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EXAMINING GLOBAL TRENDS IN 21st CENTURY SKILLS: A SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract

21st century skills have become increasingly essential in global education to prepare individuals for the rapidly evolving challenges of the modern world. This study aims to analyze global trends in the development of 21st century skills through a systematic literature review and bibliometric analysis. Using data from the Scopus database up to August 14, 2025, this research explores the distribution of publications, trends, and the theoretical and practical contributions made by existing studies. The findings indicate that, while significant attention has been given to these skills, there remains a gap in understanding their practical application and measurement, particularly in areas such as critical thinking and creativity. The analysis also highlights the need for project-based and problem-based learning models to effectively support the development of these skills. This research provides guidance for future studies by identifying areas that require further exploration, and contributes to enhancing the integration of 21st century skills into global educational curricula. The findings are expected to assist in the development of educational policies and the effective implementation of 21st century skills worldwide.

Keywords: 21st century skills, systematic literature review, bibliometric analysis.

INTRODUCTION

The 21st century skills have become a central focus in global education in recent decades (Avdeenko et al., 2018; Haug & Mork, 2021; van Laar et al., 2022; Voogt & Knezek, 2013). With rapid technological advancements and shifts in social (Farisi, 2016; Machado et al., 2024; Mensonides et al., 2024; Susrawan et al., 2024), economic (Hasan et al., 2023; Taar & Palojoki, 2022; Tanantong et al., 2024), and industrial dynamics (Müller & Pietzner, 2020; Saleem, Dhuey, et al., 2024; Yeh et al., 2024), these skills are increasingly viewed as essential to prepare individuals for the challenges and opportunities of the future . Among the 21st century skills receiving significant attention are creative problem solving, critical thinking, collaboration, and effective communication. This study focuses on understanding and analyzing global

trends in the development of 21st century skills through a systematic literature review and bibliometric analysis (Erstad et al., 2021; Serrano-Ausejo & Mårell-Olsson, 2024; Webb et al., 2018).

However, despite the growing recognition of the importance of 21st century skills in education and the workforce, there remains a lack of clarity regarding the distribution and publication trends of this subject in academic literature. Several challenges also arise in defining and measuring these skills effectively (Alhothali, 2021; Komari et al., 2024; Putri, 2023; Suresh et al., 2025), as well as in identifying research gaps that need to be filled to optimize their integration into educational curricula (Bayley, 2022; Calabrese et al., 2023; El-Haggar et al., 2019; Gratani & Giannandrea, 2022; Ioannou et al., 2025; Nothacker & Lavicza, 2020). The integration of these skills with technological advancements (Doğu & Yildirim, 2023; Liesa-Orús et al., 2020; Öztürk, 2023) and societal changes calls for further research to understand how these concepts can be practically applied across various contexts (Mensonides et al., 2024; Ross & Rajkoomar, 2024).

Although much research has been conducted on 21st century skills, there is still insufficient in-depth understanding of publication trends and the theoretical and practical contributions made by these studies. Moreover, the relationship between 21st century skills and the evolving technological landscape (Bobrowicz et al., 2022; Shareefa et al., 2024) and labor market needs has not been extensively explored (Al-Hooti et al., 2023; Guterman et al., 2024; Habets et al., 2020). Therefore, there is a need to investigate how these skills are developing in the academic literature and how prior research contributions can guide the direction of future studies.

This research presents a comprehensive approach through a systematic literature review (Koehorst et al., 2021; van Laar et al., 2017)combined with bibliometric (Chamidah et al., 2024; Prahani & Dawana, 2025; Saleem, Dhuey, et al., 2024) analysis to identify global trends in the development of 21st century skills. Using bibliometric analysis, this study aims to provide clearer insights into the distribution, development, and theoretical and practical contributions in this field, which have not been extensively discussed in previous studies. This will open new perspectives on how research in education can align 21st century skills with the ever-changing demands of the workforce.

The primary objective of this study is to analyze and explore global trends in the development of 21st century skills through systematic literature review and bibliometric analysis. This study aims to identify the trends and distribution of research on 21st century skills in academic literature, as well as analyze the theoretical contributions and practical implications derived

from existing studies on these skills. Furthermore, this study also aims to provide clear guidance for future research directions by identifying gaps and areas that require further exploration, thus enriching the understanding and application of 21st century skills in the context of education and the workforce.

This study is expected to make a significant contribution to the understanding of global trends in the development of 21st century skills, both theoretically and practically. By providing a systematic bibliometric analysis, this research aims to clarify the research landscape in this field and provide guidance for researchers, educators, and policymakers to better understand and integrate 21st century skills into educational curricula.

To achieve the aforementioned objectives, this study will address the following research questions: [RQ1]: Does the exploration of 21st century skills remain a relevant and significant subject for scholarly inquiry in the future?; [RQ2]: What is the distribution and current publication trend of research on 21st century skills within academic literature?; [RQ3]: What are the theoretical contributions and practical implications derived from existing studies on 21st century skills, and how can these findings guide future research?

This study uses a systematic literature review (SLR) and bibliometric analysis to answer these three research questions. The SLR method is highly suitable for synthesizing existing research, identifying gaps, trends, and future directions, while providing evidence-based insights that can influence policy, practice, and future studies. Complementing this, bibliometric analysis measures the distribution and impact of publications related to 21st century skills, using VOSviewer and the Scopus database to analyze publications across various journals up to August 14, 2025. This methodology provides a comprehensive mapping of the field's development, enhancing understanding of the growth and future trajectory of research on 21st century skills.

METHOD

A systematic literature review with a bibliometric approach quantitatively evaluates the literature to identify trends, patterns, and key research entities within a specific field of study. Utilizing frameworks such as PRISMA, this approach ensures a comprehensive and replicable review process, providing a clear and transparent overview of the topic under investigation. The inclusion criteria for this review are as follows: (1) articles published up to August 14, 2025, (2) publications in English, and (3) a focus on the topic of 21st century skills. Bibliometric analysis was performed using VOSviewer software to visualize bibliographic data, such as citation networks, author collaboration, and keyword co-occurrence, which reveal the intellectual structure and dynamics of the research field.

The combination of a systematic review and bibliometric analysis assists researchers in synthesizing empirical findings and mapping the landscape of research activity, including identifying key contributors and emerging trends. Integrating both approaches provides a comprehensive understanding of the development, historical flow, and future directions of the field, offering valuable insights for interdisciplinary studies. Bibliometric analysis is also employed for strategic purposes in scientific publishing. The initial phase of this study involves keyword selection, which can be conducted using a macro (top-down) methodology, starting with broad search pathways and narrowing down to specific studies and topics. After evaluating the limitations in previous research and the scarcity of studies addressing 21st century skills, this study focuses on the keyword "21st century skills" in the title, abstract, and keywords of articles. Additionally, the Scopus database was utilized by the researchers for various investigative purposes, including conducting the literature review, identifying experts in the field, and monitoring research trends.

The figure 1 illustrates the systematic process for selecting articles in the literature review, based on data retrieved from the Scopus database on August 14, 2025. Initially, a total of 3,344 articles were identified that included the keyword "21st century skills" in the title, abstract, or keywords. Following this, a more specific keyword filter was applied, focusing solely on the term "21st century skills," which reduced the number of articles to 1,189. Articles that did not meet this specific criterion were excluded, resulting in the removal of 2,155 articles from further consideration.

