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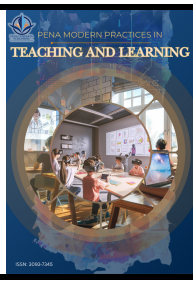

Research of Android Application in Education: Bibliometric Analysis

Siti Maryam Rohimah[1,*], Edi Supriyadi[2]

[1] Universitas Pasundan, Jl. Tamansari No. 6-8, Bandung, Jawa Barat, Indonesia
[2] Jl. Soekarno-Hatta No.378, Kb. Lega, Kec. Bojongloa Kidul, Kota Bandung, Jawa Barat, Indonesia

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ABSTRACT

The rapid advancement of mobile technology has significantly influenced education, with Android applications emerging as a key tool for enhancing learning experiences. This study conducts a bibliometric analysis of academic publications from 2010 to 2024, examining trends, influential works, and the geographical distribution of research on Android applications in education. Our findings reveal a substantial increase in scholarly interest, particularly during the COVID-19 pandemic, reflecting the growing demand for digital learning resources. Conference proceedings, especially from the Journal of Physics Conference Series, dominate the dissemination of findings, emphasizing the role of multidisciplinary collaboration in educational technology research. Contributions from Indonesian and Indian institutions highlight national efforts to explore Android's educational potential, while global research trends suggest a broader commitment to leveraging mobile learning. However, limitations such as reliance on indexed publications, the predominance of conference papers, and regional research concentration may impact the generalizability of findings. The diversity of publication formats, including systematic reviews and books, underscores the need for researchers to synthesize existing studies to identify trends, gaps, and best practices. This study provides valuable insights for researchers, educators, and policymakers, emphasizing the importance of informed decision-making to ensure the effective integration of Android applications into diverse educational settings. Given the rapid evolution of mobile learning technologies, continuous assessment is crucial to optimize their impact and sustainability in modern education.

1. Introduction

Android apps in education have many benefits but also draw drawbacks that must be considered. Android app privacy and security are major concerns. Studies on Android botnet identification and risk assessment have found concerns about user privacy and system integrity [1]. Malicious apps and vulnerabilities in the Android ecosystem constitute a significant threat, exploiting user-level security and Android OS security systems [2]. These security issues could expose educational data and Android app safety. Additionally, Android app permission issues have been thoroughly investigated, emphasizing the need for developers to make informed permission use decisions to avoid risks [3].

* *Corresponding author.*
E-mail address: sitimaryamrohimah@unpas.ac.id

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Third-party libraries in Android apps for revenue generation and user behavior tracking enhance complexity and security risks [4]. The integration of these libraries may disclose sensitive user data or have unforeseen repercussions, especially in educational programs that value student privacy.

The frequency of app collusion potential, when many apps collaborate to commit crimes, threatens user security and privacy [5]. It takes strong security and constant monitoring to detect and prevent collusion assaults, especially in educational environments where sensitive information is shared. Android apps' use of obfuscation to prevent copying and repackaging highlights the ongoing issues of assuring the authenticity and integrity of mobile educational information [6]. Changing Android permissions and security issues hampers educational app use. Educational app developers and deployers must be proactive about security and privacy due to the dynamic nature of Android permission evolution and worries about pre-installed apps with elevated rights [7]. Protecting sensitive educational data and preserving user confidence requires educational apps to follow permission management and security best practices.

Android app inter-app communication difficulties create worries about data leakage, privilege escalation, and privacy violations [8]. The seamless interaction between apps improves user experience but creates weaknesses that unscrupulous actors can exploit. To protect educational resources and student data, educators and developers must address these communication hazards. Educational institutions using mobile apps for learning face a continual threat landscape due to Android malware and the difficulty of recognizing and categorizing harmful apps [9]. Behavior-based techniques and ensemble classifiers are needed to detect malicious apps and protect educational stakeholders from security breaches [10]. The study examines the surge in research on Android applications in education "from 2010 to 2024, highlighting the COVID-19 pandemic's impact. It examines conferences, multidisciplinary interest, and global research efforts.

