A decade of research contributions and emerging trends in the IEEE International Conference on Advanced Learning Technologies

Linjing Wu, Rita Kuo and Maiga Chang*

***Abstract*—This study employs bibliometric methods to conduct a statistical analysis of 1,257 papers published at The IEEE International Conference on Advanced Learning Technologies (ICALT) between 2015 and 2024, aiming to explore the conference's contributions to the field of educational technology and identify potential future research trends. The findings reveal key research topics that have dominated scholar attention over the past decade, including virtual reality and augmented reality, learning analytics, learning design, game-based learning, machine learning, digital fabrication, and computational thinking. The study also analyzes topics that have experienced diminishing research interest and identifies emerging themes poised for growth. The research areas as likely to advance further in the future include: multimodal learning analytics, virtual reality and augmented reality, learning design, applying artificial intelligence to empower other research fields, and technology-supported education for people with disabilities. These conclusions offer valuable insights for organizing future iterations of ICALT and guiding the development of the educational technology field.**

***Index Terms*—Bibliometric analysis, Educational technology, ICALT, Review, Trends**

I. Introduction

The IEEE International Conference on Advanced Learning Technologies (ICALT) was established in 2001 to advance interdisciplinary research and innovation in both pedagogical practices and technological tools in learning. As of 2024, the conference has successfully hosted 24 editions. Over its 24-year history, ICALT has cultivated a global network of researchers, evidenced by its rotating host locations across Asia, Europe, and the Americas.

The conference has significantly facilitated academic exchange among experts and scholars in the field of educational technology and has consistently driven the advancement of the discipline. Through the collective efforts of researchers worldwide, ICALT has emerged as one of the most internationally influential conferences in educational technology. Notably, the ICALT conference was ranked 2nd by saliency in the Educational Technology domain within Microsoft Academic for the period spanning 2000 to 2020, underscoring its pivotal role in shaping global research trends.

To systematically summarize the contributions of the ICALT conference to the advancement of the educational technology field and forecast future developments in the discipline, this study conducts a bibliometric analysis of all papers presented at ICALT over the past decade (2015-2024). Through this analysis, the research seeks to address the following goals: (1) summarize the publications of the conference over the last ten years; (2) explore the main contributions of the conference to the development of educational technology field; (3) identify emerging trends in educational technology field over the past decade.

II. METHODS

To achieve the research objectives, this study primarily employs bibliometric methods to analyze target literature. All papers published in ICALT conferences from 2015 to 2024 are retrieved from the IEEE Xplore database. After removing non-relevant entries such as title pages, copyright notices, tables of contents, prefaces, committee lists, and author indices, a final dataset of 1,257 peer-reviewed academic papers is obtained. Additionally, data on track-specific paper acceptances over the decade is collected from the official conference proceedings released by the organizing committee. All subsequent analyses are conducted on this curated corpus. Bibliometric analysis is performed using CiteSpace version 6.3.R1.

Table 1 presents the corresponding analytical methods employed in this study to address six research goals. The first goal is to identify the top 10 most-cited papers and the second goal is to identify the popular topics in the last decade by using the statistical data from IEEE Xplore and adopting the word clouds based on frequency distributions. The third goal is to investigate prioritized trends in thematic tracks (2015-2024) using timeline analysis. The fourth goal is to identify the themes by clustering keywords and applying timeline analysis on their temporal evolution. The fifth goal is to examine emerging trend patterns in doctoral consortium and the sixth goal is to predict the themes which have emerging trends.

Table 1. Research goals and correspondent analysis methods

Research goals	Method
Goal 1	Analysis of the papers published per year and the top 10 cited papers using the statistical data from IEEE Xplore

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Linjing Wu is currently a Professor at the Faculty of Artificial Intelligence in Education, Central China Normal University. (email: wlj_sz@126.com)

Rita Kuo is an assistant professor in the Department of Computer Science, Utah Valley University. (email: rita.kuo@uvu.edu)

Maiga Chang, corresponding author, is currently Associate Dean, Research & Innovation and Full Professor with the Faculty of Science and Technology, Athabasca University, Canada. (corresponding e-mail: maigac@athabascau.ca)

Goal 2	Analysis of the words cloud of the paper keywords and the most frequent words using the frequency data from CiteSpace
Goal 3	Analysis of the track tendency over the past ten years using timeline analysis
Goal 4	Analysis of the clustering result and the timeline of all the paper keywords by Citespace
Goal 5	Analysis of the paper keywords in doctoral consortium by Citespace
Goal 6	Analysis of the future trends by content analysis

III. RESULTS

A. Publication overview and the top 10 cited papers

This study analyzes 1,257 papers published in the IEEE International Conference on Advanced Learning Technologies from 2015 to 2024, with an average citation count of 3.37 per paper. All the data are sourced from IEEE Xplore, with a cut-off date of March 14, 2025. Figure 1 shows the number of papers published annually. The number of papers published per year decreased from 148 in year 2015 to 87 in year 2024.

