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Augmented Reality in Higher Education: A Systematic Review and Meta-Analysis of the Literature from 2000 to 2023

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 15 March 2024 and was last updated on 15 March 2024.

INTRODUCTION

Review question / Objective This article provides a systematic review of the applications of AR in higher education from 2000 to 2023, focusing on four aspects: publication trends and applied disciplines, technical characteristics, teaching functions and methods, and learning outcomes and measurement methods. Experimental studies were then selected to examine the educational and teaching effects of AR applications and to explore the potential moderating effects. Specifically, the research questions addressed in this article are as follows:
(1) What are the overall publication trends and the characteristics of distribution across different disciplines of AR applications in higher education?
(2) What are the essential technical features and affordances of AR in higher education applications, and how are they evolving over time?
(3) What instructional design approaches are utilized to facilitate teaching and learning in AR-supported higher education?
(4) What are the common types of learning outcomes supported by AR in higher education and how are they measured?
(5) What is the overall effectiveness of the application of AR in higher education, and what are the moderating variables?

Rationale In order to understand the overall application and effect size of AR-based instruction in higher education, a systematic review and meta-analysis have been conducted, aiming to provide guidance for the subsequent teaching, learning and research of AR in the field of higher education.

Condition being studied Condition being studied is AR-based instruction in higher education.

METHODS

Search strategy We conducted an initial literature search using random combinations of two clusters of strings. The first cluster included “augmented reality” and its abbreviation “AR. The second cluster of search keywords consisted of phrases such as "higher education," "teaching*," "instruction*," and "classroom," among others. The initial search yielded a total of 3,453 articles.Based on the literature initially retrieved, we manually screened the articles. Ultimately, a total of 239 articles were included in the main library.

Participant or population Undergraduates and post-undergraduates.

Intervention Augmented reality (AR) based intervention programs.

Comparator Traditional intervention programs or no program at all.

Study designs to be included Empirical studies, design cases, systematic reviews, and theoretical articles.

Eligibility criteria The specific inclusion criteria are as follows: (1) all articles must focus on AR, excluding articles on MR or VR; (2) the educational context must target higher education, excluding articles applied to other educational stages (e.g., K-12 education, special education, vocational education); papers must be (3) peer-reviewed journal articles, excluding reports and dissertations.

Information sources SCOPUS and Web of Science (WOS).

Main outcome(s) The results indicate that such publications have followed an upward trend, with AR being more frequently applied in practical disciplines such as medicine; AR has commonly been used for content delivery, but it lacks integration with more diverse teaching methods such as collaborative learning. Insufficient attention has been paid to the long-term learning outcomes such as competency development. A meta-analysis was then conducted on 60 experimental studies selected from the literature. The results indicate that AR applications in higher education tend to have a positive effect on instructional outcomes ($g = 0.896$, 95% confidence interval = [0.685–1.107], $p = 0.000$), and instructional function and learning outcomes of AR are significant moderating factors.

Quality assessment / Risk of bias analysis We will assess and report on the potential for publication bias, which arises from the selective publication of studies with positive results. Use methods like funnel plots and statistical tests (e.g., Egger's test) to evaluate publication bias.

Strategy of data synthesis A total of five researchers were involved in the coding process. Controversies were resolved by weekly discussion to ensure coding consistency according to the formula for coding reliability: $R = (N \times K)/(1 + (N - 1) \times K)$, where N represents the number of coders, and K represents the average inter-rater agreement: $K = 5 \times S/(N1 + N2 + N3 + N4 + N5)$. S indicates the number of articles coded identically by the five coders; N1–N5 refer to the number of articles coded by each coder. The final average inter-rater agreement was $K = 0.72$, and the reliability coefficient was $R = 0.93$, which indicates good reliability of the coding.

Subgroup analysis Not applicable.

Sensitivity analysis Variation of inclusion/exclusion criteria and employment of different statistical methods/effect sizes. If these two measures do not substantially affect the results, the findings can be considered relatively stable. However, if the results are highly sensitive to these variations, further exploration and explanation of these discrepancies will be conducted.

Language restriction The selected articles must be published in English.

Country(ies) involved China.

Keywords Augmented reality; Systematic review; Higher education; Technical characteristics; Teaching functions and pedagogy; Meta-analysis.

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