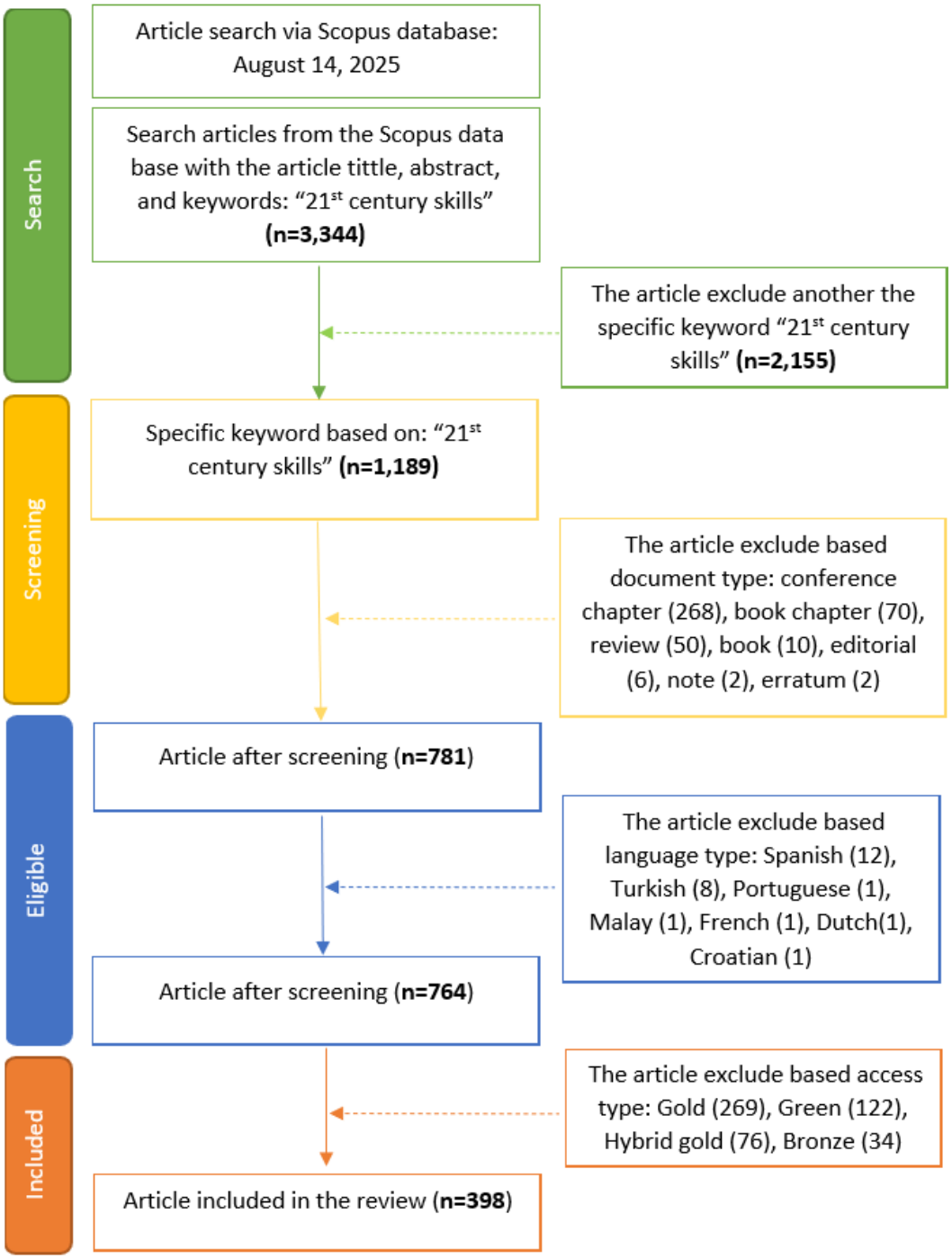

Figure 1 Systematic Literature Review process using the PRISMA framework

Subsequent filtering was conducted based on document type, eliminating conference proceedings (268 articles), book chapters (70 articles), review articles (50 articles), books (10 articles), editorials (6 articles), notes (2 articles), and errata (2 articles). After this stage, 781 articles remained. Further

refinement was performed based on language, with articles published in Spanish (12), Turkish (8), Portuguese (1), Malay (1), French (1), Dutch (1), and Croatian (1) being excluded, leaving 764 articles for the next step.

The final refinement process involved filtering based on access type, which excluded articles with Gold (269), Green (122), Hybrid Gold (76), and Bronze (34) access. As a result, 398 articles remained eligible for inclusion in the systematic literature review. This rigorous selection process ensured that only the most relevant and high-quality articles were included for comprehensive analysis.

FINDINGS AND DISCUSSION

The findings of this study focus on data from 398 articles in the Scopus database related to 21st century skills. This data was obtained by identifying the number of articles published, publication trends over the years, and the journals in which these articles were published. The study also highlights the most influential elements in the development of 21st century skills, including the authors, institutional affiliations, and the countries contributing to this field.

3.1 RQ 1: Does the exploration of 21st century skills remain a relevant and significant subject for scholarly inquiry in the future?

Based on the data obtained from the Scopus database, it is evident that over the past two decades, scholarly work on 21st century skills has been limited, with only 398 articles published, as shown in Figure 2. The exploration of 21st century skills has progressively developed over the last decade, particularly since 2016. The first study was conducted by Soh et al., (2012) with the title" M-21CSI: A validated 21st century skills instrument for secondary science students" marking the emergence of the term now widely known as 21st century skills.

Currently, the development of research on 21st century skills is receiving significant attention from many academics, with a focus on learning models (Jatmiko et al., 2024; Klaharn et al., 2025; Pantiwati et al., 2025; Saleem, Burns, et al., 2024; Zaki et al., 2024), students' higher-order thinking(Fauziah et al., 2024; Guterman et al., 2024; Müller & Pietzner, 2020; Turiman et al., 2020; Zainil et al., 2023), assessment and evaluation of learning(Braun et al., 2020; O'Reilly & Sheehan, 2009; Perry, 2018; Popandopulo et al., 2023; Shute & Rahimi, 2021; Siddiq et al., 2017; Tan et al., 2023; Ukobizaba et al., 2021; Webb et al., 2018), science education (Bircan & Çalışıcı, 2022; De Leon Saura & Mamaoag, 2023; Hiong & Osman, 2013; Maass

& Engeln, 2019; Nugroho et al., 2019; Soh et al., 2012; Turiman et al., 2019; Usman, 2022), and multidisciplinary education (Ghimouz et al., 2021; Hursen et al., 2023; Lusk, 2019; Uğur & Sungur, 2021; Yılmaz, 2021). Moreover, 21st century skills also play a significant role in the development of digital technology competencies (Erstad et al., 2021; Ngcobo, 2022; Nothacker & Lavicza, 2020; Siddiq et al., 2017; van Laar et al., 2018, 2019) and global challenges (Galeboe et al., 2025; Serrano-Ausejo & Mårell-Olsson, 2024; Webb et al., 2018).

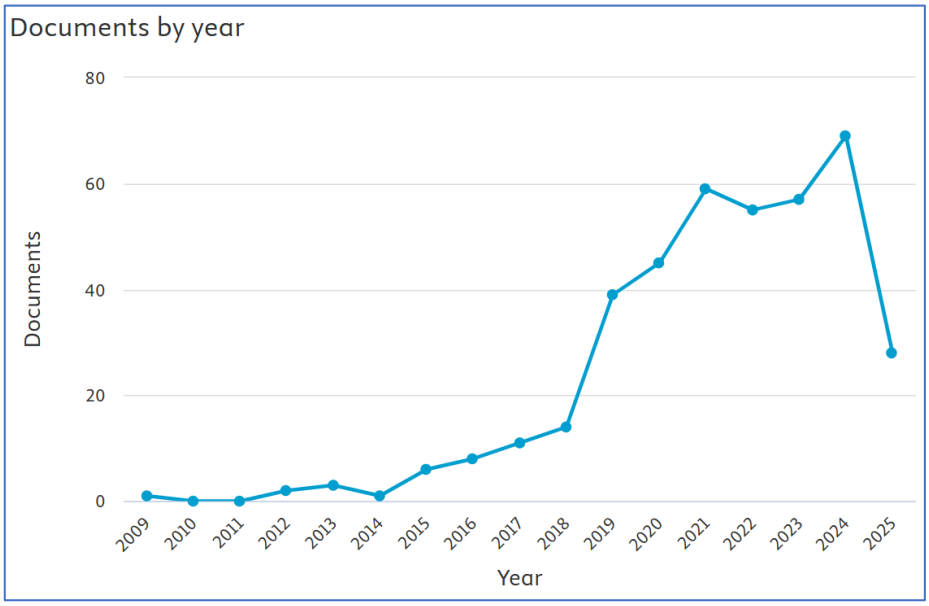

Figure 2 Distribution articles by year

Since 2009, literature on 21st century skills has remained limited due to the lack of research published in reputable journals. This creates an opportunity for future researchers to fill this gap. This study plays a crucial role in enriching the understanding of 21st century skills, which positively impacts the development of these competencies in preparing individuals to face the increasingly uncertain challenges of life. With the foundation of 21st century skills instilled in each individual, particularly students, they will be better equipped to innovate and solve the problems they encounter wisely and intelligently. This approach can foster a deeper understanding of the application of 21st century skills across various dimensions of life.

3.2 RQ2: What is the distribution and current publication trend of research on 21st century skills within academic literature?

The analysis of the distribution of research on 21st century skills was conducted by categorizing 398 articles based on classifications such as country, region, institutional affiliation, source, and authors, with the selection limited to the top 10 articles in each category. A deeper understanding of the allocation of research on 21st century skills will be highly valuable for academics and practitioners in shaping future research agendas, particularly in the development of sustainable paradigms for 21st century skills.

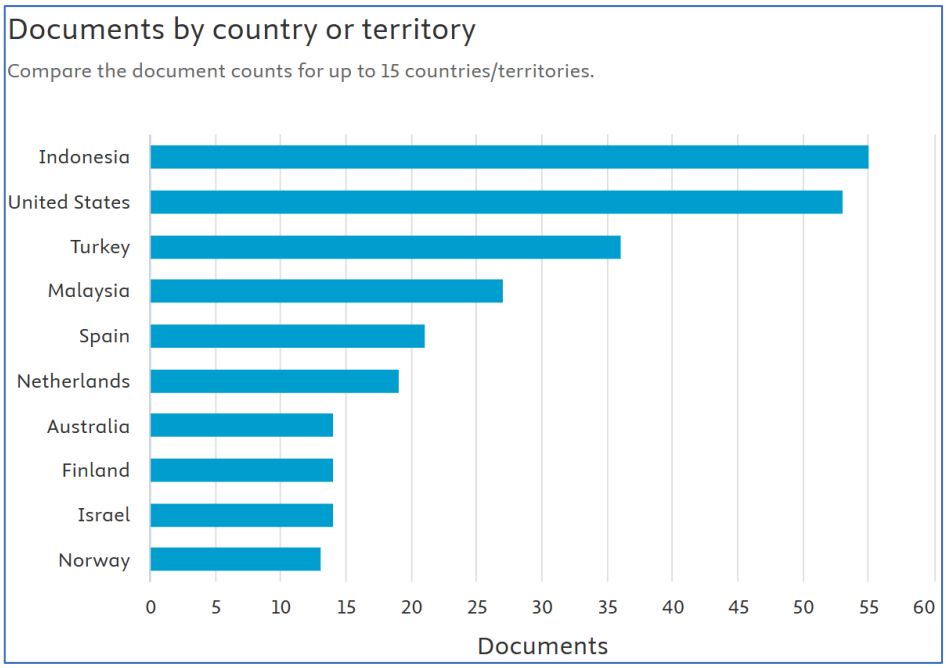

Figure 3 Distribution articles by country

The Figure 4 visualizes the global network of countries involved in research related to 21st century skills, illustrating the interconnectedness of various nations in advancing this area of study. Indonesia, the United States, and Malaysia emerge as central hubs, reflecting their significant contributions to the field. The network also shows strong connections with countries across Europe, such as the Netherlands, the United Kingdom, and Germany, as well as nations from Asia like China, Japan, and the Philippines. These countries, alongside Australia and others, highlight the global relevance of 21st century skills research and suggest a rapid progression in these regions regarding the development and integration of such skills into education. The analysis conducted with VOSviewer software reveals the collaborative relationships between countries, essential for shaping a comprehensive and systematic research agenda for 21st century skills. This collaborative global effort

demonstrates the widespread recognition of the importance of 21st century skills in educational systems worldwide.

