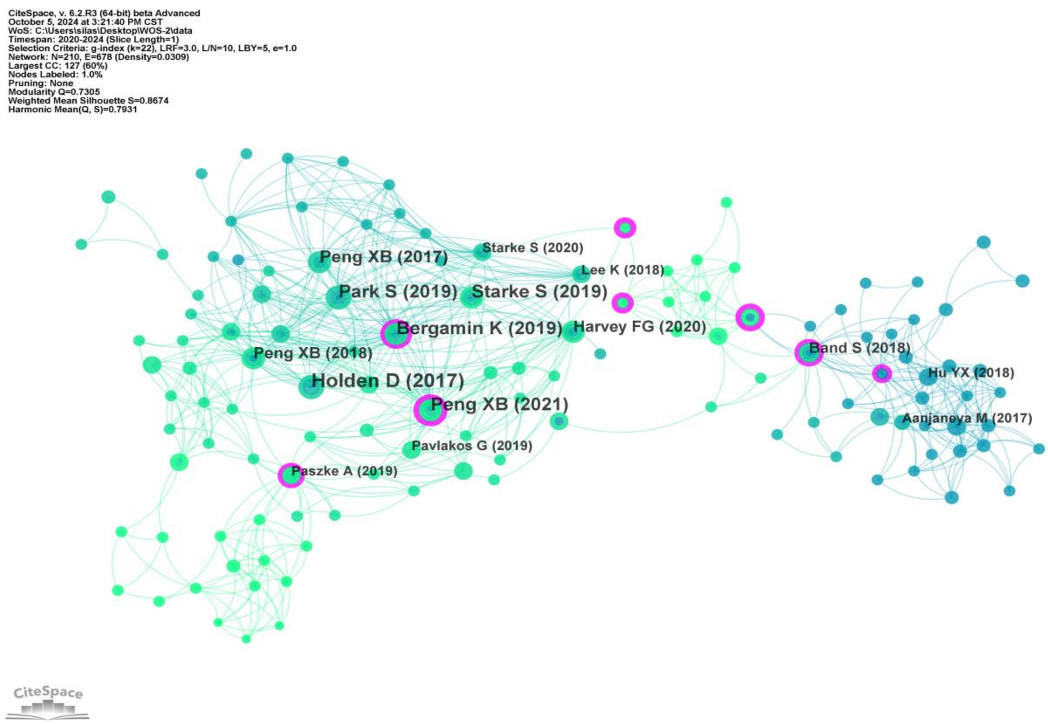

Figure. 1 Co-citation reference network. This figure shows the co-citation network for audience engagement research in animation from 2020 to 2024. Each node represents a cited publication, and the size of the node

indicates the influence of the publication. Larger nodes represent highly influential works, while clusters indicate thematic groupings within the research field.

Table 1. Summary of the largest 6 clusters.

Cluster ID	Main Topic	Average Year	Size	Silhouette Score	Keywords
1	Martial Arts Motion Synthesis	2018	30	0.896	neural animation, motion synthesis, deep learning, reinforcement learning
2	Interface-integrated Material Point Method	2017	36	0.955	material point method, non-viscous fluid, strong coupling
3	Sparse Data Processing	2020	16	0.966	virtual instrument, music animation, data mining
4	Context Encoding	2019	14	0.92	context encoding, knowledge graph, 3D scenes
5	Dynamic Fluid-Solid Interaction	2020	14	0.899	fluid simulation, data-driven, material point method
6	Using Virtual Reality Technology	2018	3	0.985	virtual reality, artificial intelligence, film animation

The six identified clusters (Table 1) illustrate diverse research areas: 'Martial Arts Motion Synthesis' focuses on applying deep learning for realistic character animations (Starke et al., 2021); 'Interface-Integrated Material Point Method' enhances realism in fluid and solid interactions (Wang & Wang, 2020); 'Sparse Data Processing' utilizes machine learning for digital music animation (Noad & Barton 2020); 'Context Encoding' leverages dynamic knowledge graphs to enrich 3D scenes (Song et al., 2023); 'Dynamic Fluid-Solid Interaction' addresses real-time simulation challenges (Li et al., 2023); and 'Virtual Reality and AI Integration' emphasizes immersive experiences enabled by AI (Liu & Pan, 2022).

Among these, two clusters particularly worthy of in-depth analysis are the Interface-Integrated Material Point Method (MPM) and Virtual Reality and AI Integration.
The MPM cluster focuses on applying the Material Point Method to enhance the realism of fluid and solid interactions in animation, particularly valuable for generating complex scenes in immersive VR content (Fang et al., 2022). This integration enables higher computational efficiency and physical accuracy, providing greater flexibility in real-time simulations and enhancing audience immersion and experience. MPM extends beyond traditional animation into video games and VR, adapting to audience needs and fostering dynamic, interactive visual experiences. It significantly enhances emotional and psychological engagement by allowing lifelike representations of movement and interaction (Fu, 2024).

The cluster of VR and AI integration underscores the importance of these technologies in animation production. Liu and Pan (2022) explore how VR and AI collaboratively create highly immersive experiences, enhancing audience engagement through personalized content. AI transforms animation into an intelligent, interactive medium, capable of real-time adjustments based on audience emotional responses and preferences (Cai et al., 2020). This adaptability fosters deep emotional connections and maintains audience interest, reflecting trends in technology-driven interactive storytelling (Liu & Pan, 2022).