2. Methodology

The methodology of the research is structured to comprehensively analyze the landscape of Android applications in education through a bibliometric approach [11-13]. This methodology involves several key components, including data sources, data collection techniques, and data analysis techniques [14-17].

2.1 Data Sources

The research utilizes academic publications from multiple databases to gather a wide range of data related to the topic. The databases include well-known academic repositories that provide access to scholarly articles, conference papers, and other relevant publications.

2.2 Data Collection Techniques

Data collection is performed systematically by extracting relevant publications from the chosen databases. The research focuses on identifying key trends, influential works, and emerging themes within the field of Android applications in education. Metrics such as publication counts, citation patterns, author contributions, and geographical distribution of research outputs are considered during the data collection phase.

2.3 Data Analysis Techniques

The collected data is subjected to bibliometric analysis, a method used to quantitatively study the bibliographic material. This involves analyzing the frequency and patterns of citations to understand the impact and development of research in this area. The analysis includes interpreting yearly data on publications, source data, affiliation data, and document types to provide a comprehensive overview of the research trends and significant contributors.

The findings from this research highlight the rapid increase in scholarly interest in Android applications for education, identifying prominent themes such as pedagogical effectiveness, user engagement, and integration strategies. The study's insights are intended to guide future research, helping educators and developers enhance educational experiences through the use of Android technology.

3. Results

3.1 Interpretation of Yearly Data on Publications

The annual distribution of publications connected to "android application" and "education" from 2010 to 2024 reveals a consistent growing trend. There was little study in this area in 2010—just one paper. This figure rose slowly, reaching 4 publications in both 2011 and 2012. A noteworthy growth began in 2013 with 9 publications, nearly doubling to 17 in 2014. Subsequent years exhibited swings, with 24 publications in 2015, a brief decrease to 18 in 2016, and an uptick to 32 in 2017. A further boost to 38 publications happened in 2019, followed by a dramatic rise in 2020 and 2021, with 52 and 59 publications, respectively, likely driven by the increased dependence on digital teaching tools during the COVID-19 epidemic. Though numbers decreased slightly in 2022 and 2023, with 43 and 41 articles, respectively, research interest remains strong, with 17 publications documented thus far in 2024.

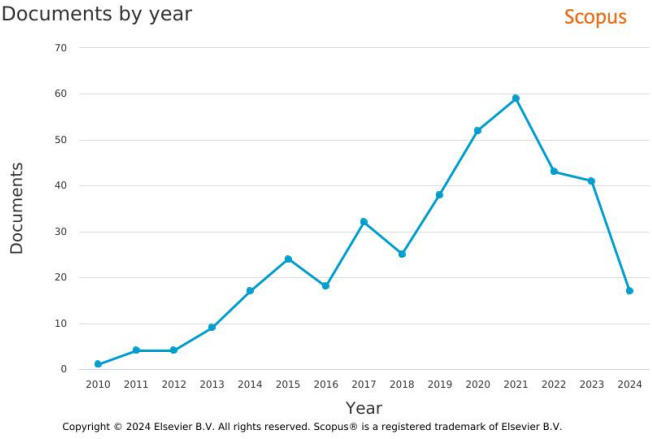

Fig. 1. Yearly data on publications

3.2 Interpretation of Source Data on Publications

The distribution of publications across multiple sources illustrates where research on "android application" and "education" is being disseminated. The Journal of Physics Conference Series leads with 28 publications, suggesting a substantial presence of educational technology research in physics-related conferences. The AIP Conference Proceedings continues with 14 articles, further stressing the contribution of applied physics conferences. The ACM International Conference Proceeding Series ranks third with 10 publications, indicating the engagement of the computer

science community in this study field. Additionally, Advances in Intelligent Systems and Computing and Communications in Computer and Information Science each contain 8 articles, illustrating the relevance of computing and intelligent systems conferences in fostering research on integrating Android applications into education. These findings underline the value of interdisciplinary and technology-focused conferences as the main forums for disseminating knowledge in this dynamic sector.