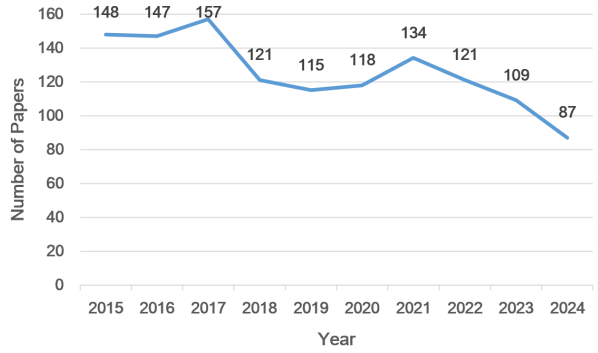

Fig. 1. The number of papers published annually

Besides, the study also calculates the top 10 most-cited papers in the past ten years (see Table 2). The results indicate that the 10 papers are research primarily in the following domains: machine learning & learning analytics (4 papers), virtual reality and augmented reality (4 papers), game-based learning (1 paper), and learning design (1 paper).

TABLE 2. THE TOP 10 MOST-CITED PAPERS IN THE PAST TEN YEARS

Title	Authors	Year	Paper Keywords	Citation Count	Research areas
Smart Attendance Monitoring System (SAMS): A Face Recognition Based Attendance System for Classroom Environment	S. Bhattacharya; G. S. Nainala; P. Das; A. Routray	2018	Attendance Monitoring, Face Quality Assessment, Face Recognition	101	Machine learning & learning analytics
A Taxonomy of Game Elements for Gamification in Educational Contexts: Proposal and Evaluation	A. M. Toda; W. Oliveira; A. C. Klock; P. T. Palomino; M. Pimenta; I. Gasparini; L. Shi; I. Bittencourt; S. Isotani; A. I. Cristea	2019	gamification; education; taxonomy; experts; survey	51	Game-based learning
Can Large Language Models Provide Feedback to Students? A Case Study on ChatGPT	W. Dai; J. Lin; H. Jin; T. Li; Y. -S. Tsai; D. Gašević; G. Chen	2023	Feedback Generation; Automated Feedback; Large Language Model; Feedback Effectiveness	50	Machine learning
A Comparison between Oculus Rift and a Low-Cost Smartphone VR Headset: Immersive User Experience and Learning	N. M. Papachristos; I. Vrellis; T. A. Mikropoulos	2017	Virtual Reality; Mobile VR Headset; Oculus Rift; User experience; Learning	46	Virtual reality
Words in Motion: Kinesthetic Language Learning in Virtual Reality	C. Vázquez; L. Xia; T. Aikawa; P. Maes	2018	Virtual Reality; Kinesthetic Learning; Language Learning; Embodied Cognition; Embodiment-based Learning	41	Virtual reality
Effectiveness of an Immersive Virtual Environment (CAVE) for Teaching Pedestrian Crossing to Children with PDD-NOS	A. Tzanavari; N. Charalambous-Darden; K. Herakleous; C. Poullis	2015	PDD-NOS; Autism; ASD; children; learning; CAVE; pedestrian crossing	40	Virtual reality
Defining Extended Reality Training: A Long-Term Definition for All Industries	F. Palmas; G. Klinker	2020	extended reality; extended reality training; xr training; corporate training; gamification; digital transformation	40	Augmented reality
Co-Designing Machine Learning Apps in K-12 With Primary School Children	T. Toivonen; I. Jormanainen; J. Kahila; M. Tedre; T. Valtonen; H. Vartiainen	2020	Machine Learning; K-12; Co-Design; Artificial Intelligence; Primary School; Neural Network; Computational Thinking	38	Machine learning
A Time Series Classification Method for Behaviour-Based Dropout Prediction	L. Haiyang; Z. Wang; P. Benachour; P. Tubman	2018	online distance learning, VLEs, MOOCS, dropout prediction, time series, student interaction and behaviour	32	Machine learning & learning analytics
A Blockchain Based Decentralized	R. Bdiwi; C. d. Runz; S. Faiz; A. A. Cherif	2018	Blockchain Technology; BC-based	31	Learning design

Platform for Ubiquitous Learning Environment	decentrilized platform; Ubiquitous Learning Environment; Internet of Things

Among these 10 papers, the paper keywords reveal that two terms, "virtual reality" and "gamification", have frequencies greater than 1. Table 3 compiles the frequency of keywords from all papers and lists the top 20 most frequent keywords. The results indicate that "virtual reality" is ranked third, while "gamification" is not included but is represented by the closely related term "game-based learning" which is ranked fifth. This observation underscores that both topics are not only prominent research themes at the ICALT conference but also reflect widely applied research outcomes in the field.

TABLE 3. TOP 20 MOST FREQUENT KEYWORDS

Keywords	Frequency	Keywords	Frequency
learning analytics	92	educational data mining	13
augmented reality	52	serious games	13
virtual reality	43	adaptive learning	12
collaborative learning	28	artificial intelligence	12
game-based learning	25	language learning	12
computational thinking	23	learning design	10
machine learning	23	multimodal learning analytics	9
higher education	20	personalized learning	9
mobile learning	17	self-regulated learning	9
online learning	15	blended learning	8

Besides, among these top 10 cited papers, only one paper, published after 2020, focuses on leveraging large language models (LLMs) to provide feedback to learners. This observation underscores that the application of LLMs in education has emerged as a growing area of research interest in recent years.

B. *Popular topics in the last decade*

Figure 2 shows the word cloud of the paper keywords of all the papers in the past ten years and Table 3 lists the top 20 most frequent keywords. The results indicate that the most frequently occurring keyword is learning analytics (92). Additionally, keywords with frequencies exceeding 20 include "augmented reality" (52), "virtual reality" (43), "collaborative learning" (28), "game-based learning" (25), "computational thinking" (23), and "machine learning" (23).

