The Effect of Digital School Culture on Science Education and Scientific Literacy: A Scoping Review

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ABSTRACT

Thesis. In today's education scene, the incorporation of digital technology in schools has brought about a significant change beyond conventional limits, promoting a new cultural mindset known as the digital school culture. The development of "digital school culture" is one of the most prominent examples of the fusion of digital culture and school culture. The convergence of digital culture and scientific competence is becoming more evident, encompassing not only the comprehension of scientific knowledge but also the ability to adapt to swiftly evolving technologies, employ creative thinking, solve problems, make informed decisions, and apply scientific reasoning to real-world scenarios. This scoping review aims to understand the impact of digital school culture on students' scientific literacy and science educational outcomes.

Concept. Digital school culture is the integration of digital technologies and educational practices in schools, involving the attitudes, behaviour, and practices of educators, students, and administrators. The key elements of digital school culture include strategy and leadership, educator preparedness, school preparedness, technological responsiveness, and digital pedagogy.

Results and conclusion. This scoping review critically examines 10 studies published between 2009 and 2022, with a primary focus on components of digital school culture in science education. The review reveals that digital learning systems, digital environments to support student learning, digital technologies and tools, a digital curriculum, and pedagogical practices involving digital technology significantly improve scientific literacy.
Keywords: digital school culture, scientific literacy, digital literacy, science education, scoping review

Introduction

Digital transformation is essential for human existence because science and technology are essential in human everyday life. Mobile devices have a significant impact on student learning by providing flexible access to information from anywhere, reducing reliance on constant learning resources such as classrooms. This improved availability ensures that research, collaboration, and homework are done outside traditional classroom settings, fostering a dynamic and interactive learning experience. Digital technologies offer new opportunities for personalised, contextualised, and limitless learning (Crompton & Burke, 2015). Artificial intelligence and learning analytics, for example, have demonstrated promising applications in chemistry education, including student feedback analysis, understanding of chemical concepts, and investigating cognitive processes (Chiu, 2021). Several other studies have shown that robotics-based education opens up several opportunities for students to design, engineer, and programme a robot as they learn sciences (Calışkan, 2020; Cavas et al., 2012). For example, a study conducted by Erkan Calışkan (2020) found that students who engage in robotic-related activities exhibit higher levels of scientific literacy and problem-solving skills in science compared to those who do not participate in such activities.

Integration of digital culture and scientific competence is becoming increasingly apparent, involving not only understanding scientific facts but also adapting to rapidly changing technologies, creative thinking, problem solving, informed decision-making, and applying scientific reasoning to real-life situations.

In the digital age, schools should make digital technologies available to all students so that they can meet the digital and scientific literacy requirements they set. The scientific society is one where students can assimilate scientific facts, understand the interconnectedness of science, technology, and society, and apply their expertise to solving real-world problems (Sholikah & Pertiwi, 2021).

Every citizen of today's age is expected to possess a scientific literacy recognised as an essential 21st century skill for the future development of scientifically competent citizens (Gurses et al., 2015; Turiman et al., 2012).

The concept of scientific literacy in education was presented for the first time by, indicating that it is an ability to understand and use scientific knowledge in everyday life (Hurd, 1998). This suggests that individuals with scientific literacy can effectively apply their acquired scientific knowledge to solve real-world problems (The Organisation for Economic Co-operation and Development, 2003). In turn, PISA science literacy was defined in 2015 as the capacity to engage critically with science-related issues and concepts. A scientifically-literate person must explain everyday phenomena, evaluate them, design investigations, and interpret evidence. It involves applying scientific thinking to real-world situations, critically analysing information, making informed decisions, and effectively communicating scientific ideas (The Organisation for Economic Co-operation and Development, 2017). Being literate in science also means using scientific principles daily (Fives et al., 2014; Okada, 2013). In the digital age, scientific literacy is also one of the essential forms of literacy, which necessitates the ability to adapt to change, think creatively, make decisions, and solve problems (National Research Council et al., 2012). As digital technologies continue to reshape our world, they have not only influenced the way we access and disseminate scientific information but have also become an integral part of what is referred to as “digital culture.” This culture is characterised by the generation of new cultural data through contemporary electronic technologies (Bowker, 2008; Faraj & Sharabi, 2021). A researcher, Charlie Gere, argues that the prevalence of digital technology in our lives is the evidence of digital culture. He observes that “digitalisation can be considered a cultural marker because it encompasses both artifacts and labeling and communication systems that most clearly differentiate and distinguish our contemporary way of life from those of other cultures” (Gere, 2002, p. 12). Digital culture is a culture of participation, in which users not only ingest information but also contribute in various ways (Buckingham, 2008; Uzelac et al., 2008). This participatory aspect of digital culture is evident in the rise of user-generated content, such as social media posts, blogs, and online forums. Users actively create and share their content, shaping the digital landscape and influencing cultural discourse. Digital culture has also brought about new forms of collaboration and collective intelligence, where individuals can come together online to solve problems, create innovative solutions, and collectively build knowledge.