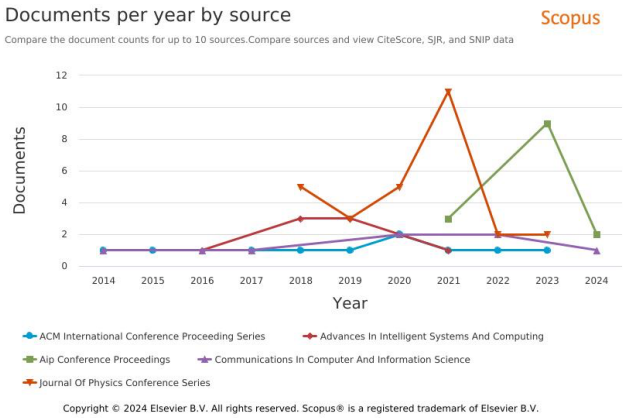

Fig. 2. Source data on publications

3.3 Interpretation of Affiliation Data on Publications

The examination of author affiliations in publications on "android application" and "education" indicates a considerable representation from Indonesian universities. Universitas Negeri Jakarta leads with 8 publications, followed by Universitas Negeri Yogyakarta with 6, demonstrating the country's active commitment in this research field. Several additional universities, including Mahidol University, University of Trás-os-Montes and Alto Douro, Sathyabama Institute of Science and Technology, Bina Nusantara University, Universitas Pendidikan Indonesia, and Universitas Negeri Malang, each contributed 4 papers. The participation of Indian institutions, such as the Indian Institute of Technology Kharagpur and SS.R.M. Institute of Science and Technology, each with 3 articles, further emphasizes the global reach of this research. This vast institutional involvement underlines the extensive and collaborative nature of studies on Android applications in education, covering many countries and academic environments.

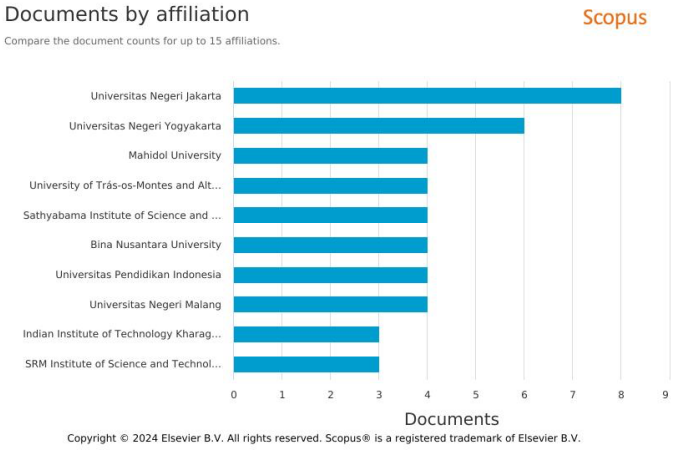

Fig. 3. Affiliation data on publications

3.4 Interpretation of Country Data on Publications

Indonesia leads in research production with 82 papers, emphasizing its commitment to incorporating Android applications into education. India follows closely with 77 articles, demonstrating its vibrant educational industry and increased focus on digital learning. The United States ranks third with 31 publications, suggesting substantial academic interest in educational technology. Malaysia (23 papers) and China (13 publications) also contribute significantly, demonstrating regional interest in mobile-based learning. Countries like Greece, Brazil, Japan, and Romania, each with roughly 10 articles, further demonstrate the worldwide aspect of this research. The Philippines, with 8 publications, adds to Southeast Asia's contributions, reinforcing the widespread acknowledgment of Android applications in education.