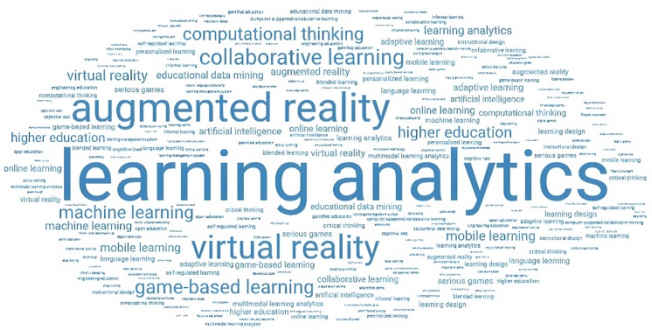

Fig. 2. Word cloud of the paper keywords

C. *Track tendency of the conference*

The conference organizing committee specifies the available submission tracks in the annual Call for Papers (CFP), which reflects the primary research domains and hotspots in academia at the time. The study analyzes track's vitality based on the percentage of papers in each track included in the proceeding catalogs published by the organizing committee over the past decade. The results reveal that from 2015 to 2024, the committee established 23 research tracks. Among these, 12 tracks (including Doctoral Consortium) consistently featured accepted papers across all 10 years, while the remaining 11 tracks were active only in specific years.

The stable annual submission count for Doctoral Consortium indicates that the ICALT conference has maintained consistent appeal to early-career scholars. Excluding Doctoral Consortium, the tracks can be categorized into four groups as Figure 3 shows:

1) Tracks with declining submissions in the latter five years:
   a) Computer Supported Collaborative Learning (CSCL)
   b) Digital Game and Intelligent Toy Enhanced Learning (DIGITEL)
   c) Technology-Enhanced Science, Technology, Engineering and Math Education (TeSTEM)
   d) Motivational and Affective/Emotional Aspects in Technology-Enhanced Learning (MATEL)
   e) Wireless/Mobile/Pervasive/Ubiquitous Technologies for Learning (WMUTE)

2) Tracks with increasing submissions in the latter five years:
   a) Technology-Enhanced Language Learning (TELL)
   b) Artificial Intelligence and Smart Learning Environments (AISLE)
   c) Augmented Reality and Virtual Worlds in Education and Training (ARVWET)
   d) Technology-Supported Education for People with Disabilities (TeDISABLE)
   e) Technologies for Open Learning and Education (i-OPENLearn)

3) Tracks with stable submission volumes annually
   a) Adaptive and Personalized Technology-Enhanced Learning (APTeL)
   b) Big Data in Education and Learning Analytics (BDELA)
   c) Technology-Enhanced Assessment in Formal and Informal Education (TeASSESS)

4) Tracks have phased out in recent years:
   a) Technology Enabled Learning of Thinking Skills

b) Recommender Systems for Learning
c) Maker Spaces and 3-D Printing Based Innovations
d) Applications of Semantic Web Technologies for Learning
e) Internet of Everything (IoE) for Smart Education
f) Technology-Enhanced Learning of Disciplinary Practices
g) Wearable Technologies in Education
h) Knowledge Management in e-Learning
i) Large Scale Implementation of Technology Supported Educational Innovations.

D. Themes based on paper keywords

To better understand the thematic distribution of the papers published at the ICALT conference over the past decade, this study conducts a clustering analysis of paper keywords. Figure 4 reveals eight (8) distinct research themes: augmented reality, virtual reality, learning analytics, learning design, game-based learning, machine learning, digital fabrication, and computational thinking.

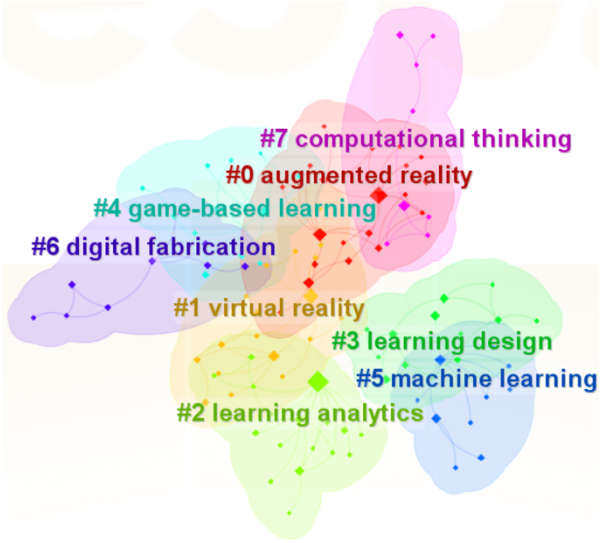

Fig. 4. The clustering result of paper keywords

Figure 5 presents the word cloud of the first cluster, "augmented reality", while Figure 6 shows the timeline of this cluster. The figures indicate that research on augmented reality primarily focuses on collaborative learning, mobile learning, critical thinking, and multimodal learning analytics. The timeline further reveals that this theme has consistently attracted scholarly attention over the past decade, with new keywords emerging progressively over time (each node on the timeline represents a keyword). Besides, the keywords appeared in the recent years under this cluster include "universal design for learning", "distance learning", "learning performance" and "reading comprehension".