To summarise, the integration of digital culture and scientific competence is becoming increasingly evident, encompassing not just understanding of scientific facts but also adapting to rapidly changing technologies, creative thinking, problem-solving, informed decision-making, and applying scientific reasoning in real-life situations.

Based in the background mentioned earlier, this scoping review could provide an opportunity to explore components of the digital school culture and, accordingly, expand traditional learning paradigms to improve student engagement and scientific success in the future.

Digital School Culture

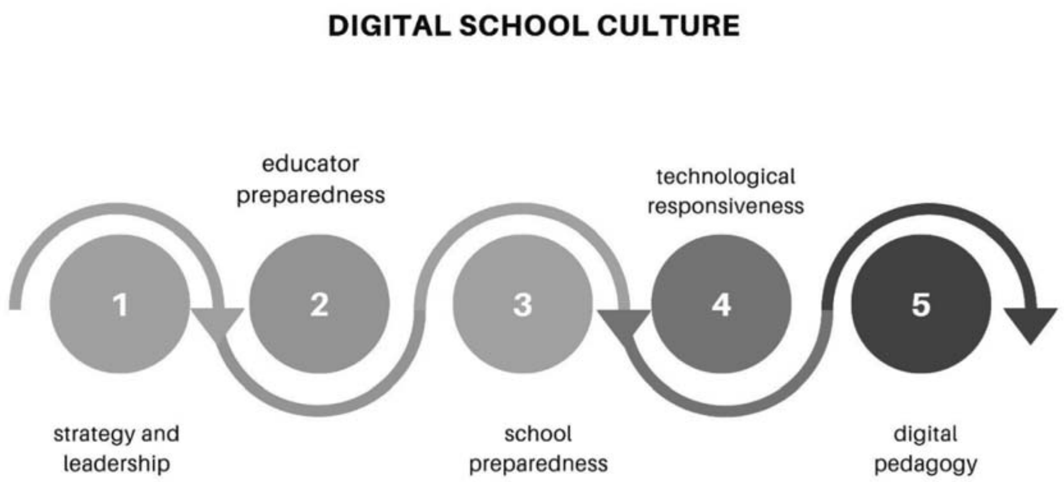
The definition of digital school culture remains non-exhaustive (?) due to its dynamic nature, as it has constantly adapted and transformed alongside technological developments. As Reynald Setyawan (2022) suggests, "digital school culture" (p. 142) is a complex combination of elements from both traditional school culture and digital culture that go beyond simply broadcasting school culture through digital means.

While no precise explanation of digital school culture can yet be found in scientific literature, some scientists have nonetheless developed digital school models that include elements closely linked to digital school cultural concepts. For example, the Innovative Digital School (IDI) model, proposed by Liisa Ilomäki and Minna Lakkala in 2018, focuses on pedagogical practices, school-level knowledge practices, digital resources, and teacher collaboration efforts. While the IDI model does not explicitly address the organisational and cultural dimensions, it indirectly underscores the importance of cultivating a culture that is characterised by creativity and adaptability, both among teachers and students. Educators who use advanced pedagogical strategies, use digital tools, actively share knowledge and good practice, and collaborate to improve digital learning experiences promote the development of a positive school culture that meets the principles of the IDI model.

Another digital school model is offered by Dirk Ifenthaler and Marc Egloffstein (2020), which introduced the Education Organizations Maturity Model (MMEO) in 2020 and was focused on assessing the maturity and development progress of educational institutions. The MMEO model takes a holistic approach, clearly incorporating the dimension associated with "culture." Given this conceptual framework, digital school culture plays a key role in assessing the institution's progress in digital transformation. For example, the MMEO model probably evaluates the collective attitudes, beliefs, and values of school culture in relation to digital technologies. The digital school culture, conceptualised as part of the MMEO model, contains a number of core elements, including a shared understanding of the role of technology in education, readiness to learn digital tools, and creating environments that foster experimentation and encourage innovative thinking.

