

# Innovative learning design and teachers' competencies: prerequisites for meaningful use of digital material in schools

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**Abstract.** *This study provides an in-depth analysis of the benefits and risks associated with the adoption of digital materials in schools. By conducting a systematic literature review and utilizing an AI tool, the study also explores the correlation between teachers' digital and pedagogical competencies and the use of these materials. The findings underscore the necessity of continuous teacher training to effectively implement innovative teaching and learning approaches that incorporate well-designed instruction and meaningful integration of digital resources. The utilization of digital materials fosters active student engagement and positively influences learning outcomes. However, it is important to consider potential challenges such as technical issues, discipline management, and waning student enthusiasm over time.*

**Keywords.** Digital textbook, e-textbook, open educational material, teachers' competences, SLR, learning

## 1 Introduction

The rapid advancement of technology has required education to adapt and support student learning and progress, both within and outside the traditional school premises. To facilitate this, teachers have increasingly embraced the use of textbooks supplemented with digital materials, such as animations, interactive simulations, videos, audio recordings, educational apps, presentations, and other forms of digital content intended to support learning and teaching, aiming for efficient delivery of relevant content and the achievement of intended learning outcomes.

A digital textbook is a specific type of digital resource that replicates the content and structure of a traditional textbook (sequence of topics, similar to their print counterparts), while digital materials encompass a broader range of digital resources used for educational purposes.

Digital materials are often used to enhance instruction, provide additional learning resources, and facilitate interactive and engaging learning experiences. Unlike digital textbooks, digital materials are not limited to replicating the structure and content of traditional textbooks but can encompass a wide range of multimedia and interactive resources.

Digital textbooks offer advantages over their traditional counterparts by incorporating multimedia, animations, and virtual reality, enabling faster and more engaging content delivery (Kim & Yu, 2019; Wang & Xing, 2019).

While the existing literature highlights the benefits associated with the use of digital materials in education, it is important to acknowledge the obstacles that impede their widespread adoption and usage in schools (Vorotnykova, 2019). These obstacles encompass various factors such as the availability of IT infrastructure, the provision of adequate support services, and even health concerns like the impact of e-books on users' vision (Masango et al., 2020).

In this paper, we aim to investigate the relationship between teachers' digital competences and the utilization of digital textbooks and other digital materials in schools. To achieve this, we employ a classical systematic literature review (SLR) enriched by the application of an artificial intelligence (AI) tool. The subsequent sections of this paper provide detailed descriptions of the research methodology, research questions, analysis of the research findings, discussion of the results, and a conclusion. Additionally, we propose avenues for future research in this field.

## 2 Research methodology and research questions

This paper addressed three research questions.

*RQ1: What are the characteristics associated with the use of digital materials in schools?*

The characteristics under investigation include the frequency of usage (occasional-continuous), the location of usage (school-based or independent study at home), the medium through which they are accessed (computer, tablet, mobile phone), their alignment with innovative learning and teaching methods/strategies (e.g., flipped classroom, project-based learning, problem-solving, inquiry-based learning), the publisher of the digital materials (commercial or public entity), and the payment method for accessing the digital materials (independent purchase or combined with a physical textbook).

*RQ2: How does the use of digital materials for teaching and learning (TL) in schools relate to teachers' digital competences?*

*RQ3: Is there a relationship between the use of digital materials for TL and the maturity level of the school or educational system?*

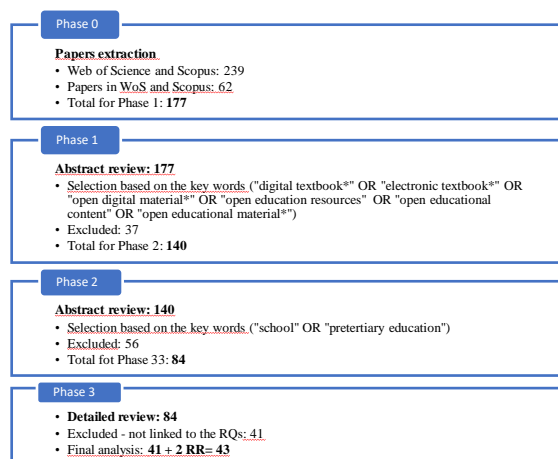
To address the research questions mentioned earlier, a systematic literature review (SLR) methodology was employed. Two databases, Web of Science (WoS) and Scopus, were selected to conduct comprehensive literature searches. Additionally, an AI-based tool called Research Rabbit (RR) was utilized to enhance the literature research process. RR is a text-based research recommender publicly available since 2021. Its purpose is to support researchers in their literature exploration without the need to switch between search and database modes. Using RR, researchers can input initial literature items, and the tool guides them through networks of related sources. The interface of RR facilitates the mapping of literature in a specific area by presenting lists and graphs of interconnected papers. These lists and graphs are dynamically adjusted in real time based on the researcher's selection (Krzton, 2023). The RR tool was used in this study to explore broader areas where digital textbooks have been discussed, while also evaluating the effectiveness of AI tools in literature research.