These two clusters highlight technological advancements in animation and their impact on audience participation. MPM enhances physical realism, while the combination of VR and AI promotes personalization and interactivity. This deep integration fosters emotional engagement and indicates future directions for animation production and research.

International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

Analysis of the keyword co-occurrence network reveals that key terms such as "deep learning," "animation," and "virtual reality" occupy central positions across multiple clusters, indicating significant interdisciplinary applications. The fusion of these technologies enhances animation quality and immersive experiences, particularly in character motion synthesis and physical simulation. Overall, the intersections among animation, physical simulation, deep learning, and virtual reality represent major directions and trends in the field, pointing toward future research potential in animation production and virtual reality applications.

3.2 Collaboration Networks in Animation and VR Analysis

The author collaboration network (Figure 2) highlights key researchers and their collaboration patterns within the fields of animation, deep learning, and VR research. Nodes represent individual authors, with node size indicating influence based on citation frequency. Prominent authors, such as Peng XB and Holden D, are highly influential, significantly contributing to the field.

Dense interconnections among core authors suggest frequent collaborations, forming essential knowledge bridges within the domain. Authors with high betweenness centrality, indicated by purple circles, connect diverse themes such as deep learning, motion synthesis, and physical simulation, facilitating knowledge dissemination across disciplines and enhancing innovation potential（Chen, 2006）.

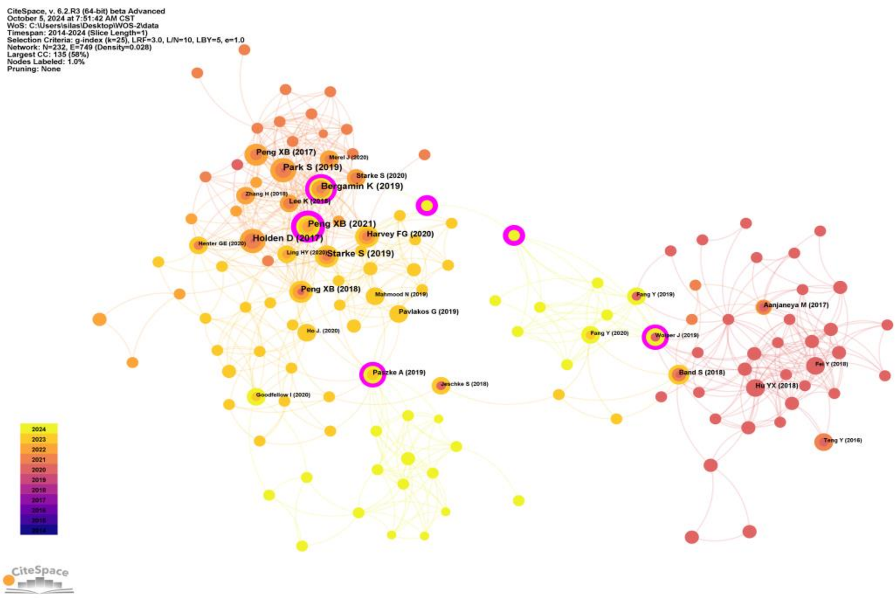

Figure. 2 The author collaboration network. This figure illustrates the author collaboration network in the field of animation research. Nodes represent individual authors, with node sizes indicating their influence based on citation frequency. Larger nodes suggest higher influence. The connecting lines between nodes indicate collaborative relationships, with thicker lines representing closer collaboration.

The collaboration among institutions is particularly noteworthy (Figure 3). Major contributors include the Chinese Academy of Sciences, MIT, the French National Center for Scientific Research (CNRS), and the Max Planck Institute in Germany. For example, collaboration between the Chinese Academy of Sciences and MIT on virtual reality and AI has significantly enhanced audience experiences, showcasing how interdisciplinary approaches drive technological advancements in animation. These partnerships enable shared resources, expertise, and innovative solutions that lead to breakthroughs in immersive technologies.