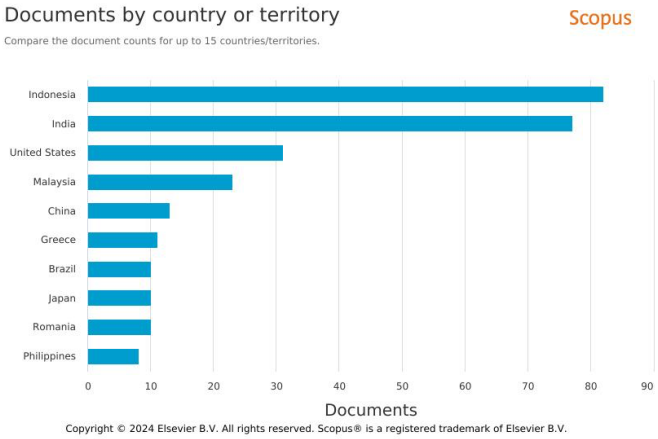

Fig. 4. Country Data on Publications

3.5 Interpretation of Author Data on Publications

Several renowned scholars have made equal contributions to this topic, each producing three articles. These include Cardeal, S.; Crisan, L.A.; Dogan, H.; Ferreira, P.J.S.G.; Funabiki, N.; Kuribayashi, M.; Morais, R.; Peres, E.; Pop, G.M.; and Reis, M.J.C.S. This balance indicates a collaborative approach inside designated research networks. Their contributions provide vital insights that affect future studies and improvements in Android applications for education. The diversity of key authors reflects a dynamic research community where multiple experts consistently expand the field's knowledge base.

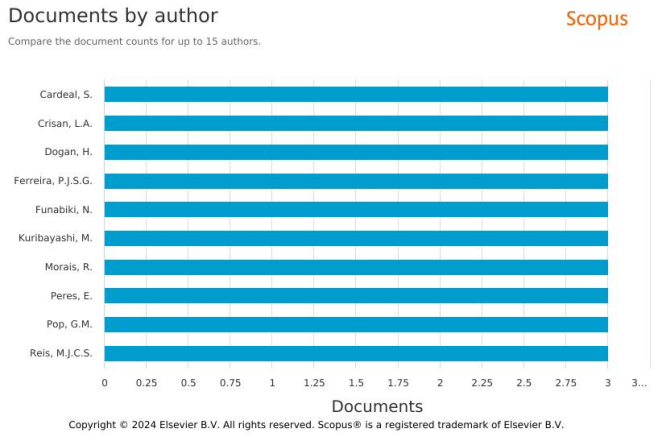

Fig. 3. Author data on publications

3.6 Interpretation of Document Type Data on Publications

The bulk of publications (253) are conference papers, demonstrating that conferences serve as the principal arena for presenting research on Android applications in education. These platforms promote information exchange, discussion, and quick distribution of results in the expanding field of educational technology. Journal papers, numbering 104, provide peer-reviewed contributions that boost academic quality. Additionally, 15 conference reviews represent efforts to summarize and evaluate current research, while 7 book chapters suggest that some discoveries are included in full academic publications. The range of publication types illustrates numerous pathways for information transmission on this topic.