Track	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Computer Supported Collaborative Learning	8.3%	5.4%	8.3%	4.8%	6.9%	5.9%	7.4%	3.3%	6.4%	2.3%
Digital Game and Intelligent Toy Enhanced Learning	9.0%	8.2%	12.1%	9.5%	11.2%	9.2%	8.9%	5.7%	8.3%	6.9%
Technology-Enhanced Science, Technology, Engineering and Math Education	8.3%	10.2%	7.6%	8.7%	7.8%	6.7%	7.4%	7.3%	4.6%	8.0%
Motivational and Affective/Emotional Aspects in Technology-Enhanced Learning	6.9%	7.5%	5.7%	7.1%	2.6%	6.7%	2.2%	2.4%	5.5%	6.9%
Wireless/Mobile/Pervasive/Ubiquitous Technologies for Learning	9.7%	5.4%	5.1%	5.6%	0.9%	2.5%	0.7%	2.4%	4.6%	4.6%
Technology-Enhanced Language Learning	4.8%	4.8%	4.5%	2.4%	6.0%	10.1%	11.9%	11.4%	4.6%	2.3%
Artificial Intelligence and Smart Learning Environments	6.2%	4.8%	3.8%	2.4%	5.2%	4.2%	9.6%	4.1%	8.3%	16.1%
Augmented Reality and Virtual Worlds in Education and Training	2.1%	7.5%	5.7%	8.7%	6.0%	7.6%	11.1%	11.4%	10.1%	9.2%
Technology-Supported Education for People with Disabilities	4.8%	3.4%	1.3%	7.9%	5.2%	3.4%	5.2%	8.1%	4.6%	10.3%
Technologies for Open Learning and Education	3.4%	3.4%	6.4%	11.9%	10.3%	11.8%	8.9%	12.2%	6.4%	
Adaptive and Personalised Technology-Enhanced Learning	12.4%	11.6%	9.6%	5.6%	6.0%	5.0%	5.2%	10.6%	13.8%	9.2%
Big Data in Education and Learning Analytics	2.1%	6.1%	7.6%	14.3%	19.8%	10.1%	14.1%	9.8%	5.5%	10.3%
Technology-Enhanced Assessment in Formal and Informal Education	8.3%	5.4%	7.6%		2.6%	2.5%		4.9%	9.2%	10.3%
Technology Enabled Learning of Thinking Skills	3.4%	2.7%	5.1%	6.3%	5.2%	9.2%				
Recommender Systems for Learning	6.2%	4.8%	0.6%							
Maker Spaces and 3-D Printing Based Innovations		2.7%	2.5%							
Applications of Semantic Web Technologies for Learning			3.2%	1.6%						
Internet of Everything (IoE) for Smart Education								3.3%	5.5%	
Technology-Enhanced Learning of Disciplinary Practices							4.4%			
Wearable Technologies in Education		2.0%								
Knowledge Management in e-Learning	2.8%									
Large Scale Implementation of Technology Supported Educational Innovations	0.7%									
Doctoral Consortium	0.7%	4.1%	3.2%	3.2%	4.3%	5.0%	3.0%	3.3%	2.8%	3.4%

Tracks in green and underline: tracks with declining submissions in the latter five years
Tracks in red and **bold**: tracks with increasing submissions in the latter five years
Tracks in blue: tracks with stable submission volumes annually
Tracks in purple and *italic*: tracks phased out in recent years

Fig. 3. Trend of tracks in the past ten years

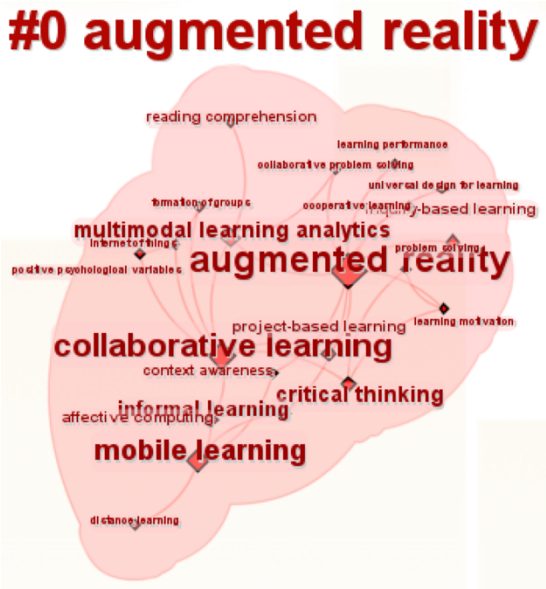

Fig. 5. Word cloud of "augmented reality"

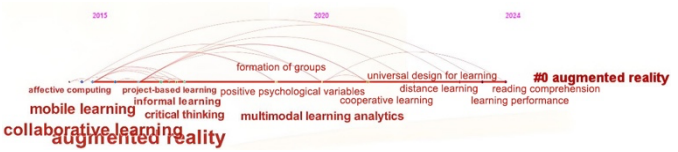

Fig. 6. Timeline of "augmented reality"

Figure 7 shows the word cloud of the cluster "virtual reality" and Figure 8 presents its corresponding timeline. As shown in the figures, the core keywords associated with virtual reality include "higher education", "blended learning", "open education", "data mining", "student engagement", and "generative AI", among others. The timeline highlights that virtual reality has maintained consistent scholarly interest over the past decade, with new keywords emerging steadily. Notably, the keyword "generative AI" appeared in 2024, signaling researchers' growing efforts to integrate generative AI technologies with virtual reality, thereby injecting new vitality into this research domain. The keywords appeared in the recent years under this cluster include "lag sequential analysis", "student engagement", "science education", "open educational resources", "educational technologies", "generative AI", and "literature review".