An analysis of these digital school models shows that key elements of digital school culture (Figure 1) include strategy and leadership, educator preparedness, school preparedness, technological responsiveness, and digital pedagogy.

Figure 1
Key elements of digital school culture



Source. Own research.

It could be said that digital school culture is a versatile confluence of the attitudes and actions of educational institutions moving towards digital technology integration.

Digital school culture shows how educators and students engage in the use of technology, adapt to change, collaborate, and generate innovative ideas in the education process.

The school administration, which manages technology, also plays a crucial role in shaping digital school culture. Researchers have concluded that working on a common vision for technology deployment (Karaca et al., 2013) is key to fostering a digital school culture. A high level of digital school culture also improves the school's communication flow, making digital platforms safe and reliable environments that foster employee collaboration and shared learning (Fazekas, 2021).

In conclusion, it can be stated that the digital school cultural models in question have provided insight into the various components that shape digital school culture, but in order to clarify the cultural elements of the digital school that directly affect scientific education and the development of students' scientific literacy, more comprehensive research is needed in this area. The forthcoming scoping review will seek to narrow this gap by exploring and identifying the specific components of digital school culture that influence scientific education and contribute to increasing students' scientific literacy.

The following study issues will dictate the direction the scoping review to achieve this: What components of digital school culture affect scientific education and contribute to increasing students' scientific literacy?

Method

The study used Hilary Arksey and Lisa O'Malley's (2005) methodology to identify components of the digital school in scientific education. This methodology involves five phases: identifying study questions, identifying relevant studies, selecting studies, mapping data, and collecting, compiling, and reporting findings.

Step 1 (Development of the Research Questions)

What elements of digital school culture influence scientific literacy or science education?

Step 2 (Identify Relevant Studies)

A search of studies was conducted in the Education Resources Information Center (ERIC), Scopus, Web of Science, and Google Scholar. The last search was conducted on November 1, 2022, using the search terms "digital school culture," "scientific literacy," and "digital school culture in science education" for the years 2009 to 2022. In Table 1, there are detailed inclusion and exclusion criteria.

Table 1

Inclusion and exclusion criteria

Criteria	Included	Excluded
Time frame	2009-2022	Before 2008 and after 2022
Focus	Studies with a primary focus on components of digital school culture in science education	Articles focusing on other topics
Language	English	Other languages
Target population	Studies focusing on school students	Studs focusing on higher education students

Source. Own research.

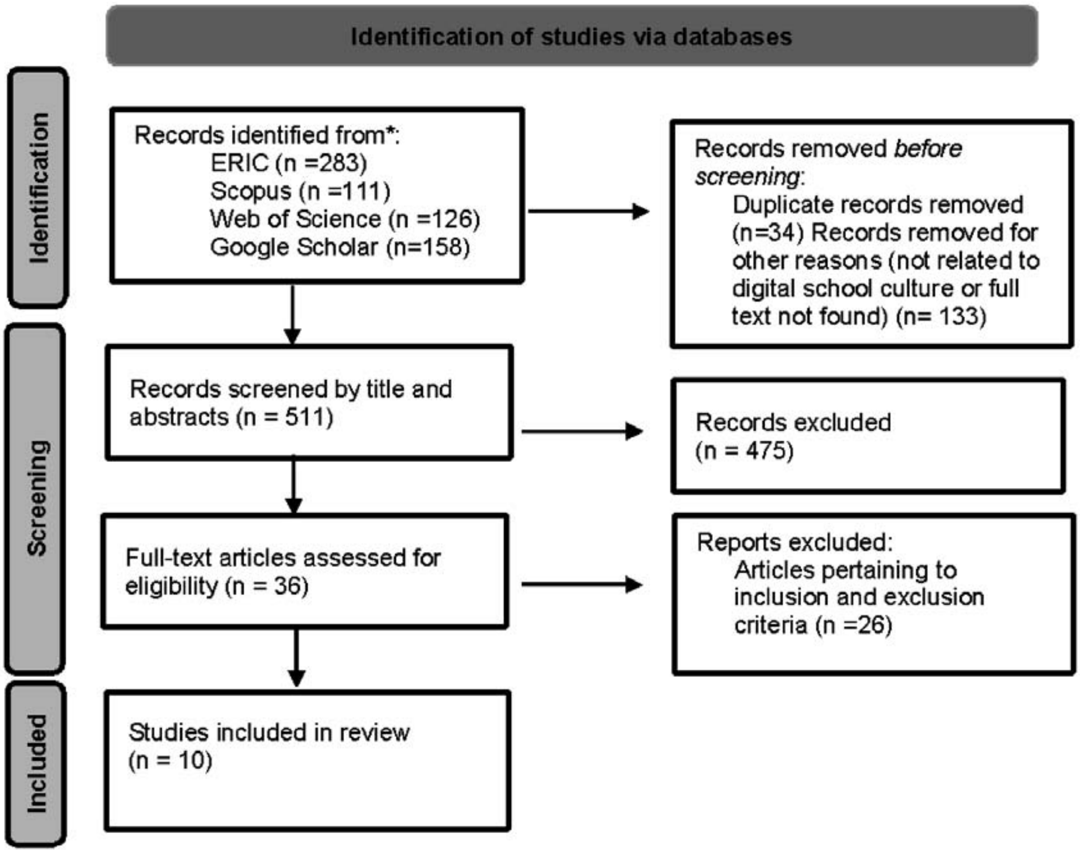
Step 3 (Study Selection)