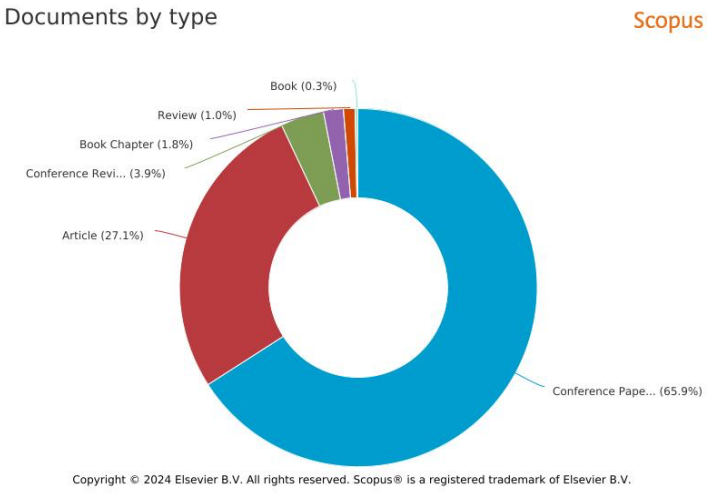

Fig. 6. Document type data on publications

There are 15 conference reviews, which suggest a reflective component where existing conference presentations and findings are summarized and evaluated. These reviews help in providing overviews of current trends and gaps in the research, offering insights into the collective progress made during conferences. Book chapters make up a smaller portion with 7 publications, indicating that some research is being incorporated into larger, comprehensive works. This allows for in-depth exploration of specific topics within the broader context of educational technology and android applications.

The presence of 4 reviews points to a growing interest in synthesizing existing research to understand the state of the art, identify patterns, and suggest future research directions. Reviews are essential for summarizing and critically evaluating the current body of literature, providing a solid foundation for new research endeavours. Lastly, there is 1 book dedicated to this topic, which underscores the importance and depth of the subject matter. A book format allows for extensive exploration and discussion of android applications in education, potentially serving as a key resource for researchers, educators, and practitioners.

The predominance of conference papers and journal articles indicates that these are the main channels for disseminating research on android applications in education. The diversity of document types, including conference reviews, book chapters, reviews, and books, reflects a comprehensive and multifaceted approach to exploring and sharing knowledge in this field.

The study of "android application" and "education" publications reveals diverse formats for dissemination. Conference papers are the primary venue for presenting new research, while journal articles are the second most common document type. 15 conference reviews summarize existing conference presentations and findings, while 7 publications incorporate research into larger works.

Four reviews synthesize existing research to understand the state of the art, identify patterns, and suggest future directions. A book dedicated to this topic underscores the importance and depth of the subject matter, potentially serving as a key resource for researchers, educators, and practitioners.

The research output on Android applications in education has significantly increased from 2010 to 2024, with various studies highlighting the effectiveness of Android-based educational apps [18-20]. These applications have been shown to enhance learning outcomes, improve student engagement, and provide innovative ways of delivering educational content [18-20]. However, the effectiveness of these apps, especially during the Covid-19 pandemic, requires thorough evaluation [21]. While Android applications have been successful in improving knowledge and attitudes in various educational contexts [22-24], there is a need for continuous assessment of their impact on different learning domains [20-21]. The trend indicates a growing reliance on Android applications for educational purposes, emphasizing the importance of evaluating their efficacy and impact on learning outcomes.

The Journal of Physics Conference Series, along with the AIP Conference Proceedings and ACM International Conference Proceeding Series, are key platforms for research on integrating Android applications into education [25-27]. These conferences have facilitated the development of various Android-based educational tools, enhancing experiential learning [28-30]. While these platforms have significantly contributed to advancing educational technology, there is a need for continuous evaluation and monitoring to ensure the effectiveness and applicability of these applications [27-31]. The research output from these conferences underscores the importance of leveraging Android applications to improve teaching methodologies and student engagement in diverse educational settings.

The research landscape on Android applications in education showcases a notable concentration of studies from various institutions. Universitas Negeri Jakarta and Universitas Negeri Yogyakarta stand out with eight and six publications, respectively, indicating a strong research focus in this area [32-33]. Conversely, Indian Institute of Technology Kharagpur and SRM Institute of Science and Technology have three publications each, reflecting a global interest in exploring the integration of Android applications in educational settings [34-35]. This diversity of contributions underscores the significance of collaborative efforts across institutions to advance the utilization of Android applications for educational purposes.