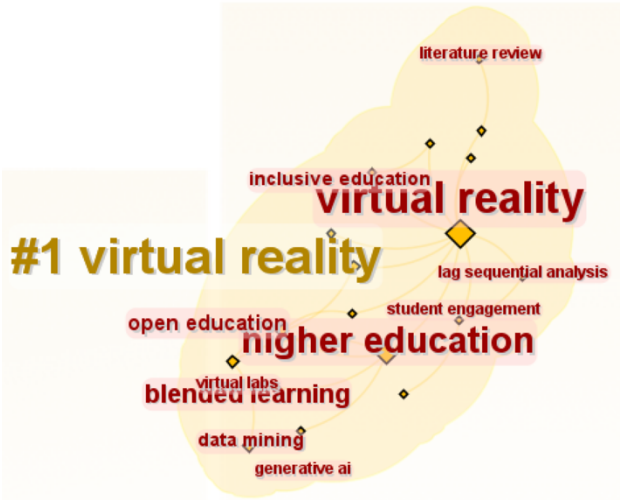

Fig. 7. Word cloud of "virtual reality"

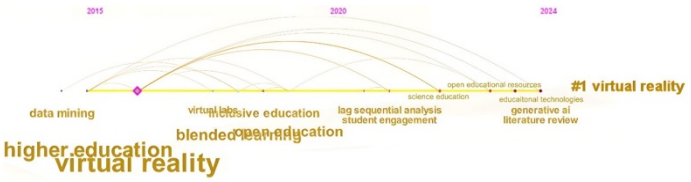

Fig. 8. Timeline of "virtual reality"

Figure 9 and Figure 10 present the word cloud and timeline of the cluster "learning analytics", respectively. As shown in Figure 9, the core keywords within this cluster include "adaptive learning", "personalized learning", "ubiquitous learning", "social network analysis", "educational game", and others. The timeline reveals that research on learning analytics has consistently garnered significant attention over the past decade. However, most keywords in this field predominantly emerged in the first five years, with relatively fewer new keywords appearing in the latter five years despite ongoing research. This phenomenon suggests a decline in the introduction of novel technologies within the learning analytics domain in recent years. Besides, the keywords appeared in the recent years under this cluster include "concept map", "learning analytics dashboard", and "individual differences".

Fig. 9. Word cloud of "learning analytics"

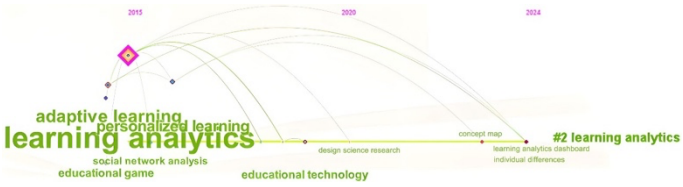

Fig. 10. Timeline of "learning analytics"

Figure 11 illustrates the word cloud of the cluster "learning design", while Figure 12 displays its corresponding timeline. As depicted in Figure 11, the keywords associated with "learning design" include "language learning", "online learning", "self-regulated learning", "artificial intelligence", "cognitive load", "prompt engineering", and others. The timeline indicates sustained scholarly interest in learning design over the past decade. Notably, keywords such as "artificial intelligence", "chatCLD Framework" and "prompt engineering" began emerging in this thematic cluster after 2020. This signifies that researchers are increasingly integrating artificial intelligence and AIGC (AI-generated content) technologies into learning design, injecting fresh momentum into the field.

Figure 11. Word cloud of "learning design"

Fig. 12. Timeline of "learning design"

Figures 14 and 15 present the word cloud and timeline of the cluster "game-based learning", respectively. The results show that the keywords associated with game-based learning include "serious games", "educational robots", "game design", "digital games", "flipped classroom", and others. The timeline distribution reveals a declining trend in research activity on game-based learning over the past two years, with no new keywords emerging during this period. This phenomenon suggests a waning scholarly attention to game-based learning in recent years.

Fig. 13. Word cloud of "game-based learning"

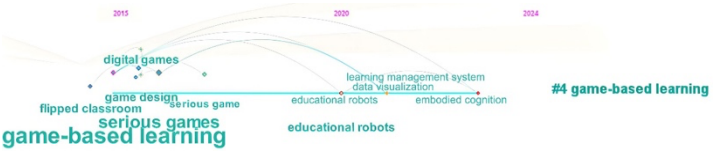

Fig. 14. Timeline of "game-based learning"

Figures 15 and 16 illustrate the word cloud and timeline of the cluster "machine learning", respectively. As shown in Figure 15, the keywords within this cluster primarily include educational data mining, deep learning, exercise recommendation, sentiment analysis, data analysis, big data, early prediction, information visualization, and others. The timeline indicates that research on machine learning predominantly concentrated on the period from 2016 to 2022, with no novel keywords emerging in recent years, suggesting a stagnation in this research domain.

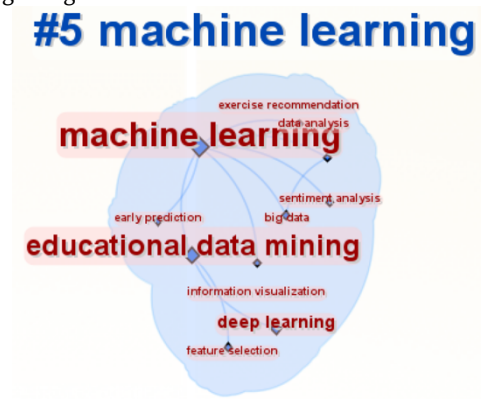

Fig. 15. Word cloud of "machine learning"

Fig. 16. Timeline of "machine learning"

Figures 17 and 18 present the word cloud and timeline of the cluster "digital fabrication", respectively. The results indicate that the keywords within this cluster primarily include "instructional

design", "computer-supported collaborative learning", "engineering education", "learning management system", "3D printing", and others. The timeline reveals that research on digital fabrication was predominantly concentrated between 2015 and 2018. After 2018, scholarly interest in this topic plummeted, with no novel keywords emerging consistently in the field.