The Checklist of Preferred Reporting Items for Systematic Reviews (PRISMA-ScR) was used to construct the reporting of the scoping review. At the outset, the search methodology resulted in the identification of 678 articles from diverse sources. After removing duplicate articles (n = 34) and articles (n = 133) that were not relevant to the educational context of digital school culture or showed full text not found, a set of 511 articles remained for initial screening based on their titles and abstracts. Following a meticulous assessment of these titles and abstracts, 475 articles were found to be ineligible for inclusion, as they did not meet the predetermined criteria for inclusion and exclusion.

Upon completion of this initial screening phase, which involved evaluating titles and abstracts, 36 studies were selected for further scrutiny through a comprehensive analysis of their entire texts. However, during this phase, an additional 26 studies were excluded because they did not align with the defined inclusion and exclusion criteria.

In the final analysis, a total of ten articles were considered eligible and met the established inclusion criteria. Figure 2 presents a flowchart that visually represents the selection process for including studies in the analysis.

Figure 2
A flowchart depicting the search process for the scoping review in accordance with the PRISMA guidelines



Source. Own research.

Step 4 (Charting Data)

In this part, the data extracted from each of the studies included key characteristics (author, year, country, research design), contextual information (components of digital school culture that affect science education), and a brief description of key findings. Table 2 presents the characteristics of the included studies.

Results and Discussion

This scoping review of ten articles from six countries (five studies from Indonesia and one each from the United Arab Emirates, Jordan, Romania, the United Kingdom, and Turkey) identifies the aspects of digital school culture that influence scientific literacy or science education. According to the specified search criteria, the database was examined for publications made over a 13-year period, and ten studies were ultimately chosen. The selected studies utilised various research designs, including qualitative, quantitative (both experimental and quasi-experimental), mixed-design, and mixed-methods designs.

The scoping review identified a number of key elements for fostering scientific literacy in digital school culture, including digital learning systems, digital environments to support student learning, digital technologies and tools, a digital curriculum, and pedagogical practices involving digital technology (Table 2).

Table 2

Characteristics of included studies

Author (Year) & Country	**Research design**	**Components of digital school culture that affect science education**	**Brief description of Key findings**
Saif Saeed Alneyadi, (2019) United Arab Emirates	Qualitative (focus group)	Digital technologies and tool (Virtual labs)	Virtual laboratories positively impact students' scientific abilities, skills, attitudes, achievement, and creativity, with 56% of respondents stating they enhance their abilities through practical work activities.
Mohammed Salameh Al-Rsa'i (2013) Jordan	Mixed-design	Digital technologies and tool Website technology Digital curriculum	The connection between website technology and student motivation is crucial to the development of scientific literacy and continuous learning. The digital curriculum makes it easier to achieve educational goals that traditional curricula, for a variety of reasons, cannot. In addition, digital curriculum can facilitate the development of positive values and attitudes toward scientific issues and phenomena among students.