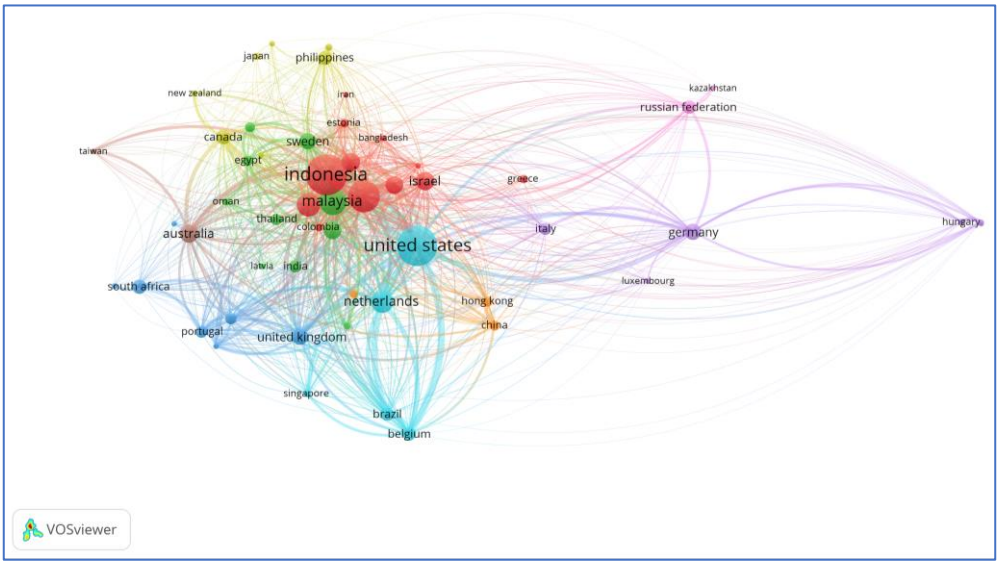

Figure 4 Network country visualization

These findings suggest that the issue of 21st century skills has gained attention not only from countries with advanced educational systems such as the United States but also from Asian nations like Indonesia, Malaysia, and Turkey, which are increasingly recognizing the importance of 21st century skills in education and innovation development. The contributions from these diverse countries further underscore the global relevance of the topic and indicate that the development of 21st century skills is progressing rapidly across various regions, reflecting efforts by these nations to equip future generations with the skills necessary for an ever-evolving world.

The figure above shows the distribution of documents related to 21st century skills based on institutional affiliations. Among the top contributing institutions, Universiti Kebangsaan Malaysia stands out with the highest number of publications (7 articles), followed by Universiteit Twente (12 articles), University of California (7 articles), Berkeley (7 articles) Universiteit Gent (7 articles), and Universitas Negeri Padang (7 articles). Other notable contributors include Helsingin Yliopisto (6 articles), Universitas Negeri Yogyakarta (6 articles), Itä-Suomen Yliopisto (6 articles), Universitas Negeri Malang (6 articles), and the Ayrton Senna Institute (5 articles). These institutions represent a diverse range of countries, underscoring the global engagement in researching 21st century skills. The substantial contributions from these universities reflect their ongoing commitment to advancing the

study and application of skills essential for the future workforce, highlighting the importance of collaboration across educational systems worldwide to promote the development of critical competencies for the 21st century.

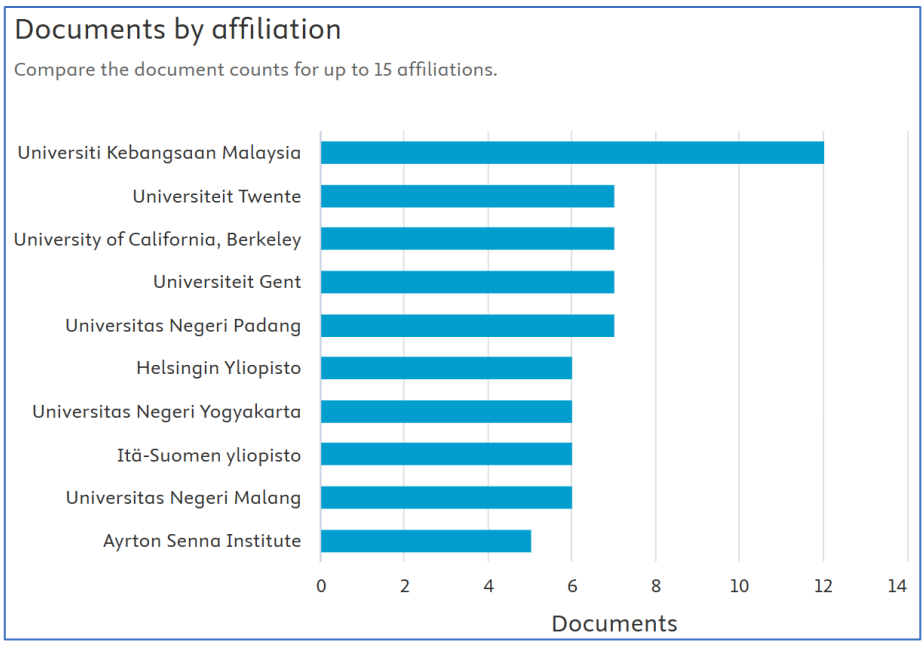

Figure 5 Distribution articles by affiliation

The Figure 6 displays the distribution of documents related to 21st century skills across various academic journals from 2015 to 2025. The data reveals significant fluctuations in the number of publications over the years. Notably, Sustainability Switzerland saw a sharp increase in 2020, while journals like Education Sciences, Frontiers in Education, and Jurnal Pendidikan IPA Indonesia showed a more consistent publication trend. The Eurasia Journal of Mathematics Science and Technology Education and International Journal of Learning Teaching and Educational Research demonstrated modest but steady growth in their published articles throughout the years. Conversely, journals like Participatory Educational Research, International Journal of Instruction, and Computers in Human Behavior exhibited less frequent publication. These trends highlight the evolving academic interest in 21st century skills across various educational fields, indicating both concentrated bursts of research activity and ongoing, steady contributions from multiple scholarly sources.

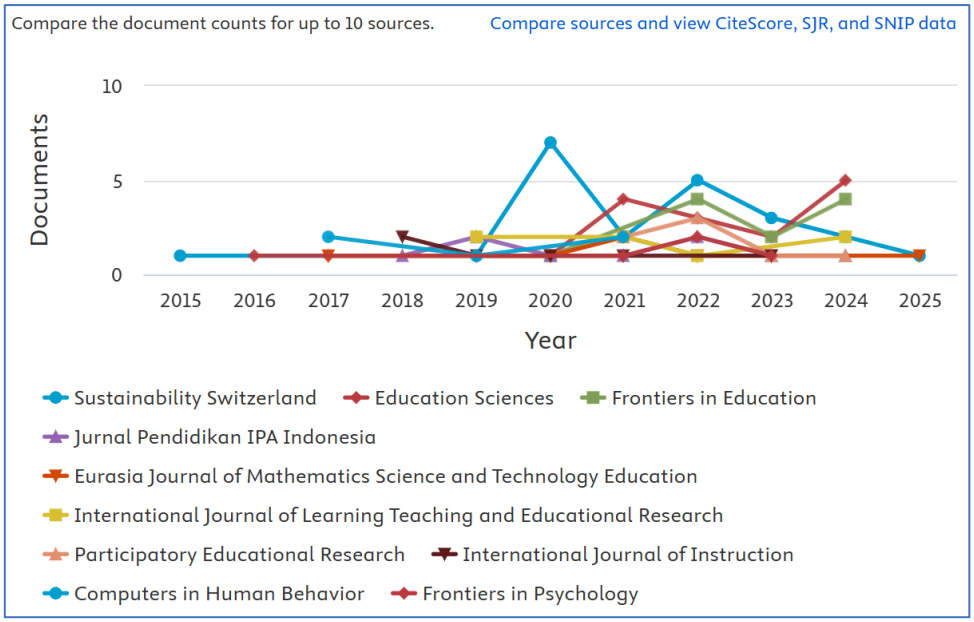

Figure 6 Number of Article by Sources (top 10 sources)

The Figure 7 presents the distribution of documents related to 21st century skills by author. It highlights the authors who have contributed the most publications in this field, with van Deursen, A.J.A.M. leading the list, followed closely by van Dijk, J.A.G.M. and John, O.P. Each of these authors has published multiple works, with van Deursen contributing the highest number. Other significant contributors include Primi, R., de Haan, J., and van Laar, E., all of whom have made notable contributions to the research on 21st century skills. The data also indicates the contributions of other authors, such as Feraco, T., Meneghetti, C., Osman, K., and De Fruyt, F., though their publication counts are relatively lower. These findings reflect the key individuals shaping the body of research in this area, underlining their ongoing role in advancing the understanding of 21st century skills.