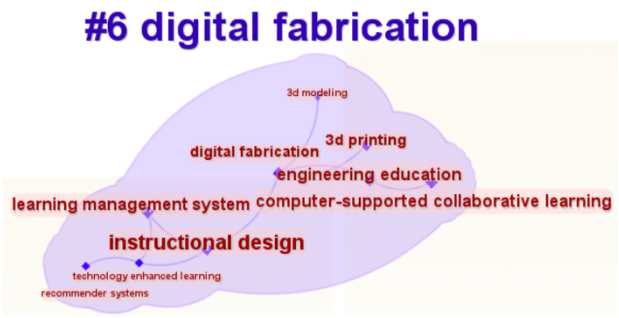

Fig. 17. Word cloud of "digital fabrication"

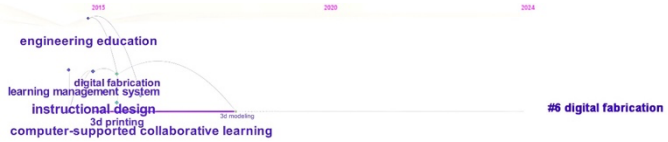

Fig. 18. Timeline of "digital fabrication"

Figures 19 and 20 present the word cloud and timeline of the cluster "computational thinking", respectively. The results indicate that the keywords associated with this cluster primarily include "drama-based learning", "digital learning theater", "automated assessment", "authentic assessment", "educational robot", and others. The timeline reveals that research on computational thinking was predominantly concentrated between 2016 and 2020, with no novel keywords emerging in this field since 2020. This suggests a significant decline in scholarly attention to computational thinking in recent years.

Fig. 19. Word cloud of "computational thinking"

Fig. 20. Timeline of "computational thinking"

E. Themes in the doctoral consortium

Doctoral students are the backbone of future disciplinary development. Therefore, the conference has established a dedicated "Doctoral Consortium" track in its annual Call for Papers to support early-career scholars in conducting academic research. From 2015 to 2024, the conference accepted a total of 41 Doctoral Consortium papers (see Figure 3 for the annual publication counts). Figure 21 displays the word cloud of all keywords from these 41 papers.

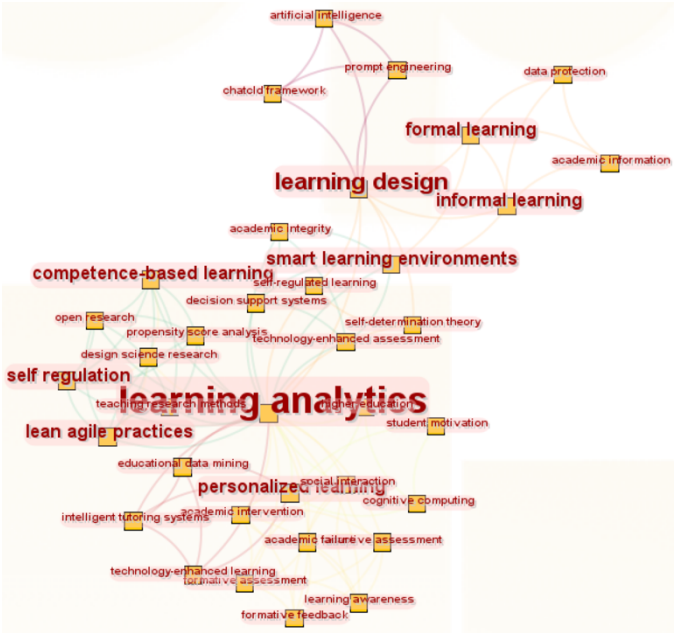

Fig. 21. Word cloud of the paper keywords of doctoral consortium

Table 4 lists the keywords that have frequencies greater than 2. The keywords can be categorized into three themes: learning analytics, learning design, and machine learning. These keywords reflect the research hotspots that young scholars have focused on over the past decade.

- Keywords under learning analytics: learning analytics, multimodal learning analytics, lean agile practices.
- Keywords under learning design: learning design, self-regulation, smart learning environments, formal learning, competence-based learning, personalized learning, informal learning, and mobile application.
- Keywords under machine learning: machine learning and recommender system.

TABLE 4
KEYWORDS WITH FREQUENCIES GREATER THAN 2 IN DOCTORAL CONSORTIUM

Keywords	Freq	Keywords	Freq
learning analytics	7	competence-based learning	2
multimodal learning analytics	3	personalized learning	2
learning design	3	informal learning	2
lean agile practices	2	mobile application	2
Self-regulation	2	machine learning	2
smart learning environments	2	recommender system	2

formal learning	2

F. Themes which have emerging trends

Based on the aforementioned findings, we propose that the following topics are likely to emerge as key research priorities in future studies:

1) Multimodal learning analytics

The results of the most frequent keywords reveal that learning analytics has been the hottest research topic over the past decade, with its frequency count far exceeding other keywords. Additionally, multimodal learning analytics also demonstrates high frequency and ranks among the top 20 most frequent keywords. This indicates that researchers have maintained strong interest in learning analytics in recent years, with multimodal learning analytics being a critical subfield. In future research, as multimodal data collection devices (e.g., eye-tracking devices, galvanic skin response sensors, EEG devices) continue to advance and proliferate, the acquisition and analysis of multimodal learning data will become increasingly convenient, thereby fostering further advancements in multimodal learning analytics research.