Author (Year) & Country	Research design	Components of digital school culture that affect science education	Brief description of Key findings
Crăciun & Bunoiu (2019) Romania	Mixed-design	Digital technologies and tool (Digital science comics)	The study found that students favour using comics in science education, regardless of gender. However, as age and grade increased, interest in incorporating comics decreased, with rural students being more eager.
Timothy G. Harrison et al. (2009) UK	Qualitative	Digital technologies and tool (Dynamic Laboratory Manual (DML)	The findings of the study indicate that the DLM was well-received by both students and instructors and that it assisted in enhancing students' understanding of scientific concepts and practical skills.
Nurullah Korkman & Mustafa Metin (2021) Turkey	Quantitative Quasi-experimental design	Pedagogical practices with digital technology (Inquiry based online collaborative learning)	In terms of student accomplishment, inquiry-based online collaborative learning is more effective than inquiry-based collaborative learning.
Nurwahidah et al. (2017) Indonesia	Quantitative Quasi-experimental design	Pedagogical practices with digital technology (project based learning model with an Android)	Android-based online education improves scientific literacy, critical thinking, and overall knowledge through active, creative learning. The PBL model significantly improves science literacy and critical thinking, enhancing students' overall science knowledge.
Sri Lestari at el. (2020)	mixed-methods with explanatory sequential design	Pedagogical practices with digital technology (PBL assisted by digital storytelling Media)	The study found that PBL with digital storytelling media improved students' science literacy and critical thinking skills, compared to conventional lessons.

Author (Year) & Country	Research design	Components of digital school culture that affect science education	Brief description of Key findings
Indira Bernica Krida Putri & Fitria Wulandari (2022) Indonesia	Quantitative Pre-Experimental Design	Digital technologies and tool (Flip pdf-based digital book media)	This study concludes that the professional flip-book-based digital book media has increased scientific literacy skills in science learning materials, specifically the application of sound properties and their relationship to hearing.
Risniawati et al. (2020) Indonesia	Mixed-design	Digital learning system (E-learning media)	The N-gain result of 0.57 (medium category) demonstrates that this E-learning can enhance students' science literacy. Therefore, the evolution of E-learning can enhance students' scientific literacy.
Suryanti et al., (2021) Indonesia	Mixed-design	Digital technologies and tool (Gadgetbased interactive multimedia)	Gadget-Based Interactive Multimedia (GBIM) is a legitimate alternative for enhancing elementary students' scientific literacy, scoring 3.55.

Source. Own research.

Digital technologies and tools, such as virtual labs, dynamic laboratory manual website technology, digital science comics, flip pdf-based digital book media, and gadget-based interactive multimedia, were cited most frequently as promoting scientific literacy or science education. Pedagogical practices involving digital technology, such as inquiry-based online collaborative learning, project-based learning models using Android, and problem-based learning (PBL) supplemented by digital storytelling media, constitute an additional crucial aspect of digital school culture.

The studies included in this scoping review indicate that digital learning programmes can support students' information literacy and prepare them for a technology-driven world if they are developed and designed appropriately. According to Nurwahidah et al. (2017), online learning using Android can improve students' natural science knowledge and scientific abilities.

Miranti Risniawati and colleagues discovered that the use of e-learning media enhanced students' science literacy skills in comparison to conventional instruction. Thirty-two pupils from a senior high school in West Sumatra, Indonesia, were divided into two groups for the research: an experimental group that received instruction using the developed e-learning media and a control group that received traditional instruction. The experimental group performed better than the control group on the post-test, especially in terms of identifying scientific information and employing scientific concepts (Risniawati et al., 2020).

Interactive gadget-based multimedia is a viable alternative learning aid that can be used to enhance the scientific competence of primary school students. In a quasi-experimental study, Suryanti Suryanti and colleagues exposed a treatment group to interactive multimedia that was device-based during the intervention. A control group, in contrast, was instructed using conventional learning methods (Suryanti et al., 2021). The findings revealed that the treatment group demonstrated a significant improvement in their scientific literacy abilities compared to the control group.

Korkman and Metin (2021) found that online collaborative learning was more effective than inquiry-based collaborative learning at cultivating scientific process skills in students.

In addition, practical activities utilising virtual laboratories had a positive effect on students' scientific knowledge and enhanced the outcomes of their scientific processes. Alneyadi's (2019) article examines the use of virtual labs to promote scientific literacy among Emirati science teachers. According to the study's findings, the majority of Emirati science teachers viewed virtual laboratories as an effective instrument for promoting scientific literacy. Teachers identified a number of advantages to virtual labs, including increased pupil engagement and motivation, enhanced comprehension of scientific concepts, and enhanced critical thinking skills (Alneyadi, 2019).