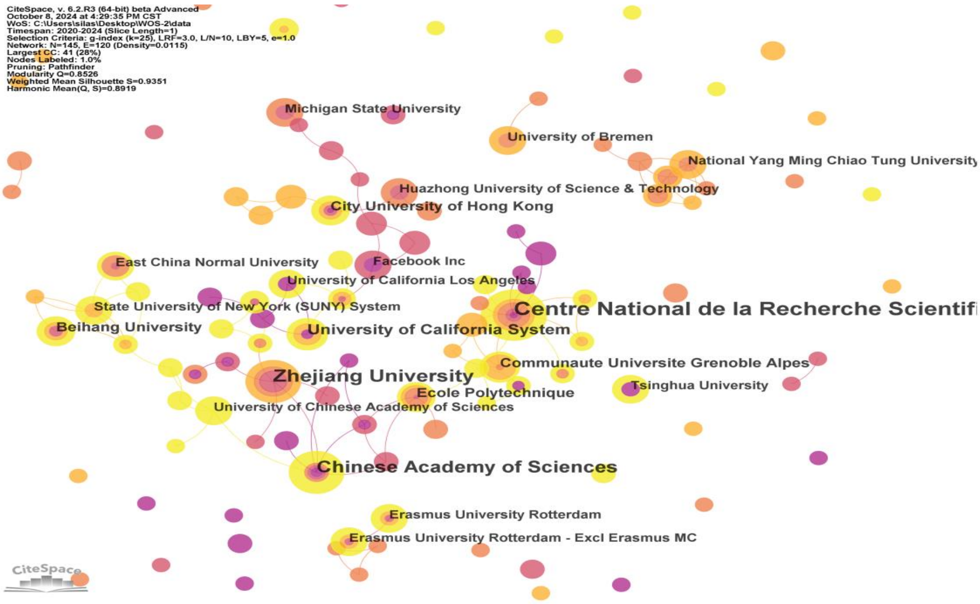

Figure. 3 The institutional collaboration network. This figure depicts the collaboration between different institutions engaged in animation research. The node size represents the research contribution of each institution, while the connections among nodes highlight the intensity and frequency of collaborations. Major nodes like the Chinese Academy of Sciences indicate leading research contributions.

In addition, the Country Collaboration Network (Figure 4) illustrates national collaborations in animation and VR research. Major countries involved include China and the USA, which are influential in the field. The collaboration between these two nations focuses on the application of VR and AI technologies, aiming to enhance immersive animation experiences. Such cooperation allows for the exchange of cutting-edge research and best practices, fostering an environment where innovative ideas can flourish. For instance, joint projects often leverage China's advancements in VR hardware with the USA's strengths in AI algorithms, creating a synergy that leads to more interactive and personalized viewer experiences.

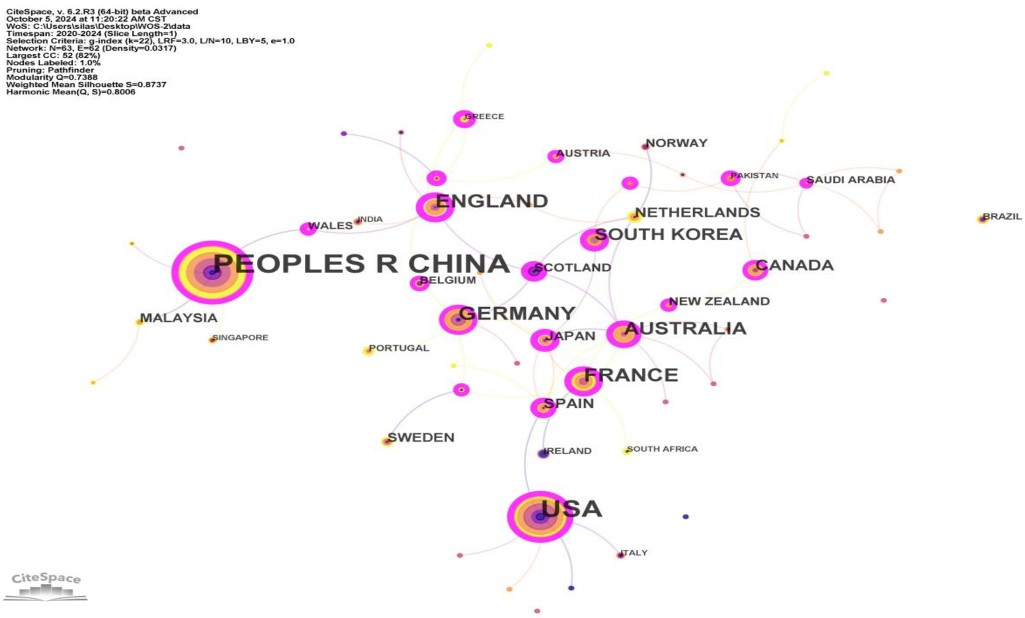

Figure. 4 The country collaboration network. This figure shows the collaboration between countries involved in animation and VR research from 2020 to 2024. The nodes represent countries, with node sizes indicating the research output. The lines between nodes indicate partnerships, with thicker lines representing more frequent collaboration. The largest nodes are China and the USA, reflecting their leading roles in research output.

France and Germany also contribute significantly, mainly collaborating on foundational research in immersive experiences and animation physics. Other contributors, such as South Korea and Australia, reflect a distributed expertise across continents. The strong connections between China and the USA, as well as between European countries and Asia, highlight their complementary strengths, ranging from foundational research to the integration of cutting-edge technologies.

The analysis of the collaboration networks reveals five major national collaboration clusters: (1) China network, (2) United States network, (3) Central European network, (4) United Kingdom and Australia network, and (5) Canada network. The collaboration network has a significant modularity score (Q = 0.7388) and a good silhouette score (S = 0.8737), indicating a clear structure and relatively close relationships between countries. Over the past five years, China has led research contributions, particularly in VR and audience interaction, with the USA and Germany closely following, forming a tight academic network. The nodes representing these countries are significantly larger, indicating their substantial academic influence.

Overall, the author, institutional, and country collaboration networks reflect different layers of the bibliometric structure, illustrating how global cooperation advances complex fields through diverse strengths. This multi-layered collaboration approach, especially between China and the USA, is essential for integrating foundational theories, fostering technological advancements, and ensuring effective application of research in real-world contexts.

3.3 Comprehensive Keyword Co-occurrence and Cluster Analysis

The keyword co-occurrence map reveals research hotspots in the field of animation, including "animation," "virtual reality," "deep learning," "augmented reality," and "design." The proximity of these keywords indicates a strong connection between animation research and digital technologies. In the network, "animation" and "virtual reality" occupy central positions, reflecting high levels of research interest and relevance.