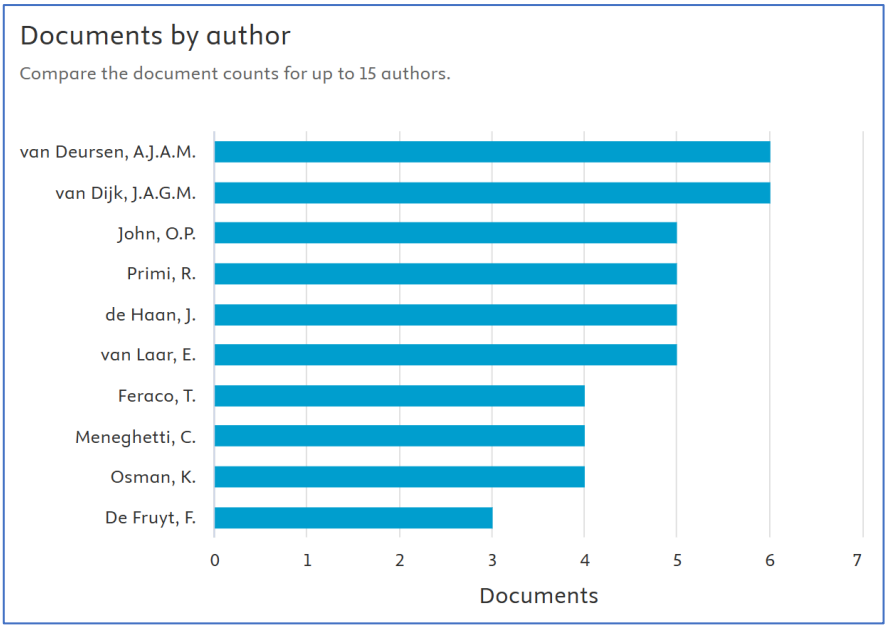

Figure 7 Number of Article by author (top 10 sources)

3.3 RQ3: What are the theoretical contributions and practical implications derived from existing studies on 21st century skills, and how can these findings guide future research?

An examination was conducted on 398 manuscripts collected from the Scopus repository. VOSviewer software was used to demonstrate that the findings of this study may have both theoretical and practical implications for future research on 21st century skills. The metadata analysis using VOSviewer will assist researchers and practitioners in gaining a deeper understanding of the assumptions and findings related to 21st century skills more effectively. Bibliometric analysis using VOSviewer can highlight which variables have been extensively researched by previous scholars and which ones remain underexplored, thus providing a foundation for future research. From a practitioner's perspective, the literature analysis using VOSviewer will support the ongoing application of 21st century skills in the future and encourage their integration into educational institutions worldwide.

The Figure 8 and Table 1 illustrate a keyword mapping related to 21st-century skills, derived from bibliometric analysis using VOSviewer. The keyword "21st century skills" dominates both in terms of frequency (207 occurrences) and total link strength (566), highlighting its central position in

research concerning education and skill development. Other significant keywords such as education, learning, critical thinking, creativity, and problem solving also appear prominently, reflecting the considerable focus on developing cognitive and social competencies within the context of contemporary education.

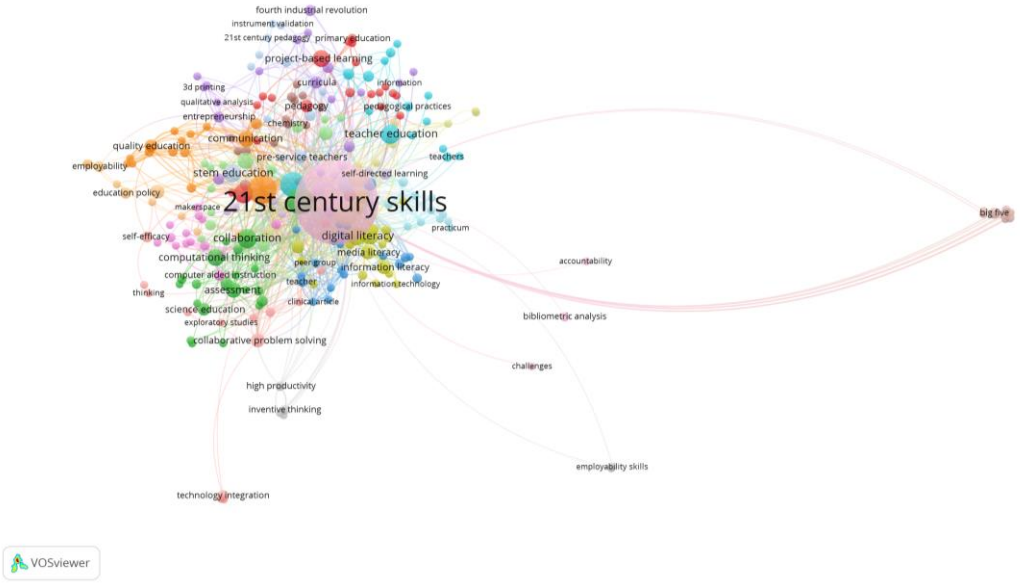

Figure 8 Keywords by author

Furthermore, the analysis reveals strong interconnections between keywords such as digital literacy, collaboration, and communication, underscoring their increasing importance in light of technological advancements in education. Keywords such as information and communication technology (ICT) and employability skills reflect the growing trend of equipping students with practical, future-ready skills. This map underscores the importance of integrating diverse skill sets to adequately prepare individuals for the ever-evolving global landscape, emphasizing the pivotal role of 21st-century skills in driving current educational reforms.

Table 1 Keywords by authors

Rank	Keyword	Occurences	Total link strength
1	21st century skills	207	566
2	Education	24	349
3	Learning	19	164
4	Critical thinking	21	138

5	Creativity	18	135
6	Problem solving	12	113
7	Digital literacy	10	67
8	Collaboation	11	48
9	Communication	8	44
10	Information and communication technology	3	44

The concept of 21st-century skills has become a focal point in educational discourse as the world rapidly shifts towards an increasingly interconnected, technology-driven environment (Galeboe et al., 2025; Shute & Rahimi, 2021). These skills go beyond traditional academic knowledge (Gay & Betts, 2020; González et al., 2020; Molnár & Kocsis, 2024), incorporating cognitive (Molnár & Kocsis, 2024; Mufit et al., 2023; Tan et al., 2023), social (Cristea et al., 2024; Feraco et al., 2025; Feraco & Meneghetti, 2023; Pellegrino et al., 2025), and technological capabilities (Aktaş & Karaca, 2022; Dahri et al., 2023; Fajrina et al., 2020) necessary for individuals to thrive in modern society. Key competencies such as critical thinking (Campoy-Cubillo & Jimenez-Estrada, 2024; Gentile et al., 2019; Rinholm et al., 2023; Yasa et al., 2024), creativity (Hondzel & Hansen, 2015; Saleem, Burns, et al., 2024; Tang et al., 2020), problem-solving (Jaleniauskienė & Jucevičienė, 2018; Jatmiko et al., 2024; Ukobizaba et al., 2021), collaboration (Campoy-Cubillo & Jimenez-Estrada, 2024; Hendarwati et al., 2021), communication (Al-Hooti et al., 2023; Mavuru et al., 2024; Oktasari et al., 2019), and digital literacy (Mahmud & Wong, 2022; van Laar et al., 2017; Yasa et al., 2024) have emerged as essential components in preparing students for future challenges. As revealed by the keyword analysis, these skills are central to the evolving educational landscape, underlining the need for systems that not only impart knowledge but also cultivate the abilities necessary for innovation, effective communication, and digital engagement.

The indicators of 21st-century skills are equally vital to guide the integration of these competencies into educational curricula. Digital literacy, for example, equips students to navigate the digital world confidently, making it a cornerstone of modern education. Similarly, the development of collaboration and communication skills has gained prominence, as they are crucial for success in the workplace, which is increasingly collaborative and technologically oriented (Arizona, 2020; Arizona et al., 2013; Sucilestari & Arizona, 2018). The analysis highlights the growing importance of these indicators and points to their intersection as essential components of a well-rounded skillset. These skills are no longer optional but are indispensable for students to effectively engage in a rapidly changing global workforce, thus

making them integral to education systems worldwide (Arizona et al., 2024; Arizona, Sucilestari, Mutiara, et al., 2025; Sucilestari et al., 2025).