The research by Dana Crăciun and Mădălin Bunoiu (2019) examines the potential of digital comics as a visual means of improving scientific education in Romania. The authors contend that traditional approaches to science education may fail to engage students and propose that digital comics can effectively promote interest in and comprehension of scientific concepts.

Moreover, a study by Lestari (2020) suggests that digital storytelling media can be used to create meaningful and engaging learning experiences for students, which can aid in the growth of their science literacy and critical thinking skills.

Although the scope review mostly focuses on the positive potential generated by digital transformation, it is important to acknowledge and emphasise the associated risks as well. The rapid advancements of technology offer immense opportunities for positive progress, particularly in the field of education. However, the process of digitisation is often seen as a catalyst for unprecedented threats to humanity, which can greatly affect the development of students and their overall well-being in the future. Researchers highlight several risks associated with the increasing reliance on technology in our daily lives. Firstly, there is a concern that people are becoming increasingly dependent on technology for their security and prosperity, rather than relying on their own abilities. This can lead to a shift in the social ecology, where technology becomes the determining factor for well-being. Secondly, there is a worry that excessive use of technology may lead to a decline in social skills, which are crucial for human interaction and communication. This can potentially hinder our capacity to effectively interact with others. Lastly, the significance of social values may be diminished as technology takes a more prominent role in society (Rubene, 2018). This can have an impact on the norms and attitudes of individuals, which are traditionally shaped by social values. It is important to note that these risks are particularly relevant in the context of school culture. Therefore, it is essential for educators to strike a balance between incorporating technology in education and promoting face-to-face interactions. By fostering a healthy school culture that values both technological advancements and interpersonal relationships, students can develop into well-rounded individuals equipped to navigate the digital age.

One additional point we want to emphasize in this analysis is that the advancement of digital school culture, and its influence on scientific education and scientific literacy, relies significantly on the digital proficiency of both educators and students. As a part of the education process, it is crucial to assess the level of digital proficiency among both teachers and learners. Evaluating the extent of digital proficiency can enhance the ability to adjust and adapt the learning environment, allowing students to engage in learning across various contexts and to gain diverse learning experiences. Nevertheless, it is crucial to note that the effective integration of digital culture in science education necessitates a strong and reliable infrastructure, the development of teachers' digital competencies, and administrative support.

Conclusions

In the digital age, scientific literacy is one of students' crucial skills, and the digital culture of schools plays an important role in supporting those skills. By integrating digital resources and tools into school culture, students can gain new learning opportunities and engage in science education. However, as part of the scoping review carried out, it can be concluded that there are currently relatively few studies that have addressed the impact of digital school culture on science education. This scoping review identified digital school culture components (digital learning systems, digital environments to support learning, digital technologies and tools, a digital curriculum, and pedagogical practices innovating digital technology) and explained their impact on scientific literacy or science education.

Understanding digital school culture can help educators and policymakers identify factors contributing to the transformation of the school environment and contribute to the development of scientific literacy. By integrating technology and digital tools, schools can strengthen their education system, adapt to the rapidly evolving digital landscape, and cultivate digitally literate thinking in students and staff. Through a comprehensive digital school culture, schools can prepare students more effectively for the challenges and opportunities that await them in the digital age.

Understanding the impact of digital school culture on scientific literacy can help educators identify effective strategies for integrating technology into science learning. With knowledge of the impact of digital school culture on scientific literacy, educators can build a more engaging and interactive learning experience that fosters student curiosity and critical thinking skills. This research may ultimately improve scientific education in the digital age.

Further research in this area can provide valuable insights into the potential benefits of digital school culture for science education and support the development of students' digital scientific literacy.