The research landscape on Android applications in education reveals a global interest in leveraging mobile technology for educational purposes. Indonesia leads with 82 publications, showcasing a strong commitment to integrating Android applications into education [25]. India closely follows with 77 publications, reflecting the diverse educational sector and the growing emphasis on digital education [36]. In contrast, the United States ranks third with 31 publications, while Malaysia, China, Greece, Brazil, Japan, and Romania each contribute around 10 publications, indicating a widespread trend in utilizing mobile technology for educational enhancement [35]. This global distribution of research efforts underscores the importance of exploring the potential of Android applications in diverse educational contexts to improve learning outcomes.

The group of leading contributors including Cardeal, Crisan, Dogan, Ferreira, Funabiki, Kuribayashi, Morais, Peres, Pop, and Reis, who have each contributed to three publications, exemplify a collaborative and knowledgeable approach to research at the intersection of Android technology and education. Their collective expertise and shared commitment to this field have paved the way for future studies and innovations, fostering a conducive research environment [25], [37-38]. By consistently contributing to the discourse on technology-driven learning approaches, these authors have significantly enriched the understanding of integrating Android applications into educational settings, thereby influencing the trajectory of educational technology research.

The dissemination of research on Android applications in education encompasses various formats, with conference papers being the primary avenue for new research presentations, followed by journal articles [39-41]. Conference reviews play a crucial role in summarizing existing findings, while some publications integrate research into larger works [42-44]. Notably, reviews that synthesize existing research contribute to understanding the state of the art and guiding future research directions [45-47]. Furthermore, a dedicated book on this topic signifies the depth and importance of the subject matter, potentially serving as a valuable resource for researchers, educators, and practitioners . This diverse range of dissemination formats underscores the multifaceted nature of research on Android applications in education and its significance in advancing the field.

The expanding body of Android education research affects researchers, educators, and policymakers. Increasing conference papers, journal articles, and reviews highlight the need for researchers to study Android-based educational aids in varied learning situations. Systematic reviews emphasize the need to synthesize studies to find trends, gaps, and best practices. Using well-researched Android apps in the classroom can improve student engagement and learning. However, careful selection and adaptation are needed to meet instructional aims. The global distribution of research indicates that policymakers should make educated decisions about integrating mobile technologies into national education systems. The growing use of Android apps in education requires policies that ensure equitable access and rigorous impact assessment. A specialized book on this issue shows the breadth of information available and serves as a crucial resource for stakeholders seeking to use Android technology to improve education.

The study on Android apps for education contains flaws. We only examined indexed materials, which may have missed important research in non-indexed journals, institutional reports, and grey literature. Conference papers dominate the dataset, reflecting an emphasis on emergent research rather than well-established conclusions, which may affect generalizability. Publications on Android apps in education are mostly from Indonesia and India, which may not represent global perspectives. No individual research is evaluated, limiting insights into Android-based educational programs' efficacy. Mobile technology changes quickly; therefore, some findings may become outdated quickly, requiring ongoing study to meet technical improvements and educational needs.

4. Conclusions

This study highlights the significant growth of research on Android applications in education from 2010 to 2024, reflecting the increasing interest in mobile technology's role in learning. The surge in publications, particularly during the COVID-19 pandemic, underscores the demand for digital teaching resources and the evolving relationship between technology and education. The dominance of conference papers, particularly from the Journal of Physics Conference Series and other multidisciplinary proceedings, emphasizes the importance of conferences in disseminating findings. Contributions from Indonesian and Indian universities indicate national efforts to explore Android's educational potential, while global research trends suggest a broader commitment to leveraging mobile learning. However, limitations such as reliance on indexed materials, the predominance of conference papers over well-established studies, and regional concentration of research may impact the generalizability of findings. The increasing variety of publication formats, including systematic reviews and books, highlights the need for researchers to synthesize existing studies to identify trends, gaps, and best practices. Educators must carefully select and adapt Android-based tools to align with instructional goals, while policymakers should develop strategies for equitable access and rigorous impact assessment of mobile learning technologies. As Android applications continue to

shape modern education, ongoing research is necessary to evaluate their effectiveness and ensure their integration meets evolving educational needs.

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