As the emphasis on 21st-century skills intensifies, it opens numerous avenues for research to explore the most effective ways to nurture these competencies. There is a growing demand for educational practices that integrate real-world problem-solving and collaboration, with an increasing focus on project-based learning (Abidin et al., 2020; Arizona, Sucilestari, & Suhardi, 2025; Arizona, Sucilestari, Mutiara, et al., 2025; Asyari et al., 2024; Sucilestari et al., 2023, 2025; Sucilestari & Arizona, 2018) and problem-based learning (Raehan et al., 2020)(Aroyandini & Rusilowati, 2024; Louis et al., 2021). These educational models encourage students to apply knowledge to solve complex issues while fostering critical thinking, creativity, and teamwork. The relationship between digital literacy and employability skills also presents an intriguing research opportunity, as technology continues to reshape industries and job markets (Ghafar, 2020; Khodeir & Nessim, 2020; Tanantong et al., 2024; van Laar et al., 2022). By investigating how to best integrate technology into teaching practices, researchers can contribute valuable insights into preparing students for a workforce that demands both technical skills and the ability to think critically and creatively (Cristea et al., 2024; Dagienė et al., 2022; Gentile et al., 2019; Hendarwati et al., 2021).

To achieve the development of 21st-century skills, it is crucial that educational models adopt active, student-centered approaches (Alharbi, 2024; Hadiyanto, 2024; Karnain et al., 2019; Kensicki et al., 2022). Project-based learning and problem-based learning have shown to be particularly effective in this regard, as they place students in dynamic, real-world contexts that require the application of multiple skills. These models align with the broader goals of 21st-century education, encouraging students to engage in hands-on, collaborative projects that mimic real-life scenarios. Moreover, the integration of technology into these learning models enhances digital literacy while providing students with the tools they need to collaborate and innovate in a digital world (Campoy-Cubillo & Jimenez-Estrada, 2024; Fajrina et al., 2020). The shift towards flipped classrooms further complements these approaches, providing students with the opportunity to take ownership of their learning while ensuring that they have access to the digital resources necessary to enhance their competencies.

Despite the widespread adoption of 21st-century skills frameworks, there remain significant gaps in both the measurement and assessment of these skills. While much of the research emphasizes their importance, there is a lack of standardized tools to assess critical thinking, creativity, or problem-solving in meaningful ways. The keyword analysis reveals that there is a need for more

research into innovative assessment techniques that capture these skills accurately. Furthermore, while teaching practices have increasingly integrated 21st-century skills, there is insufficient empirical evidence on the long-term impact of these approaches on students' future success. Research that explores how these skills translate into tangible outcomes, such as employability or job performance, would significantly contribute to the understanding of their real-world applicability and value.

In conclusion, the findings from the keyword mapping and the broader body of research emphasize the centrality of 21st-century skills in modern education. These skills are essential not only for personal development but also for addressing global challenges in technology, communication, and collaboration. Moving forward, it is essential to develop effective teaching models that prioritize collaboration, digital literacy, and critical thinking, while also innovating assessment methods that can truly capture these complex skills. By doing so, educatiVonal systems can better prepare students for the demands of an ever-evolving global landscape, ensuring that they are equipped with the competencies needed for future success.

CONCLUSION

This study has provided valuable insights into the global trends in the development of 21st century skills, showing that these competencies remain highly relevant and significant for future scholarly inquiry. The growing body of research since 2016 highlights the increasing recognition of the importance of 21st century skills in preparing individuals for the challenges and opportunities of an evolving world. The distribution of research across various countries, including Indonesia, the United States, and Turkey, demonstrates a broad, global commitment to understanding and integrating these skills into educational frameworks. Although there have been fluctuations in publication volumes over the years, the continuous and expanding focus on these skills in academic literature reflects their long-term significance for education systems worldwide.

The theoretical and practical contributions derived from the existing studies emphasize the critical role that 21st century skills play in education. The research points to the need for innovative assessment techniques that can accurately measure competencies such as creativity, critical thinking, and problem-solving, while also investigating their long-term impact on students' future success. Additionally, the study reveals the importance of adopting educational models that integrate project-based learning and problem-based learning, which can more effectively develop the skills needed to address real-world challenges. Moving forward, it is crucial to focus on developing

standardized assessment tools and exploring how these skills can be integrated with technological advancements in educational systems. Policymakers and educators should prioritize frameworks that blend academic knowledge with the development of 21st century skills, ensuring that students are equipped not only with technical knowledge but also with the practical, cognitive, and interpersonal competencies required to navigate the complexities of the modern world.

REFERENCES

Abidin, Z., Rumansyah, & Arizona, K. (2020). Pembelajaran Online Berbasis Proyek Salah Satu Solusi Kegiatan Belajar Mengajar Di Tengah Pandemi Covid-19. *Jurnal Ilmiah Profesi Pendidikan*, *5*(1), 64–70. https://doi.org/10.29303/jipp.v5i1.111

Aktaş, N., & Karaca, F. (2022). The relationship between Turkish high school administrators' technology leadership self-efficacies and their attitudes and competencies towards technology use in education. *Participatory Educational Research*, *9*(5), 430–448. https://doi.org/10.17275/per.22.122.9.5

Al-Hooti, M., Al-Barwani, T., & Al-Mekhlafi, A. (2023). Alignment of 21st century oral English curriculum and communication skills with labor market and higher education in Oman: The stakeholders' perspective. *International Journal of English Language and Literature Studies*, *12*(1), 60–73. https://doi.org/10.55493/5019.v12i1.4722

Alharbi, N. S. (2024). Exploring the perspectives of cross-cultural instructors on integrating 21st century skills into EFL university courses. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1302608

Alhothali, H. M. (2021). Inclusion of 21st century skills in teacher preparation programs in the light of global expertise. *International Journal of Education and Practice*, *9*(1), 105–127. https://doi.org/10.18488/journal.61.2021.91.105.127

Arizona, K. (2020). Elevating Students' Competence Based Ict in the Era of Industrial Revolution 4.0. *Journal of Teaching and Learning Physics*, *5*(2), 48–59. https://doi.org/10.15575/jotalp.v5i2.7987

Arizona, K., Harjono, A., & Jufri, A. W. (2013). Pengaruh Implementasi Media Tiga Dimensi Kemagnetan Berbasis Inkuiri (Mtdkbi) Melalui Strategi Kooperatif Terhadap Kecakapan Sosial. *Erudio Journal of Educational Innovation*, *1*(2), 66–70. https://doi.org/10.18551/erudio.1-2.9

Arizona, K., Rokhmat, J., Ramdani, A., Gunawan, & Sukarso, A. (2024). Learning Model KoPI Lokal Islami: Philosophical and Theoretical Perspectives Kurniawan. *Proceedings of the 2nd International Conference on Islamic Education and Science Development (ICONSIDE)*, *June*, 334–341. https://proceeding.uinmataram.ac.id/index.php/iconside/article/view/146

Arizona, K., Sucilestari, R., Mutiara, B., Nirmala, A., & Didik, L. A. (2025). Project-Based Science-Physics E-Book to Train Student Creativity. *Jurnal Penelitian Pendidikan IPA*, *11*(6), 718–725. https://doi.org/10.29303/jppipa.v11i6.11112

Arizona, K., Sucilestari, R., & Suhardi, R. M. (2025). The influence of web-based projects on students digital creativity in physics education : a gender-based analysis. *Compton : Jurnal Ilmiah Pendidikan Fisika*, *12*(1), 121–134.

Aroyandini, E. N., & Rusilowati, A. (2024). Disaster Education Model for Prospective

Science Teachers: Needs Analysis and Initial Development. *Journal of Disaster Research*, *19*(3), 560–569. https://doi.org/10.20965/jdr.2024.p0560

Asyari, A., Meiliyadi, L. A. D., Sucilestari, R., & Arizona, K. (2024). Exploring Student Creativity and Collaboration Through Project-Based Learning With Google Sites. *Jurnal Pendidikan Islam*, *10*(2), 308–322. https://doi.org/10.15575/jpi.v10i2.40215

Avdeenko, N., Denishcheva, L., Krasnyanskaya, K., Mikhaylova, A., & Pinskaya, M. (2018). Creativity for everyone: Integrating encouragement of 21st century skills in Russian schools. *Voprosy Obrazovaniya / Educational Studies Moscow*, *17*(4), 282–304. https://doi.org/10.17323/1814-9545-2018-4-282-304

Bayley, S. H. (2022). Learning for adaptation and 21st-century skills: Evidence of pupils' flexibility in Rwandan primary schools. *International Journal of Educational Development*, *93*(March), 102642. https://doi.org/10.1016/j.ijedudev.2022.102642

Bircan, M. A., & Çalışıcı, H. (2022). The Effects of STEM Education Activities on Fourth Grade Students' Attitudes to Stem, 21st-Century Skills and Mathematics Success. *Egitim ve Bilim*, *47*(211), 87–119. https://doi.org/10.15390/EB.2022.10710

Bobrowicz, K., Han, A., Hausen, J., & Greiff, S. (2022). Aiding Reflective Navigation in a Dynamic Information Landscape: A Challenge for Educational Psychology. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.881539

Braun, H. I., Shavelson, R. J., Zlatkin-Troitschanskaia, O., & Borowiec, K. (2020). Performance Assessment of Critical Thinking: Conceptualization, Design, and Implementation. *Frontiers in Education*, *5*. https://doi.org/10.3389/feduc.2020.00156