Limitations

The scoping evaluation conducted had certain limitations. First, the selection procedure and inclusion and exclusion criteria affected the findings of the review. In addition, relevant findings may have been overlooked due to excluding studies conducted in languages other than English. It is possible that certain pertinent research might have been overlooked as a result of the database selection process or the omission of grey literature. The term "digital school culture" lacks a standardised and universally accepted definition in the existing literature. As a result, the interpretation of this concept can vary across different studies and contexts. The absence of a clear, agreed-upon definition poses a challenge when attempting to synthesise and analyse the literature comprehensively. In addition, a quality assessment of the research included should have been conducted, which may have affected the interpretation of the results. The field of educational technology and digital culture is continually evolving. The literature reviewed in this study reflects the state of knowledge up to a certain point in time. New developments and emerging technologies may have emerged since the publication of these studies, which could impact the relevance of the findings. Despite these limitations, this study provides a valuable starting point for understanding the multifaceted concept of digital school culture and its implications for science education. Researchers and educators should consider these limitations when interpreting the findings and explore these areas further to address gaps in our understanding of digital school culture in diverse educational contexts.

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REFERENCES

Al-Rsa'i, M. S. (2013). Promoting scientific literacy by using ICT in science teaching. *International Education Studies*, *6*(9), 175-181. http://dx.doi.org/10.5539/ies.v6n9p175

Arksey, H. & O'Malley L. (2005). Scoping studies: Towards a Methodological Framework. *International Journal of Social Research Methodology, 8*(1), 19–32. https://doi.org/10.1080/1364557032000119616

Alneyadi, S. S. (2019). Virtual Lab Implementation in Science Literacy: Emirati Science Teachers' Perspectives. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(12), Article em1786. https://doi.org/10.29333/ejmste/109285

Bowker, G. (2008). *Structures of participation in digital culture*. In J. Kargnis (Ed.), *Structures of participation in digital culture* (pp. 24- 36). Social Science Research Council.

Buckingham, D. (2008). Defining Digital Literacy. What do Young People Need to Know About Digital Media? In C. Lankshear & M. Knobel (Eds.), *Digital Literacies: Concepts, Policies, and Practices* (pp. 73-91). Peter Lang. https://doi.org/10.18261/ISSN1891-943X-2006-04-03

Calışkan, E. (2020). The effects of robotics programming on secondary school students' problem-solving skills. *World Journal on Educational Technology: Current Issues*, *12*(4), 217-230.

Cavas, B., Kesercioglu, T., Holbrook, J., Rannikmae, M., Ozdogru, E., & Gokler, F. (2012). The effects of robotics club on the students' performance on science process & scientific creativity skills and perceptions on robots, human and society. In M. Moro & D. Alimisisi (Eds.), *Proceedings of 3rd International Workshop Teaching Robotics, Teaching with Robotics Integrating Robotics in School Curriculum* (pp. 40-50). AIP Publishing. https://www.terecop.eu/TRTWR2012/trtwr2012_submission_06.pdf

Chiu, W. K. (2021). Pedagogy of emerging technologies in chemical education during the era of digitalization and artificial intelligence: A systematic review. *Education sciences*, *11*(11), Article 709.

Crompton, H. & Burke, D. (2015). School Culture for the Mobile Digital Age. *Teaching & Learning Faculty Publications*, *6*(2), 208-223. https://digitalcommons.odu.edu/teachinglearning_fac_pubs/27

Crăciun, D. & Bunoiu, M. (2019). Digital Comics, a Visual Method for Reinvigorating Romanian Science Education. *Revista Romaneasca pentru Educatie Multidimensionala*, *11*(4), 321-341. https://doi.org/10.18662/rrem/172

Faraj, A. O. K. & Sharabi, W. A. N. (2021). Developing the digital culture among the students of educational faculties in Prince Sattam Bin Abdulaziz University. *International Journal of Higher Education*, *10*(3), 158-168.

Fazekas, N. (2021). Learning organizations and organizational digital competencies in the field of public education. In M. Baksa, N. Fazekas, & V. Harmat (Eds.), *New Horizons in Business and Management Studies. Conference Proceedings* (pp. 25-36). Corvinus University of Budapest. https://doi.org/10.14267/978-963-503-867-1_03

Fives, H., Huebner, W., Birnbaum, A. S., & Nicolich, M. (2014). Developing a measure of scientific literacy for middle school students. *Science Education*, *98*(4), 549-580.

Gere, Ch. (2002). *Digital Culture*. Reaktion Books.

Gurses, A., Gunes, K., Barin, T. B., Eroglu, Z., & Cozel, F. S. (2015). Relation between pre-service chemistry teachers' science literacy levels and their some scientific process skills. *Procedia-Social and Behavioral Sciences*, *197*, 2395-2402.