2) Virtual Reality and Augmented Reality

Virtual Reality (VR) and Augmented Reality (AR) are ranked second and third among the top 20 most frequent keywords, respectively. Notably, 4 out of the 10 most-cited papers focus on this theme, indicating strong research interest in this field. The track "Augmented Reality and Virtual Worlds in Education and Training", established by the conference organizing committee, has shown a continuous increase in its proportion of published papers relative to the total number of papers over the past decade. A timeline analysis reveals that research on VR and AR has remained highly active over the past decade, with new keywords consistently emerging. This suggests that research in VR and AR continues to evolve rapidly, driven by technological advancements. Cutting-edge innovations, such as multimodal learning analytics and generative AI, are injecting fresh momentum into the development of VR and AR applications.

3) Learning design

The frequency of "learning design" as a keyword over the past decade is 10. Timeline analysis reveals that learning design has consistently maintained researchers' attention throughout this period, with continuous emergence of new keywords. Recent emerging keywords include "self-regulated learning", "digital storytelling", "artificial intelligence", and "prompt engineering". Furthermore, in the keyword analysis of doctoral consortiums, "learning design" ranks among the top three keywords, with eight keywords belonging to the learning design theme. These phenomena indicate that research on learning design has remained highly active in recent years, with artificial intelligence technologies and AIGC (prompt engineering) beginning to be applied in learning design studies. Doctoral students, as future backbone forces in field research, also demonstrate significant interest in learning design. This suggests that research on learning design will remain an academic focus in the foreseeable future.

4) Applying artificial intelligence to empower other research fields

Both "artificial intelligence" and "machine learning" rank among the top 20 most frequent keywords, reflecting researchers' strong focus on this theme. However, timeline analysis of machine learning reveals that no new keywords have emerged in this field over the past two years, suggesting a temporary absence of novel AI technologies impacting education. In contrast, emerging keywords such as generative AI and prompt engineering have recently appeared in timeline analysis of other themes like virtual reality and learning design. The trend analysis also reveals that the proportion of accepted papers in the track "Artificial Intelligence and Smart Learning Environments" has been consistently increasing. This phenomenon highlights two critical aspects: first, it exemplifies the interdisciplinary nature of educational technology research; second, it demonstrates how AI technologies empower educational technology studies through diverse forms such as tools, resources, and environments. These developments have revitalized traditional educational technology research areas including learning design, learning analytics, and VR & AR, infusing them with renewed dynamism.

5) Technology-supported education for people with disabilities

Although technology-supported education for people with disabilities has not emerged as an independent research theme in cluster analysis results, the track trend analysis shows that the proportion of published papers on this theme has exhibited a consistently upward trend over the years. This phenomenon indicates that over the past decade, both the conference organizers and a dedicated group of scholars have consistently cultivated this field through ongoing research efforts. It further reflects the human-centered commitment of educational technology researchers to address the needs of people with disabilities, demonstrating the discipline's ethical responsibility in advancing inclusive educational practices.

IV. Summary and Discussion

This study conducts a bibliometric analysis of all papers published at the ICALT conference between 2015 and 2024. The specific analytical components include the publications of the conference over the last ten years, the main contributions of the conference to the development of the educational technology field, and emerging trends in the educational technology field over the past decade. The primary conclusions derived from the data analysis are as follows:

1) Learning analytics has been the most prominent research theme at the ICALT conference over the past decade.

Learning analytics refers to the domain for identifying students' behaviors, academic performance, academic achievement, and other related learning issues [1]. It is considered as the third wave in educational technology and it is a new and promising field of study [2]. The most cited paper in ICALT over the past ten years is also related to learning analytics which is focused on face recognition and attendance monitoring [3]. Additionally, ICALT has published diverse studies on learning analytics applications, including prediction models [4], learner modeling supported by learning analytics technologies [5], Real-Time Learning Analytics [6], and Collaboration Quality Assessment [7]. These contributions highlight the conference's role in providing a robust platform for researchers in this field to share insights and foster collaboration.

2) Research themes that once garnered attention at the ICALT conference but have gradually declined in prominence include

game-based learning, digital fabrication, and computational thinking.

Among the top 10 most-cited papers, one study focused on game-based learning [8]. This paper proposed a taxonomy to standardize the terminology used to define the game elements as a mean to design and deploy gamification strategies in the educational domain. However, research on this topic has decreased in 2023 and 2024. Similarly, studies on digital fabrication and computational thinking were predominantly published before 2020, with a notable decline in submissions afterward. This trend is further reflected in the number of papers included in the conference tracks over the years, as released by the organizing committee. For instance, the track "Digital Game and Intelligent Toy Enhanced Learning" has seen a decline in accepted papers, while "Maker Spaces and 3-D Printing Based Innovations" only featured submissions in 2016 and 2017. Several factors may explain this shift. On one hand, researchers' interests may have shifted toward emerging topics. On the other hand, the interdisciplinary nature of educational technology might have led scholars to integrate studies on these themes into cross-cutting research areas, redirecting submissions to other tracks or conferences.