Calabrese, J. E., Butler Songer, N., Cordner, H., & Kalani Aina, D. (2023). How do we design curricula to foster innovation, motivation and interest in STEM learning? *Journal of Research in Innovative Teaching and Learning*. https://doi.org/10.1108/JRIT-06-2023-0064

Campoy-Cubillo, M. C., & Jimenez-Estrada, V. (2024). A critical approach to SDGs through Collaborative Online International Learning: experiences from Canada and Spain. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1520859

Chamidah, D., Suwono, H., Susilo, H., Sulisetijono, S., Munzil, M., & Zubaidah, S. (2024). NAVIGATING THE GLOBAL LANDSCAPE ON PROJECT-BASED LEARNING AND 21ST-CENTURY SKILLS RESEARCH (2020–2023): A BIBLIOMETRIC ANALYSIS. *Malaysian Journal of Learning and Instruction*, *21*(2), 187–238. https://doi.org/10.32890/mjli2024.21.2.7

Cristea, T. S., Snijders, C., Matzat, U., & Kleingeld, A. (2024). Do 21st-century skills make you less lonely? The relation between 21st-century skills, social media usage, and students' loneliness during the COVID-19 pandemic. *Heliyon*, *10*(3). https://doi.org/10.1016/j.heliyon.2024.e25899

Dagienė, V., Jevsikova, T., Stupurienė, G., & Juškevičienė, A. (2022). Teaching Computational Thinking in Primary Schools: Worldwide Trends and Teachers' Attitudes. *Computer Science and Information Systems*, *19*(1), 1–24. https://doi.org/10.2298/CSIS201215033D

Dahri, N. A., Al-Rahmi, W. M., Almogren, A. S., Yahaya, N., Vighio, M. S., Al-maatuok, Q., Al-Rahmi, A. M., & Al-Adwan, A. S. (2023). Acceptance of Mobile Learning

Technology by Teachers: Influencing Mobile Self-Efficacy and 21st-Century Skills-Based Training. *Sustainability (Switzerland)*, *15*(11). https://doi.org/10.3390/su15118514

De Leon Saura, R. B., & Mamaoag, N. (2023). MICROCLASS: A PEDAGOGICAL INNOVATION FOR TEACHING-LEARNING PROCESS IN SCIENCE. *Malaysian Journal of Learning and Instruction*, *20*(1), 33–61. https://doi.org/10.32890/mjli2023.20.1.2

Doğu, K., & Yildirim, A. (2023). Exploring the relationship between technological leadership self-efficacy of primary school administrators and 21st century skills. *Participatory Educational Research*, *10*(4), 16–28. https://doi.org/10.17275/per.23.57.10.4

El-Haggar, N., Mezhoudi, N., & Alrawjih, F. (2019). The impact of co-curricular activities supported by generic skills on students' performance at university level. *International Journal of Innovative Technology and Exploring Engineering*, *8*(11), 4159–4164. https://doi.org/10.35940/ijitee.K1290.0981119

Erstad, O., Kjällander, S., & Järvelä, S. (2021). Facing the challenges of 'digital competence' a Nordic agenda for curriculum development for the 21st century. *Nordic Journal of Digital Literacy*, *16*(2), 77–87. https://doi.org/10.18261/ISSN.1891-943X-2021-02-04

Fajrina, S., Lufri, L., & Ahda, Y. (2020). Science, technology, engineering, and mathematics (STEM) as a learning approach to improve 21st century skills: A review. *International Journal of Online and Biomedical Engineering*, *16*(7), 95–104. https://doi.org/10.3991/ijoe.v16i07.14101

Farisi, M. I. (2016). Developing the 21st-century social studies skills through technology integration. *Turkish Online Journal of Distance Education*, *17*(1), 16–30. https://doi.org/10.17718/tojde.47374

Fauziah, A. N. M., Hendratmoko, A. F., Mahdiannur, M. A., Ermawan, M. Z. F., Suwandi, E., & Ratri, S. Y. (2024). THE RELATIONSHIP BETWEEN CRITICAL THINKING AND SCIENTIFIC ARGUMENTATION IN SCIENCE LEARNING. *Jurnal Pendidikan IPA Indonesia*, *13*(2), 239–254. https://doi.org/10.15294/pwqxcp96

Feraco, T., & Meneghetti, C. (2023). Social, Emotional, and Behavioral Skills: Age and Gender Differences at 12 to 19 Years Old. *Journal of Intelligence*, *11*(6). https://doi.org/10.3390/jintelligence11060118

Feraco, T., Pellegrino, G., Casali, N., Carretti, B., & Meneghetti, C. (2025). Social, emotional, and behavioral skills in students with or without specific learning disabilities. *Learning and Individual Differences*, *117*. https://doi.org/10.1016/j.lindif.2024.102581

Galeboe, K. A., Moalosi, R., Rapitsenyane, Y., & Ruele, V. (2025). What is the impact of using design and technology pedagogy to support the attainment of 21st-century skills? *Discover Education*, *4*(1). https://doi.org/10.1007/s44217-025-00604-5

Gay, G. H. E., & Betts, K. (2020). From discussion forums to emeetings: Integrating high touch strategies to increase student engagement, academic performance, and retention in large online courses. *Online Learning Journal*, *24*(1), 92–117. https://doi.org/10.24059/olj.v24i1.1984

Gentile, M., Città, G., Perna, S., Signa, A., Dal Grande, V., Ottaviano, S., La Guardia, D., & Allegra, M. (2019). The role of disposition to critical thinking in digital game-based learning. *International Journal of Serious Games*, *6*(3), 51–63.

https://doi.org/10.17083/ijsg.v6i3.316

Ghafar, A. (2020). Convergence between 21st century skills and entrepreneurship education in higher education institutes. *International Journal of Higher Education*, *9*(1), 218–229. https://doi.org/10.5430/ijhe.v9n1p218

Ghimouz, R., O'Sullivan, S., Baltatu, O. C., & Campos, L. A. (2021). Bang the gavel: animal experimentation on trial—an interdisciplinary mock trial at the school of health sciences. *Advances in Physiology Education*, *45*(1), 44–47. https://doi.org/10.1152/ADVAN.00171.2020

González, R. A., de la Hoz-Ruiz, J., & Gámez, J. M. (2020). The 2030 challenge in the quality of higher education: Metacognitive, motivational and structural factors, predictive ofwritten argumentation, for the dissemination of sustainable knowledge. *Sustainability (Switzerland)*, *12*(19). https://doi.org/10.3390/su12198266

Gratani, F., & Giannandrea, L. (2022). Towards 2030. Enhancing 21st century skills through educational robotics. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.955285

Guterman, O., Neuman, A., & Gill, E. (2024). Home Schooling and the Future Labor Market—Is There an Adequate Educational Answer for the Extensive Changes in the Labor Market? *Education Sciences*, *14*(7). https://doi.org/10.3390/educsci14070800

Habets, O., Stoffers, J., Van der Heijden, B., & Peters, P. (2020). Am i fit for tomorrow's labor market? The effect of graduates' skills development during higher education for the 21st century's labor market. *Sustainability (Switzerland)*, *12*(18). https://doi.org/10.3390/su12187746

Hadiyanto, H. (2024). Application of Student-Centered Learning in Improving Teaching English as a Foreign Language Students' 21st-Century Skills Performance. *Education Sciences*, *14*(9). https://doi.org/10.3390/educsci14090938

Hasan, M., Arisah, N., Supatminingsih, T., Ma'ruf, M. I., & Aini, F. H. (2023). Project-Based Learning in Economics Learning: Can it Improve 21st Century Skills Through Online Learning? *Pedagogika*, *152*(4), 5–27. https://doi.org/10.15823/p.2023.152.1

Haug, B. S., & Mork, S. M. (2021). Taking 21st century skills from vision to classroom: What teachers highlight as supportive professional development in the light of new demands from educational reforms. *Teaching and Teacher Education*, *100*. https://doi.org/10.1016/j.tate.2021.103286

Hendarwati, E., Nurlaela, L., & Bachri, B. S. (2021). The collaborative problem based learning model innovation. *Journal of Educational and Social Research*, *11*(4), 97–106. https://doi.org/10.36941/jesr-2021-0080

Hiong, L. C., & Osman, K. (2013). A conceptual framework for the integration of 21st century skills in biology education. *Research Journal of Applied Sciences, Engineering and Technology*, *6*(16), 2976–2983. https://doi.org/10.19026/rjaset.6.3681

Hondzel, C. D., & Hansen, R. (2015). Associating creativity, context, and experiential learning. *Education Inquiry*, *6*(2). https://doi.org/10.3402/edui.v6.23403

Hursen, C., Paşa, D., & Keser, H. (2023). High School Students' Use of Information, Media, and Technology Skills and Multidimensional 21st-Century Skills: An

Investigation within the Context of Students, Teachers, and Curricula. *Sustainability (Switzerland)*, *15*(16). https://doi.org/10.3390/su151612214

Ioannou, A., Miliou, O., Adamou, M., Kitsis, A., Timotheou, S., & Mavri, A. (2025). Understanding practicing and assessment of 21st-century skills for learners in makerspaces and FabLabs. *Education and Information Technologies*, *30*(7), 8829–8846. https://doi.org/10.1007/s10639-024-13178-w