Harrison, T. G., Shallcross, D. E., Heslop, W. J., Eastman, J. R., & Baldwin, A. J. (2009). Transferring Best Practice from Undergraduate Practical Teaching to Secondary Schools: The Dynamic Laboratory Manual. *Acta Didactica Napocensia*, *2*(1), 1-8.

Hurd, P. D. (1998). Scientific literacy: new minds for changing world. *Science Education*, *8*, 407-416.

Ifenthaler, D. & Egloffstein, M. (2020). Development and implementation of a maturity model of digital transformation. *TechTrends*, *64*(2), 302–309. https://doi.org/10.1007/s11528-019-00457-4

Ilomäki, L. & Lakkala, M. (2018). Digital technology and practices for school improvement: Innovative digital school model. *Research and practice in technology enhanced learning*, *13*(1), Article 25.

Karaca, F., Can, G., & Yildirim, S. (2013). A path model for technology integration into elementary school settings in Turkey. *Computers & Education*, *68*(1), 353-365. Elsevier Ltd. https://doi.org/10.1016/j.compedu.2013.05.017

Korkman, N. & Metin, M. (2021). The Effect of Inquiry-Based Collaborative Learning and Inquiry-Based Online Collaborative Learning on Success and Permanent Learning of Students. *Journal of Science Learning*, *10*(2), 45-57. https://files.eric.ed.gov/fulltext/EJ1292922.pdf

Lestari, S., Sugianto, S., & Setiawan, D. (2020). The Effectiveness of PBL Assisted by Digital Storytelling Media towards Science Literacy and Critical Thinking Skills. *Journal of Primary Education*, *9*(4), 329-341. https://journal.unnes.ac.id/sju/jpe/article/view/40495

National Research Council, Division of Behavioral and Social Sciences, Board on Science Education, & Committee on a Conceptual Framework for New K-12 Science Education Standards. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

Nurwahidah, N., Wilujeng, I., Jumadi, J., & Senam, S. (2017). The Effects of Project Based Learning Model with Android on Scientific Literacy and Digital Equipedness/ICT Literacy. *International Journal of Sciences: Basic and Applied Research*, *36*(7), 190-205.

The Organisation for Economic Co-operation and Development. (2003). *Literacy skills for the world of tomorrow—Further results from PISA 2003*. OECD Publishing.

The Organisation for Economic Co-operation and Development. (2017). *PISA 2015 assessment and analytical framework: Science, reading, mathematic, financial literacy and collaborative problem solving revised edition*. OECD Publishing.

Okada, A. (2013). Scientific literacy in the digital age: Tools, environments and resources for coinquiry. *European Scientific Journal*, *4*, 263–274.

Putri, I. B. K. & Wulandari, F. (2022). Scientific literacy skill through digital media professional PDF flip-based book in elementary school. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2266–2271. https://doi.org/10.29303/jppipa.v8i5.2181

Risniawati, M., Serevina, V., & Delina, M. (2020). The development of E-learning media to improve students' science literacy skill in Senior High School. *Journal of Physics: Conference Series*, *1481*, Article 012075. https://doi.org/10.1088/1742-6596/1481/1/012075

Rubene, Z. (2018). Digital childhood: Some reflections from the point of view of philosophy of education. In L. Daniela (Ed.), *Innovations, Technologies and Researches in Education*, (pp. 64-77). University of Latvia.

Setyawan, R. (2022). Embracing the future: Digital school culture in Tabanan high schools. *Kata Kita*, *10*(1), 141-148. https://doi.org/10.9744/katakita.10.1.141-148

Sholikah, L. & Pertiwi, F. N. (2021). Analysis of Scientific Literacy Skills of Junior High School Students: A Case Study in Indonesia. *Journal of Science Education and Teaching*, *4*(2), 84-90. https://doi.org/10.21154/insecta.v2i1.2922

Suryanti, S., Widodo, W. & Yermiandhoko, Y. (2021). Gadget-Based Interactive Multimedia on Socio-Scientific Issues to Improve Elementary Students' Scientific Literacy. *International Journal of Instructional Media*, *15*(1), 56-69. https://doi.org/10.3991/ijim.v15i01.13675

Turiman, P., Jizah, O., Adzliana, M. D., & Kamisah. (2012). Fostering the 21st century skill through scientific literacy and science process skill. *Social and Behavioral Sciences*, *59*, 110-116.

Uzelac, A. & Cvjeticanin, B. (Eds.). (2016). *Digital culture: The changing dynamics*. Institute for International Relations.