3) Promising future research directions likely to gain further attention include multi-modal learning analytics, virtual reality (VR) and augmented reality (AR), learning design, and AI-empowered research.

Multi-modal learning analytics represents an emerging subfield within learning analytics. It is a novel technology that leverages diverse data sources to deliver deeper insights into the learning process [9]. With advancements in sensor technology, the collection of multi-modal data has become increasingly accessible, enabling more diversified data sources for learning analytics. In recent years, ICALT has published numerous studies on multi-modal learning analytics, including the systematic review [10], methodological frameworks [11][12], and applied research [13][14][15]. Virtual reality and augmented reality are also current hotspots in educational technology research, demonstrating rapid growth. Among the top 10 most-cited papers, four focus on VR and AR, underscoring ICALT's contribution to high-quality research in this domain [16][17][18][19].

4) Furthermore, an analysis of annual submissions to the conference's "Augmented Reality and Virtual Worlds in Education and Training" track, as well as thematic timelines, reveals accelerated development in VR/AR research, suggesting a future influx of innovative studies.

The evolution of learning design research is closely intertwined with advancements in AI technologies. As shown in Figure 4, keyword clusters for "learning design" and "machine learning" exhibit significant overlap. A timeline analysis of the "learning design" theme also highlights emerging keywords such as "artificial intelligence" and "prompt engineering" in recent years [20][21]. These trends indicate a growing fusion of AI technologies with learning design, yielding substantial research outcomes and injecting new momentum into the field's future development.

V. Limitation and Conclusion

There are two limitations to this study. First, we only collected and analyzed metadata from papers published within the past decade. Temporally, this fails to cover earlier publications, potentially compromising the comprehensiveness of the findings. Second, during data analysis, we primarily focused on author-provided keywords without conducting in-depth content analysis of full texts, which may impact the depth of the analytical results.

Despite these limitations, this study holds irreplaceable academic value: it systematically reviews the main contributions of the ICALT conference to educational technology development over the past decade, delineates the evolving research themes prioritized by scholars, and provides analysis and predictions for future research trends. These insights offer critical reference value for advancing the field.

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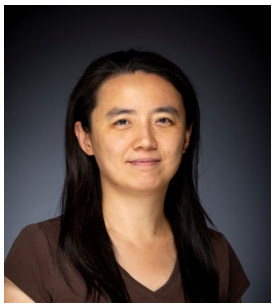
Linjing Wu is a Professor at the Faculty of Artificial Intelligence in Education, Central China Normal University. Her research interests include learning analytics, educational data mining, and artificial intelligence in education.

Linjing Wu received her Ph.D. in Educational Technology from Central China Normal University in 2013. And she works as a visiting scholar in Athabasca university in 2025.

Linjing Wu hosted and participated in several research projects of the National Natural Science Foundation of China. She published more than 50 papers in academic journals and conferences.



Rita Kuo (IEEE Member since 2017) is an assistant professor in the Department of Computer Science, Utah Valley University. Her research interests include e-learning, computerized adaptive testing, computerized item generation, cognitive theory, intelligent agent, mobile learning, and game-based learning.

Rita Kuo received her B.S. and M.S. degrees in the Information and Computer Engineering and her Ph. D degree in the Electronic Engineering from Chung-Yuan Christian University, Chung Li, Taiwan, in 2000, 2002, and 2007, respectively. She was an instructor (2015 ~ 2022) in New Mexico Tech, an assistant research fellow (2011 ~ 2015) in the academic and industrial research centre of Knowledge Square, Inc. and an assistant professor (2007 ~ 2011) associated with the department of digital design, Mingdao University, Taiwan.

She is the Chair of IEEE Technical Community on Learning Technology (TCLT) from 2023 July and was the Vice Chair in EDI (Equity, Diversity & Inclusion) & Event between June 2021 and July 2023. She has been the Chair of Educational Gamification and Game-based Learning Special Interest Group in Asia-Pacific Society for Computers in Education (APSCE) (2020 - 2021). She has also been the track coordinator of Track 7: Technology-Enhanced Science, Technology, Engineering and Math Education (TeSTEM) in ICALTs (International Conference on Advanced Learning Technologies) since 2018.

Maiga Chang (IEEE Member 1997-2021, IEEE Senior Member since 2022) is currently Associate Dean, Research & Innovation and Full Professor with the Faculty of Science and Technology, Athabasca University, Canada. He is an IEEE Senior Member. Dr. Chang has been appointed as an IEEE Computer Society Distinguished Visitor on AI and Chatbot areas for 2023 to 2025 and recently received Distinguished Researcher Award from Asia Pacific Society on Computers in Education (APSCE) in 2022.

Dr. Chang has given more than 185 talks and lectures in different conferences, universities, and events. He has (co-)authored more than 265 book chapters, journal and international conference papers. His research interests include artificial intelligence; natural language processing; intelligent agent and chatbot technology; game-based learning, training and assessment; learning behaviour analysis; learning analytics and academic analytics; health informatics; data mining; computational intelligence; museum education mobile learning and ubiquitous learning; healthcare technology, etc.

Dr. Chang is now secretary of IEEE Computer Society Technical & Conference Activities Board (2022~2025) and Vice Chair of IEEE Northern Canada Section (2025~). He is also Vice President (2022~) of International Association of Smart Learning Environments, executive committee member of Asia-Pacific Society for Computers in Education (2017~2028) and Global Chinese Society for Computing in Education (2016~2025).