Jaleniauskienė, E., & Jucevičienė, P. (2018). Educational system for the development of collaborative Ill-structured problem-solving skills. *Pedagogika*, *132*(4), 5–22. https://doi.org/10.15823/p.2018.132.1

Jatmiko, B., Prahani, B. K., Saphira, H. V, & Siswanto, J. (2024). Investigation-based multiple representation online model to improve students' problem-solving skills. *Perspektivy Nauki i Obrazovania*, *69*(3), 621–636. https://doi.org/10.32744/pse.2024.3.38

Karnain, R., Rahman, S., Surat, S., & Ali, M. T. (2019). Usability of M-PA21 module to improve teachers' metacognitive regulation in teaching and application of 21st century basic skills. *International Journal of Emerging Technologies in Learning*, *14*(20), 87–105. https://doi.org/10.3991/ijet.v14i20.11462

Kensicki, A. E., Harlow, J., Akhilandeswari, J., Peacock, S., Cohen, J., Weissman, R., & Gordon, E. (2022). Exploring the Impacts of Educational Simulations on The Development of 21st Century Skills and Sense of Self-Efficacy. *Journal of Political Science Education*, *18*(4), 635–651. https://doi.org/10.1080/15512169.2022.2080071

Khodeir, L. M., & Nessim, A. A. (2020). Changing skills for architecture students employability: Analysis of job market versus architecture education in Egypt. *Ain Shams Engineering Journal*, *11*(3), 811–821. https://doi.org/10.1016/j.asej.2019.11.006

Klaharn, R., Chaleoykitti, S., & Chakchaichon, C. (2025). Developing an active learning model using problem-based learning to enhance the 21st century skills. *Humanities and Social Sciences Letters*, *13*(1), 187–199. https://doi.org/10.18488/73.v13i1.4046

Koehorst, M. M., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2021). A Systematic Literature Review of Organizational Factors Influencing 21st-Century Skills. *SAGE Open*, *11*(4). https://doi.org/10.1177/21582440211067251

Komari, A., Yuliarto, H., Solikhin, M. N., Sadewa, Y. R., & Setyawan, H. (2024). Differences in the implementation of physical education (pe) planning containing 21st-century skills based on period of work and gender. *Retos*, *57*, 697–706. https://doi.org/10.47197/retos.v57.105895

Liesa-Orús, M., Latorre-Cosculluela, C., Vázquez-Toledo, S., & Sierra-Sánchez, V. (2020). The technological challenge facing higher education professors: Perceptions of ICT tools for developing 21st Century skills. *Sustainability (Switzerland)*, *12*(13). https://doi.org/10.3390/su12135339

Louis, A. T. S., Thompson, P., Sulak, T. N., Harvill, M. L., & Moore, M. E. (2021). Infusing 21st century skill development into the undergraduate curriculum: The formation of the iBEARS network. *Journal of Microbiology and Biology Education*, *22*(2). https://doi.org/10.1128/JMBE.00180-21

Lusk, B. G. (2019). The importance of the democratic and multidirectional exchange

of values between scientists, STEM educators, and historically underrepresented members of the community. *Journal of Responsible Innovation*, *6*(2), 248–254. https://doi.org/10.1080/23299460.2019.1571894

Maass, K., & Engeln, K. (2019). Professional development on connections to the world of work in mathematics and science education. *ZDM - Mathematics Education*, *51*(6), 967–978. https://doi.org/10.1007/s11858-019-01047-7

Machado, C., Hsiao, P. Y., Vaccaro, C., & Baker, C. (2024). Entering the Social Media Stratosphere: Higher Education Faculty Use of Social Media with Students Across Four Disciplines. *Journal of Interactive Media in Education*, *2024*(1). https://doi.org/10.5334/jime.854

Mahmud, M. M., & Wong, S. F. (2022). Digital age: The importance of 21st century skills among the undergraduates. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.950553

Mavuru, L., Kuyayama, A., & Mukaro, J. P. (2024). Development of Early Childhood Education Teachers in Information and Communication Technologies for Literacy or Pedagogy. *International Journal of Learning, Teaching and Educational Research*, *23*(4), 321–333. https://doi.org/10.26803/ijlter.23.4.18

Mensonides, D., Smit, A., Talsma, I., Swart, J., & Broersma, M. (2024). Digital Literacies as Socially Situated Pedagogical Processes: Genealogically Understanding Media, Information, and Digital Literacies. *Media and Communication*, *12*. https://doi.org/10.17645/MAC.8174

Molnár, G., & Kocsis, Á. (2024). Cognitive and non-cognitive predictors of academic success in higher education: a large-scale longitudinal study. *Studies in Higher Education*, *49*(9), 1610–1624. https://doi.org/10.1080/03075079.2023.2271513

Mufit, F., Hendriyani, Y., Dhanil, M., & Tanjung, M. R. (2023). The Effectiveness of Smartphone-Based Interactive Multimedia Integrated Cognitive Conflict Models to Improve 21st-Century Skills. *International Journal of Information and Education Technology*, *13*(11), 1793–1801. https://doi.org/10.18178/ijiet.2023.13.11.1991

Müller, S., & Pietzner, V. (2020). Comparative study of divergent thinking among participants in a German science competition and pupils in a control group. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(10). https://doi.org/10.29333/EJMSTE/8408

Ngcobo, N. F. (2022). Enablements and Constraints in the Uptake of Digital Technologies for Teaching and Learning: Implications for the Development of Digital Literacies. *International Journal of Mobile and Blended Learning*, *14*(3). https://doi.org/10.4018/IJMBL.314584

Nothacker, J., & Lavicza, Z. (2020). Digital Didactic Objectives of Primary, Secondary, and Higher Education Curricula in the 21st Century Executable with a Single-board Computer. *Open Education Studies*, *2*(1), 344–359. https://doi.org/10.1515/edu-2020-0135

Nugroho, O. F., Permanasari, A., & Firman, H. (2019). The movement of stem education in Indonesia: Science teachers' perspectives. *Jurnal Pendidikan IPA Indonesia*, *8*(3), 417–425. https://doi.org/10.15294/jpii.v8i3.19252

O'Reilly, T., & Sheehan, K. M. (2009). COGNITIVELY BASED ASSESSMENT OF, FOR, AND AS LEARNING: A FRAMEWORK FOR ASSESSING READING COMPETENCY.

ETS Research Report Series, *2009*(2), i–43. https://doi.org/10.1002/j.2333-8504.2009.tb02183.x

Oktasari, D., Hariadi, M. H., & Syari, E. L. (2019). 3d page-flipped worksheet on impulse-momentum to develop students' scientific communication skills. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 211–219. https://doi.org/10.15294/jpii.v8i2.15737

Öztürk, Ö. T. (2023). Examination of 21st Century Skills and Technological Competences of Students of Fine Arts Faculty. *International Journal of Education in Mathematics, Science and Technology*, *11*(1), 115–132. https://doi.org/10.46328/ijemst.2931

Pantiwati, Y., Aminudin, Waluyo, L., Permana, F. H., Sari, T. N. I., & Nurrohman, E. (2025). E-Module Based on LI-PRO-GP Learning Model to Improve Students' Conceptual Understanding and Problem-Solving Abilities in Science Learning. *International Journal of Information and Education Technology*, *15*(3), 549–564. https://doi.org/10.18178/ijiet.2025.15.3.2265

Pellegrino, G., Feraco, T., Meneghetti, C., & Carretti, B. (2025). Ready for What's Next? The Associations Between Social, Emotional, and Behavioral Skills and Career Adaptability in High School Students. *Journal of Adolescence*, *97*(5), 1200–1210. https://doi.org/10.1002/jad.12486

Perry, M. S. (2018). 21st Century Skills through Film Production in Tertiary Education: A transformative assessment in a literature and media course. *3L: Language, Linguistics, Literature*, *24*(4), 214–232. https://doi.org/10.17576/3L-2018-2404-16

Popandopulo, A., Kudysheva, A., Fominykh, N., Nurgaliyeva, M., & Kudarova, N. (2023). Assessment of students' metacognitive skills in the context of education 4.0. *Frontiers in Education*, *8*. https://doi.org/10.3389/feduc.2023.1182377

Prahani, B. K., & Dawana, I. R. (2025). Exploring the potential of technology in physics education: current research and innovation trends to support 21st century skills. *Perspektivy Nauki i Obrazovania*, *73*(1), 349–361. https://doi.org/10.32744/pse.2025.1.23

Putri, R. I. I. (2023). Web-based realistic mathematics learning environment for 21st-century skills in primary school students. *Journal on Mathematics Education*, *14*(2), 253–274. https://doi.org/10.22342/jme.v14i2.pp253-274

Raehan, R., Arizona, K., & Bahtiar, B. (2020). PENERAPAN PEMBELAJARAN BERBASIS MASALAH UNTUK MENINGKATKAN PENGUASAAN KONSEP DAN KETERAMPILAN BERPIKIR KREATIF. *Journal of Teaching and Learning Physics*. https://doi.org/10.15575/jotalp.v5i1.5755

Rinholm, H., Fredriksen, B., & Onsrud, S. V. (2023). Critical Reflection in Music Teacher Education: Contradictions and Dilemmas in Theory, Policy, and Practice. *Action, Criticism, and Theory for Music Education*, *22*(3), 41–72. https://doi.org/10.22176/act22.3.41