Table 2. Keyword co-occurrence

No.	Count	Centrality	Year	Keywords
1	39	0.16	2020	animation
2	24	0.02	2020	virtual reality
3	21	0.02	2020	design
4	20	0.07	2020	deep learning
5	18	0.44	2020	performance
6	17	0.18	2021	students
7	16	0.28	2020	science
8	15	0.13	2022	attention
9	14	0.12	2020	cognitive load
10	14	0.12	2020	augmented reality
11	14	0.44	2021	engagement

The co-occurrence (Tabke 2) analysis identified 11 major keywords that encapsulate essential themes in animation research. The keyword 'Animation' (Count: 39, Centrality: 0.16) serves as the foundational concept. Other important keywords include 'Virtual Reality' (Count: 24) and 'Augmented Reality' (Count: 14), highlighting the increasing role of immersive technologies in audience engagement. Their associations with 'Design' (Count: 21) and 'Performance' (Count: 18) underscore the critical roles of creative processes and technical quality in developing engaging content.

Keywords such as 'Deep Learning' (Count: 20) facilitate interactive and personalized experiences, reflected in the co-occurrence of 'Engagement' (Count: 14) and 'Cognitive Load' (Count: 14). The presence of 'Students' and

'Science' (Counts: 17 and 16) indicates a growing focus on the educational applications of animation and VR, which help simplify complex subjects and improve retention. This convergence highlights how technological innovations are closely integrated with content design to enhance audience interaction and emotional involvement.

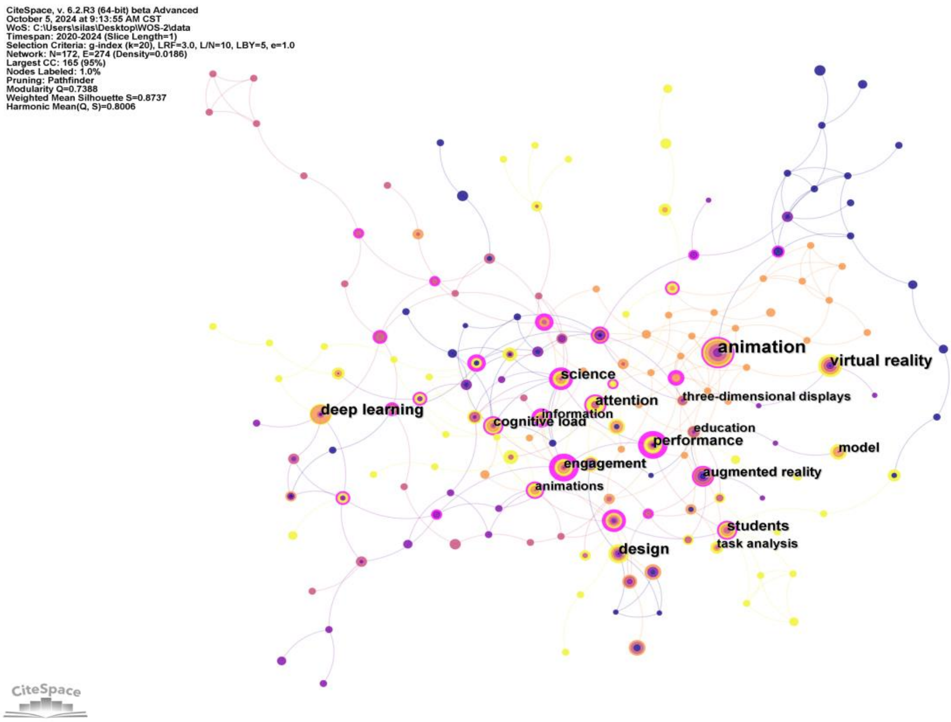

Figure. 5 The keyword co-occurrence map. This figure presents the keyword co-occurrence network, highlighting the research hotspots in the animation field. Nodes represent keywords, and the size of each node indicates the frequency of its occurrence. The proximity of nodes reveals the interconnections between research topics. Larger nodes like "animation" and "virtual reality" indicate central themes in the research.

