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Shan Wang
University of Saskatchewan, Saskatoon, SK S7N 5A7, Canada

Tam Tran
University of Saskatchewan, Saskatoon, SK S7N 5A7, Canada

Jingxuan Wang
China University of Geosciences, Wuhan, 430079, China

Fang Wang
Wilfrid Laurier University, Waterloo, Ontario N2L 3C5, Canada, fwang@wlu.ca

Zhen Zhu
China University of Geosciences, Wuhan, 430079, China

See next page for additional authors

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Authors
Shan Wang, Tam Tran, Jingxuan Wang, Fang Wang, Zhen Zhu, and Zhao Du

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Artificial Intelligence in Education: A Systematic Literature Review

Shan Wang[1], Tam Tran[1], Jingxuan Wang[2], Fang Wang[3], Zhen Zhu[2], Zhao Du[4]

[1] University of Saskatchewan, Saskatoon, SK S7N 5A7, Canada

[2] China University of Geosciences, Wuhan 430079, China,

[3] Wilfrid Laurier University, Waterloo, Ontario N2L 3C5, Canada

[4] Beijing Sport University, Beijing 100084, China

fwang@wlu.ca(Fang Wang,corresponding author)

1. INTRODUCTION AND RESEARCH QUESTIONS

Artificial intelligence (AI), a fast-developing information technology, is redefining modern education. The COVID-19 pandemic expedites the use of AI in education [1], which further stimulates the investment and development of AI applications in education. According to Grand View Research [2], the global AI in education market size was valued at USD 1.82 billion in 2021 and is expected to expand at a compound annual growth rate of 36.0% from 2022 to 2030. Research also exploded in the past few years to understand the design of AI applications in education and their effectiveness and outcomes. With the substantial and continuously growing body of studies, a systematic literature review is necessary. It can identify the main interests in the field, current knowledge, major theoretical lens, and existing gaps and ongoing research opportunities, offering important value to researchers.

This adopts mixed research methods, including bibliometric analysis and content analysis, to symmetrically examine the literature on AI in education. The bibliometric analysis produces an overview of the research field, while content analysis of selected research papers offers in-depth insights into key aspects, such as the major categories of applications studied, research topics, and theoretical lens, that may be of great interest to researchers in this field.

2. BIBLIOMETRIC ANALYSIS RESULTS

In line with many previous systematic literature reviews [3], we searched the Web of Science database in June 2022 to generate an initial set of papers. A search with the keywords “artificial intelligence or AI” and “education” returned 3,690 documents. These papers were screened for their quality and relevance to AI in education. Only peer-reviewed articles with full content were retained for analysis. The final dataset includes 1,174 papers published in 529 sources from 1984 to June 2022. A bibliometric analysis is conducted using the Biblioshiny app of the R package bibliometrix Aria and Cuccurullo [4]. This part of the study reveals some patterns of research on AI in education.

- The explosion of research on AI in education started in 2017. From 1984 to 2016, the number of articles published each year is generally below 10. From 2017, the publication numbers quickly increase. It reaches a peak of 409 articles in 2021. The intensive research attention to AI in education can be largely attributed to Covid-19, where online education became prevalent.
- In terms of the number of publications, *The Journal of Intelligent & Fuzzy Systems*, *Sustainability*, and *Wireless Communications and Mobile Computing*, are the top three common destinations of research in this field.
- The most locally cited journal is *Computers and Education* with 643 times of references. *Lecture Notes in Computer Science* ranks second with 307 citations. *Computers in Human Behavior*, *International Journal of Artificial Intelligence in Education*, and *IEEE Access* are also widely cited, with 303, 266, and 243 times of references, respectively.
- The study also reveals the trending research topics on AI in education. A general trend observed is that the topics studied evolved from general discussions of IT in education and system design to more nuanced studies on technologies such as virtual reality and neural networks, as well as behavioral studies on perceptions of AI by stakeholders.

3. CONTENT ANALYSIS

From the initial pool of 1,174 papers for bibliometric analysis, we applied the following criteria to screen and select a subset of papers for content analysis: (1) the papers are from the top 15 journals that published the articles on the topic, as identified in the bibliometric analysis; (2) the paper clearly describes the AI application and reports its effect on teaching and learning. As a result, 125 papers are identified for content analysis. We coded each paper on the types of AI applications studied, research topics, and theories applied.

For AI applications in education, we identified four major categories of AI applications with seven sub-categories: (1) adaptive learning and personalized tutoring, (2) profiling and prediction, (3) intelligent assessment and management, and (4) emerging technologies or products.

For the research topics, extant research centers around four main research themes: (1) AI adoption and acceptance in education, (2) AI system and application design, (3) the impacts of AI education, and (4) the development and evolution of AI in education.

A wide range of theories is applied in the research on AI in education. In total, 45 theories are coded from 125 articles in our sample. The most frequently used theories are constructivist learning theory (in 6 articles), learning style theory (6), cognitive theories of learning (5), item response theory (5), cognitive load theory (3), and the theory of multimedia learning (3).

4. DISCUSSION AND CONCLUSIONS

Using bibliometric analysis and content analysis, this research systematically reviews the literature on AI in education. It enriches our understanding of the literature by providing a multiple-perspective view of the extant research. It suggests some future research opportunities. For example, most studies apply theories marginally [5]; a thorough and systematic use of theories to guide the research design can greatly improve the quality of research. The impact assessment of AI applications in education focuses on teaching effectiveness and student learning performance, however, the social impacts as well we the digital competence of instructors in using AI applications are less studied. Future research can examine diverse outcomes of AI applications in education, including societal, organizational and individual outcomes.

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