Ross, N. S., & Rajkoomar, M. (2024). Exploring student-centred assessment practices in higher education for developing adaptive graduates. *Perspectives in Education*, *42*(4), 153–170. https://doi.org/10.38140/pie.v42i4.8153

Saleem, S., Burns, S., & Perlman, M. (2024). Cultivating young minds: Exploring the relationship between child socio-emotional competence, early childhood education and care quality, creativity and self-directed learning. *Learning and*

Individual Differences, *111*. https://doi.org/10.1016/j.lindif.2024.102440

Saleem, S., Dhuey, E., White, L., & Perlman, M. (2024). Understanding 21st century skills needed in response to industry 4.0: Exploring scholarly insights using bibliometric analysis. *Telematics and Informatics Reports*, *13*. https://doi.org/10.1016/j.teler.2024.100124

Serrano-Ausejo, E., & Mårell-Olsson, E. (2024). Opportunities and challenges of using immersive technologies to support students' spatial ability and 21st-century skills in K-12 education. *Education and Information Technologies*, *29*(5), 5571–5597. https://doi.org/10.1007/s10639-023-11981-5

Shareefa, M., Moosa, V., Hoo, W. C., Wider, W., & Wolor, C. W. (2024). Intellectual landscape of scholarly work on 21st century skills: A bibliometric and science mapping analysis. *Edelweiss Applied Science and Technology*, *8*(6), 1774–1789. https://doi.org/10.55214/25768484.v8i6.2342

Shute, V. J., & Rahimi, S. (2021). Stealth assessment of creativity in a physics video game. *Computers in Human Behavior*, *116*. https://doi.org/10.1016/j.chb.2020.106647

Siddiq, F., Gochyyev, P., & Wilson, M. (2017). Learning in Digital Networks – ICT literacy: A novel assessment of students' 21st century skills. *Computers and Education*, *109*, 11–37. https://doi.org/10.1016/j.compedu.2017.01.014

Soh, T. M. T., Osman, K., & Arsad, N. M. (2012). M-21CSI: A validated 21st century skills instrument for secondary science students. *Asian Social Science*, *8*(16), 38–44. https://doi.org/10.5539/ass.v8n16p38

Sucilestari, R., & Arizona, K. (2018). Pengaruh Project Based Learning pada Matakuliah Elektronika Dasar terhadap Kecakapan Hidup Mahasiswa Prodi Tadris Fisika UIN Mataram. *KOSNTAN Jurnal Fisika Dan Pendidikan Fisika*, *3*(1), 26–35.

Sucilestari, R., Arizona, K., Mutiara, B., Nirmala, A., & Aspia, A. (2025). Exploring the Effectiveness of Project-Based Blended Learning in Science E-Books for Improving Digital Literacy. *Jurnal Penelitian Pendidikan IPA*, *11*(6), 509–518. https://doi.org/10.29303/jppipa.v11i6.11131

Sucilestari, R., Ramdani, A., Sukarso, A., Susilawati, S., & Rokhmat, J. (2023). Project-Based Learning Supports Students' Creative Thinking in Science Education. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 1038–1044. https://doi.org/10.29303/jppipa.v9i11.5054

Suresh, K., Balamurugan, R., & Lavanya, M. (2025). ITEP: An Idiosyncratic Programme for Generating Teachers with 21st Century Skills. *International Research Journal of Multidisciplinary Scope*, *6*(1), 790–802. https://doi.org/10.47857/irjms.2025.v06i01.02654

Susrawan, I. N. A., Suandi, N., Sudiana, I. N., & Dewantara, I. P. M. (2024). Indonesian Textbooks Oriented on Social Integration and 21st Century Skills in Higher Education: Validity, Practicality, and Effectiveness. *International Journal of Language Education*, *8*(1), 83–96. https://doi.org/10.26858/ijole.v8i1.60910

Taar, J., & Palojoki, P. (2022). Applying interthinking for learning 21st-century skills in home economics education. *Learning, Culture and Social Interaction*, *33*. https://doi.org/10.1016/j.lcsi.2022.100615

Tan, M., Kilani, H., Markov, I., Hein, S., & Grigorenko, E. L. (2023). Assessing Cognitive Skills in Early Childhood Education Using a Bilingual Early Language Learner

Assessment Tool. *Journal of Intelligence*, *11*(7). https://doi.org/10.3390/jintelligence11070143

Tanantong, T., Moolngearn, P., Kraiwanit, T., Limna, P., & Rafiyya, A. (2024). People Skills in the 21st Century: A Perspective on the Smart City in an Emerging Economy. *Human Behavior and Emerging Technologies*, *2024*. https://doi.org/10.1155/2024/5211958

Tang, T., Vezzani, V., & Eriksson, V. (2020). Developing critical thinking, collective creativity skills and problem solving through playful design jams. *Thinking Skills and Creativity*, *37*. https://doi.org/10.1016/j.tsc.2020.100696

Turiman, P., Osman, K., & Wook, T. S. M. T. (2020). Inventive thinking 21st century skills among preparatory course science students. *Asia Pacific Journal of Educators and Education*, *35*(2), 145–170. https://doi.org/10.21315/APJEE2020.35.2.9

Turiman, P., Wook, T. S. M. T., & Osman, K. (2019). 21 st century skills mastery amongst science foundation programme students . *International Journal on Advanced Science, Engineering and Information Technology*, *9*(1), 46–53. https://doi.org/10.18517/ijaseit.9.1.6431

Uğur, Ü. E., & Sungur, S. (2021). Middle school students' perceptions about twenty-first-century learning practices in science classes: A multidimensional approach. *Hacettepe Egitim Dergisi*, *36*(1), 186–200. https://doi.org/10.16986/HUJE.2020058877

Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment Strategies for Enhancing Students' Mathematical Problem-solving Skills: A Review of Literature. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(3), 1–10. https://doi.org/10.29333/ejmste/9728

Usman, E. A. (2022). ICT THEMATIC SCIENCE TEACHING MATERIAL WITH 5E LEARNING CYCLE MODEL TO DEVELOP STUDENTS' 21ST-CENTURY SKILLS. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 61–72. https://doi.org/10.15294/jpii.v11i1.33764

van Laar, E., van Deursen, A. J. A. M., & van Dijk, J. A. G. M. (2022). Developing policy aimed at 21st-century digital skills for the creative industries: an interview study with founders and managing directors. *Journal of Education and Work*, *35*(2), 195–209. https://doi.org/10.1080/13639080.2022.2036710

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, *72*, 577–588. https://doi.org/10.1016/j.chb.2017.03.010

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2018). 21st-century digital skills instrument aimed at working professionals: Conceptual development and empirical validation. *Telematics and Informatics*, *35*(8), 2184–2200. https://doi.org/10.1016/j.tele.2018.08.006

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2019). Determinants of 21st-century digital skills: A large-scale survey among working professionals. *Computers in Human Behavior*, *100*, 93–104. https://doi.org/10.1016/j.chb.2019.06.017

Voogt, J., & Knezek, G. (2013). Building a global community of policymakers, researchers and educators to move education systems into the digital age.

Journal of Computer Assisted Learning, *29*(5), 399–402. https://doi.org/10.1111/jcal.12028

Webb, M. E., Prasse, D., Phillips, M., Kadijevich, D. M., Angeli, C., Strijker, A., Carvalho, A. A., Andresen, B. B., Dobozy, E., & Laugesen, H. (2018). Challenges for IT-Enabled Formative Assessment of Complex 21st Century Skills. *Technology, Knowledge and Learning*, *23*(3), 441–456. https://doi.org/10.1007/s10758-018-9379-7

Yasa, A. D., Rahayu, S., Handayanto, S. K., & Ekawati, R. (2024). Evaluating the Impact of Smart Learning-Based Inquiry on Enhancing Digital Literacy and Critical Thinking Skills. *Ingenierie Des Systemes d'Information*, *29*(1), 219–233. https://doi.org/10.18280/isi.290122

Yeh, L. H., Seng, W. Y., Yin, K. Y., Mohd Nor, N., Juan, W. M., Ling, L. H., & Zhiqiang, S. (2024). Defining the Collaborative-Constructivism Based Learning and Teaching Approach in Malaysian Primary Schools in Supporting the Hybrid Learning of Visual Arts Education: A Fuzzy Delphi Method Study. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *41*(2), 62–81. https://doi.org/10.37934/araset.41.2.6281

Yılmaz, A. (2021). The effect of technology integration in education on prospective teachers' critical and creative thinking, multidimensional 21st century skills and academic achievements. *Participatory Educational Research*, *8*(2), 163–199. https://doi.org/10.17275/per.21.35.8.2

Zainil, M., Kenedi, A. K., Indrawati, T., & Handrianto, C. (2023). The influence of a STEM-based digital classroom learning model and high-order thinking skills on the 21st-century skills of elementary school students in Indonesia. *Journal of Education and E-Learning Research*, *10*(1), 29–35. https://doi.org/10.20448/jeelr.v10i1.4336

Zaki, A., Mulbar, U., Husniati, A., & Naufal, M. A. (2024). Integrating Local Wisdom with Project-Based Learning to Enhance 21st-Century Skills in the Society 5.0 Era. *Journal of Ecohumanism*, *3*(7), 1821–1831. https://doi.org/10.62754/joe.v3i7.4341