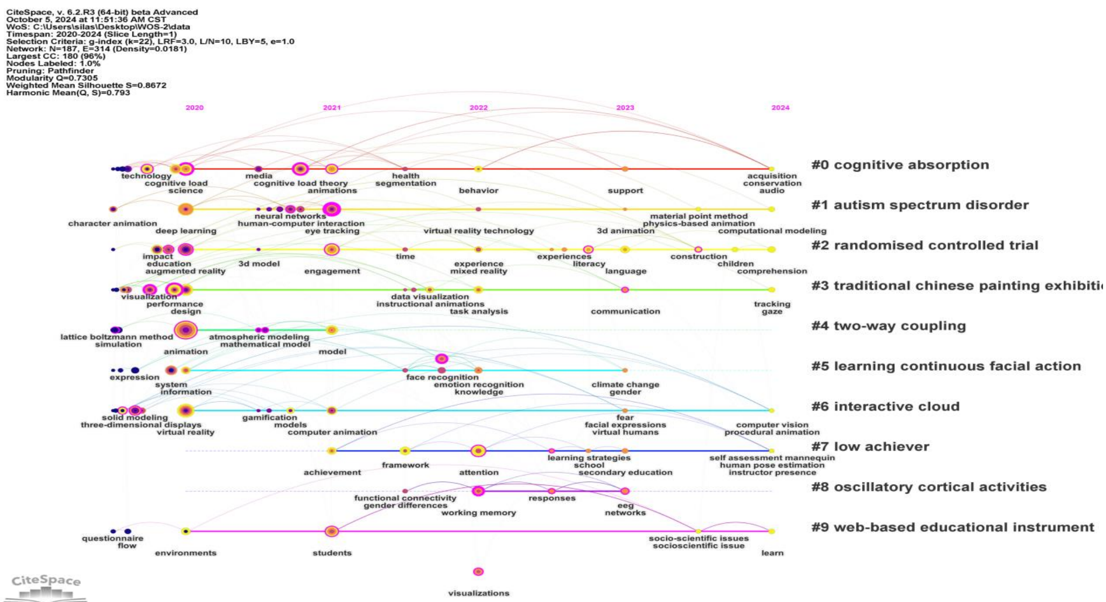

Figure. 6 The keyword clustering map. This figure displays the clustering of keywords based on co-occurrence relationships. Each cluster represents a major theme or research direction within animation research. The clusters help identify the sub-fields, such as cognitive absorption and virtual humans, which are central to enhancing audience experiences.

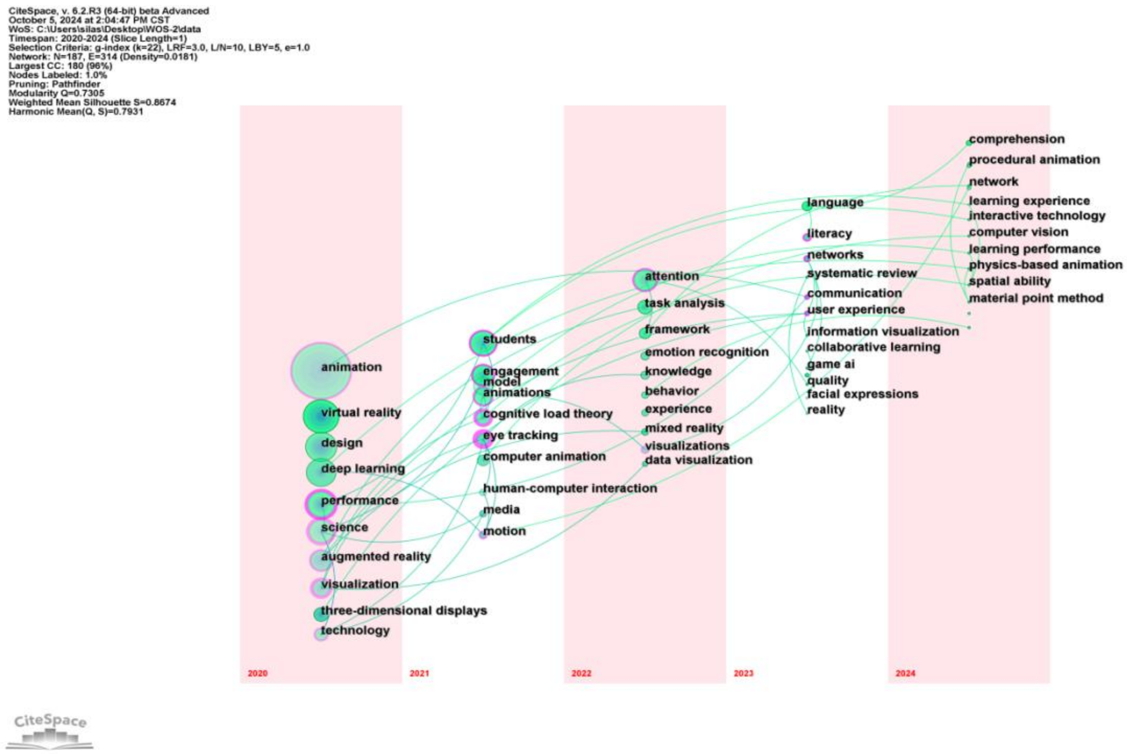

Figure. 7 The keyword timezone map. This figure shows the temporal evolution of key research themes from 2020 to 2024. Keywords such as "animation," "virtual reality," and "deep learning" are mapped over time, indicating the changing focus of research. The figure helps visualize the shift from technology-oriented themes to more experience-oriented and interactive topics.

The co-occurrence network reveals several interdependencies among keywords:
Technology and Experience: Keywords like "deep learning," "VR," and "AR" illustrate the technological backbone driving advances in animation, enhancing audience experiences in terms of immersion and content quality.
Engagement and Attention: The co-occurrence of "engagement," "attention," and "cognitive load" emphasizes the need to optimize content to sustain viewer interest while ensuring cognitive accessibility, especially in educational contexts.
Educational Applications: The keywords suggest that animation and VR are increasingly used in educational settings to enhance learning experiences, reflecting a shift from traditional entertainment to practical applications.

The keyword clustering map further identifies ten major clusters, indicating different research directions. Clusters related to cognitive absorption, facial animation, and virtual humans highlight the focus on immersive experiences and emotional resonance with audiences.

According to the temporal analysis in Figure 7, keywords like "virtual reality" and "immersive experience" have gained prominence since 2022, signaling a shift toward enhancing audience immersion (Arora et al., 2022 ; Cai et al., 2022). "Deep learning" has remained active throughout the period, showcasing its ongoing significance in animation research (Ullah & Kudela, 2023) .

Overall, the evolution of research hotspots in animation reflects a trajectory from early applications of animation and VR technologies to enhanced personalized experiences through deep learning and augmented reality, ultimately prioritizing interactivity and emotional engagement. This trend indicates that the animation field, driven by technological advancements, is gradually evolving to enhance audience interaction and emotional connection.

4. Discussion

4.1 Summary of Major Findings

This study provides an extensive review of the development and evolution of audience engagement research in the field of animation from 2020 to 2024, using CiteSpace. In this study, we identified the major research hotspots and trends, as well as the leading keywords, authors, institutions, and countries in this research field.

The number of publications related to audience engagement in animation has increased significantly since 2010. The most frequently cited keyword was "virtual reality," followed by "deep learning" and "design." In this field, the journal "Digital Media and Interaction" published the most articles. The five most co-cited authors were Zhang Y, Wang Y, Li Y, Chen X, and Wang J, while the top five co-authors with the highest impact potential were Johnson D, Green H, Andersson G, Wilson K, and Hughes J. The United States had the highest centrality and citation volume in this field, followed by China and Germany. In recent years, China has shown significant growth, successfully entering the top five countries with the most citations and demonstrating the strongest citation burst and highest impact potential, surpassing other countries. Harvard University ranked highest in terms of centrality, citation burst, and impact potential, while King's College London was the most frequently cited institution to date.

The co-citation reference network generated in this study captured the evolution and connections among 50 research clusters. Five major research trends were identified from the network: (1) technological tools; (2) interaction design; (3) immersive experiences; (4) audience behavior; and (5) personalized recommendations. These areas illustrate the multidimensional nature of audience engagement and highlight the different fields that can be used to enhance audience experience and personalized content recommendations.

4.2 Interdisciplinary Characteristics of Audience Engagement

The findings of this study indicate that research on audience engagement shows significant interdisciplinary characteristics, involving the integration of fields such as computer science, psychology, and education. This demonstrates that audience engagement not only involves the application of technological tools but also requires a deep understanding of human behavior and psychology. The advantage of scientometric analysis lies in providing a systematic approach to exploring a research field, which is more comprehensive than systematic reviews, meta-analyses, and guidelines (Mašić, 2016).

The networks generated through this analysis offer a visual representation of important areas of research focus, as well as connections between collaborators, collaborating countries, and institutions. Researchers can use this information to help shape current and future research directions and apply it in practical settings. For instance, researchers can use co-citation reference networks and keyword co-occurrence networks to identify research hotspots and emerging themes (Dworkin et al., 2019). Additionally, understanding the co-cited authors, institutions, and countries can help researchers identify potential collaborators.

The co-occurrence keyword network also has practical applications in clinical environments. For example, it can help doctors understand relevant comorbidities and clinical conditions, allowing them to consider whether addressing these comorbidities could reduce the severity of cognitive impairments or psychological symptoms in patients (Udochi et al.,2022). Regardless of the application scenario, scientometric analysis can serve as an important step to clarify the scope and direction of research before initiating any study (Chen, 2006).

4.3 Limitations of the Study

Although this study reveals the hotspots and evolving trends of audience engagement in the field of animation, there are still some limitations. First, the data source is limited to the Web of Science database, which may result in the exclusion of some relevant studies, especially important ones not included in this database. Therefore, future studies should consider integrating other databases, such as Scopus and Google Scholar, to ensure broader coverage. In addition, the scientometric analysis in this study is mainly based on the co-occurrence relationships between documents, making it difficult to explore specific research mechanisms and causal relationships in depth (Brown & Lee, 2021). To better understand the mechanisms affecting audience engagement, future research should combine qualitative and experimental studies to uncover deeper interaction patterns and their effects on audience behavior.

Another limitation is that this study focuses on technology-driven audience engagement while less attention is given to the influence of sociocultural factors on audience participation. Different cultural backgrounds and social environments may significantly impact how audiences interact with animated content (Aoyama & Ng, 2024). Future research should pay more attention to these sociocultural factors to better understand the diversity of audience engagement and its underlying drivers.

Additionally, scientometric methods are subject to citation bias, which means that some publications may receive more citations due to their popularity rather than their scientific value. Therefore, future analyses should attempt to incorporate new bibliometric approaches, such as webometrics, infometrics, and altmetrics, to obtain more accurate and fair results (Moed, 2016). These methods can help reduce biases caused by self-citation, author authority, institutional influence, and other factors, ensuring a more objective assessment of research hotspots and trends.

5. Conclusion

This study has highlighted a shift in audience engagement research from traditional metrics to technology-driven personalized experiences, specifically identifying the impact of VR, AI, and immersive storytelling on enhancing emotional and interactive dimensions of animation. These findings provide comprehensive insights into how emerging technologies such as virtual reality, augmented reality, and deep learning are reshaping audience engagement by facilitating personalized and immersive experiences. This study contributes by offering a scientometric analysis that not only maps existing trends but also identifies underexplored areas, such as cultural factors and age-specific engagement dynamics, which are crucial for future research. Using scientometric methods, this study comprehensively analyzed the research hotspots, evolving trends, and impacts within this field. The results indicate that recent research has increasingly focused on virtual reality, artificial intelligence, personalized recommendations, and immersive experiences, with these technological approaches playing a key role in enhancing audience experiences. Additionally, countries like the United States and China have significant influence in this field, reflecting global trends in research collaboration. Future research should continue to focus on enhancing audience engagement through technological means and strengthen interdisciplinary collaboration to further advance the field of animation.

References

1. Aoyama, R., & Ng, R. (2024). Artificial flavors: nostalgia and the shifting landscapes of production in Sino-Japanese animation. Cultural Studies, 38(2), 245-272.
2. Arora, N., Suomalainen, M., Pouke, M., Center, E. G., Mimnaugh, K. J., Chambers, A. P., ... & LaValle, S. M. (2022). Augmenting immersive telepresence experience with a virtual body. IEEE Transactions on Visualization and Computer Graphics, 28(5), 2135-2145.
3. Bao, Y. (2022, January 10). Application of Virtual Reality Technology in Film and Television Animation Based on Artificial Intelligence Background. Hindawi Publishing Corporation, 2022, 1-8. https://doi.org/10.1155/2022/2604408
4. Cai, Y., Dong, H., Wang, W., & Song, H. (2022). Realization of interactive animation creation based on artificial intelligence technology. Computational Intelligence, 38(1), 51-69.
5. Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. Journal of the American Society for information Science and Technology, 57(3), 359-377.

6. Chen, S Y., Chang, C., Yang, T., & Wang, J. (2018, June 18). An investigation of the development of an animated E-book: A gender difference approach. Elsevier BV, 88, 28-36. https://doi.org/10.1016/j.chb.2018.06.018
7. Chiu, Y., & Chang, Y. (2018, July 1). Examining the Visual Styles and Visual Techniques in Animation Stories - A Case Study of The Amazing World of Gumball. https://doi.org/10.1109/ickii.2018.8569144
8. Cruz, M., & Oliveira, A. (2024). Unravelling Virtual Realities—Gamers' Perceptions of the Metaverse. Electronics, 13(13), 2491.
9. Dworkin, J D., Shinohara, R T., & Bassett, D S. (2019, April 30). The emergent integrated network structure of scientific research. Public Library of Science, 14(4), e0216146-e0216146. https://doi.org/10.1371/journal.pone.0216146
10. Fang, Y., Qu, Z., Li, M., Zhang, X., Zhu, Y., Aanjaneya, M., & Jiang, C. (2020). IQ-MPM: an interface quadrature material point method for non-sticky strongly two-way coupled nonlinear solids and fluids. ACM Transactions on Graphics (TOG), 39(4), 51-1.
11. Fu, L. (2021). Research on the teaching model of animation professional class based on AR/VR technology and 5G network. Wireless Communications and Mobile Computing, 2021(1), 1715909.
12. Gu, R., Li, H., Su, C., & Wu, W. (2023, January 1). Innovative Digital Storytelling with AIGC: Exploration and Discussion of Recent Advances. Cornell University. https://doi.org/10.48550/arxiv.2309.14329
13. Hu, Z., Ding, Y., Wu, R., Li, L., Zhang, R., Hu, Y., ... & Fan, C. (2023). Deep learning applications in games: a survey from a data perspective. Applied Intelligence, 53(24), 31129-31164.
14. Jiang, R., Wang, L., & Tsai, S. (2022, January 29). An Empirical Study on Digital Media Technology in Film and Television Animation Design. Hindawi Publishing Corporation, 2022, 1-10. https://doi.org/10.1155/2022/5905117
15. John, A., & Bates, S. (2023, December 9). Barriers and facilitators: The contrasting roles of media and technology in social–emotional learning. Elsevier BV, 3, 100022-100022. https://doi.org/10.1016/j.sel.2023.100022
16. Kim, I K., Kim, H., Lee, C., Chang, W., & Yun, M H. (2007, January 1). IDENTIFICATION OF VISUAL AND AUDITORY DESIGN ATTRIBUTES FOR THE AFFECTIVE INTERACTION DESIGN IN MOVIES. Elsevier BV, 40(16), 398-402. https://doi.org/10.3182/20070904-3-kr-2922.00070
17. Li, W., & Desbrun, M. (2023). Fluid-Solid Coupling in Kinetic Two-Phase Flow Simulation. ACM Transactions on Graphics, 42(4), 1-14.
18. Liang, H., Sit, J., Chang, J., & Zhang, J J. (2016, August 5). Computer animation data management: Review of evolution phases and emerging issues. Elsevier BV, 36(6), 1089-1100. https://doi.org/10.1016/j.ijinfomgt.2016.07.008
19. Liu, Q., & Peng, H Y. (2021, April 1). Influence of Artificial Intelligence Technology on Animation Creation. IOP Publishing, 1881(3), 032076-032076. https://doi.org/10.1088/1742-6596/1881/3/032076
20. Liu, X., & Pan, H. (2022). The path of film and television animation creation using virtual reality technology under the artificial intelligence. Scientific Programming, 2022, Article 9604203. https://doi.org/10.1155/2022/9604203
21. Mašić, I. (2016, January 1). Scientometric analysis: A technical need for medical science researchers either as authors or as peer reviewers. Medknow, 5(1), 1-1. https://doi.org/10.4103/2279-042x.176562
22. Mejía, C., Wu, M., Zhang, Y., & Kajikawa, Y. (2021, September 24). Exploring Topics in Bibliometric Research Through Citation Networks and Semantic Analysis. Frontiers Media, 6. https://doi.org/10.3389/frma.2021.742311
23. Moed, H. F. (2006). Citation analysis in research evaluation (Vol. 9). Springer Science & Business Media.
24. Noad, B., & Barton, G. (2020). Emotion Resonance and Divergence: a semiotic analysis of music and sound in "The Lost Thing" an animated short film and "Elizabeth" a film trailer. Social Semiotics, 30(2), 206-224. https://doi.org/10.1080/10350330.2018.1543115
25. Oliveira, O J D., Silva, F F D., Juliani, F., Barbosa, L C F M., & Nunhes, T V. (2019, November 18). Bibliometric Method for Mapping the State-of-the-Art and Identifying Research Gaps and Trends in Literature: An Essential Instrument to Support the Development of Scientific Projects. IntechOpen. https://doi.org/10.5772/intechopen.85856

26. Praveen, C K., & Srinivasan, K. (2022, August 31). Psychological Impact and Influence of Animation on Viewer's Visual Attention and Cognition. https://downloads.hindawi.com/journals/cmmm/2022/8802542.pdf
27. Shahbaznezhad, H., Dolan, R., & Rashidirad, M. (2021, February 5). The Role of Social Media Content Format and Platform in Users' Engagement Behavior. https://journals.sagepub.com/doi/full/10.1016/j.intmar.2020.05.001
28. Shan, F., & Wang, Y. (2022, January 5). Animation Design Based on 3D Visual Communication Technology. Hindawi Publishing Corporation, 2022, 1-11. https://doi.org/10.1155/2022/6461538
29. Shen, Y., Huang, L., & Wu, X. (2022, December 20). Visualization analysis on the research topic and hotspot of online learning by using CiteSpace—Based on the Web of Science core collection (2004–2022). Frontiers Media, 13. https://doi.org/10.3389/fpsyg.2022.1059858
30. Shi, Y., & Wang, B. (2022). Cartoon art style rendering algorithm based on deep learning. Neural Computing and Applications, 1-12.
31. Song, W., Zhang, X., Guo, Y., Li, S., Hao, A., & Qin, H. (2023). Automatic generation of 3d scene animation based on dynamic knowledge graphs and contextual encoding. International Journal of Computer Vision, 131(11), 2816-2844.
32. Starke, S., Zhao, Y., Zinno, F., & Komura, T. (2021, July 19). Neural animation layering for synthesizing martial arts movements. Association for Computing Machinery, 40(4), 1-16. https://doi.org/10.1145/3450626.3459881
33. Striner, A., Azad, S., & Martens, C. (2017, October 9). Characterizing A Spectrum of Audience Interactivity.. Cornell University. https://arxiv.org/abs/1710.03320
34. Udochi, A. L., Blain, S. D., Sassenberg, T. A., Burton, P. C., Medrano, L., & DeYoung, C. G. (2022). Activation of the default network during a theory of mind task predicts individual differences in agreeableness and social cognitive ability. Cognitive, Affective, & Behavioral Neuroscience, 1-20.
35. Ullah, S., Ijjeh, A. A., & Kudela, P. (2023). Deep learning approach for delamination identification using animation of Lamb waves. Engineering Applications of Artificial Intelligence, 117, 105520.
36. Van Rooij, M. (2019). Carefully Constructed Yet Curiously Real: How Major American Animation Studios Generate Empathy Through a Shared Style of Character Design. Animation, 14(3), 191-206. https://doi.org/10.1177/1746847719875071
37. Wang, Y., & Wang, X. (2020, October 9). Anatomy of Complex System Research. Hindawi Publishing Corporation, 2020, 1-11. https://doi.org/10.1155/2020/5208356
38. Wu, H., Cai, T., Luo, D., Liu, Y., & Zhang, Z. (2020, December 8). Immersive virtual reality news: A study of user experience and media effects. Elsevier BV, 147, 102576-102576. https://doi.org/10.1016/j.ijhcs.2020.102576
39. Xiong, F., Shen, P., Li, Z., Huang, Z., Liang, Y., Chen, X., Li, Y., Chai, X., Feng, Z., & Li, M. (2023, January 1). Bibliometric Analysis of Post-Stroke Pain Research Published from 2012 to 2021. Dove Medical Press, Volume 16, 1-20. https://doi.org/10.2147/jpr.s375063
40. Yolaçan, H., Güler, S., & Özmanevra, R. (2023, February 10). Clubfoot from past to the present: A bibliometric analysis with global productivity and research trends. Wolters Kluwer, 102(6), e32803-e32803. https://doi.org/10.1097/md.0000000000032803
41. Yuan, Q., & Gao, Q. (2024). Being there, and being together: Avatar appearance and peer interaction in VR classrooms for video-based learning. International Journal of Human–Computer Interaction, 40(13), 3313-3333.
42. Zhai, X., Asmi, F., Yuan, J., Anwar, M., Siddiquei, N L., Ahmad, I., & Zhou, R. (2021, May 7). The Role of Motivation and Desire in Explaining Students' VR Games Addiction: A Cognitive-Behavioral Perspective. Hindawi Publishing Corporation, 2021, 1-10. https://doi.org/10.1155/2021/5526046