The databases were accessed on October 6, 2022, and April 6, 2023, with a search conducted across all fields using three main topics: digital maturity ("digital readiness" OR "digital maturity"), school (school\* OR "pre-tertiary education"), and digital textbooks ("digital textbook\*" OR "electronic textbook\*" OR "open digital material\*" OR "open educational resources" OR "open educational content" OR "open educational material\*").

Unfortunately, no articles were found that matched the specified query in any of the databases. Even the query combining the topics of digital maturity and digital textbooks did not yield any results. However, an article by (Milić & Divjak, 2022) covered the query with the keywords "digital maturity" and school\*.

Given these findings, the search was continued without the inclusion of the digital maturity keyword. The final query focused on the topic of school and digital textbooks, using the following query: (school\* OR "pre-tertiary education") AND ("digital textbook\*" OR "electronic textbook\*" OR "open digital material\*" OR "open educational resources" OR "open educational content" OR "open educational material\*")

OR "open educational resources" OR "open educational content" OR "open educational material\*"). While RR did not identify any papers matching this query, numerous relevant articles were found in the WoS and Scopus databases. To refine the search, the results were narrowed down to articles written in English within the last ten years, following the approach outlined by (Divjak et al., 2022). The various stages of this search process are depicted in Figure 1.



**Figure 1.** Methodology of the SLR research

A comprehensive search of the WoS and Scopus databases, considering the specified keywords and limitations, resulted in the identification of 239 scientific articles. Among these, 62 articles were found in both databases, leaving a total of 177 unique scientific articles for Phase 1 of the analysis.

During Phase 1, the abstracts of the articles were examined to identify those directly related to the topic of digital textbooks. Out of the initial set, 37 articles were unrelated to the specified keywords, narrowing down the selection to 140 articles for Phase 2. In Phase 2, the abstracts of the remaining articles were further scrutinized to determine their relevance to the keywords "school" or "pre-tertiary education." The majority of the 56 articles that met this criterion focused on the use of digital materials in higher education, which led to their exclusion from further analysis. As a result, 84 articles remained for thorough examination in Phase 3.

In Phase 3, a detailed review and analysis were conducted on the 84 selected articles. Upon closer inspection, 41 articles were excluded from further analysis as they did not provide answers to any of the research questions, placed excessive emphasis on the technology itself, or lacked appropriate research design. Consequently, a total of 43 papers were identified as suitable for in-depth discussion and analysis. Table 1 provides a classification of these papers based on the country where the studies were conducted. Notably, the highest number of papers originated from the USA (8), followed by China and

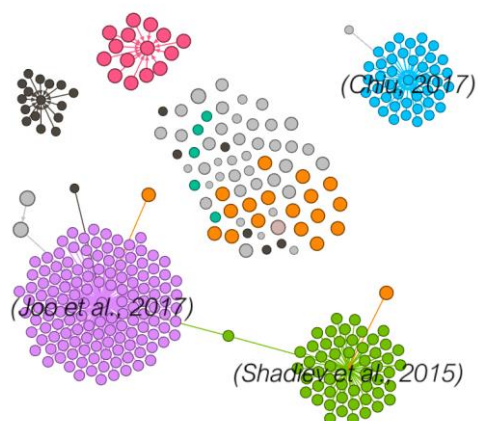
Indonesia (4). Generally, a significant portion of the studies (15) were conducted in Asian countries.

**Table 1.** List papers for discussion (additional 2 papers from RR are marked with the asterisk)

USA	(Bouck et al.,2016), (Bruhn & Hasselbring, 2013), (Chen, 2017), (Fouh et al., 2014) *, (Gerard et al., 2022), (Roskos & Neuman, 2014), (Richardson & Roebuck Sakho, 2022), (Lee et al., n.d.)
China	(Shen et al., 2015), (Sun & Jiang, 2015), (Wang & Xing, 2019), (Wijaya et al., 2022)
Indonesia	(Farisi, 2014), (Hermita et al., 2023), (Pratama & Firmansyah, 2021), (Sinaga et al., 2022)
Hong Kong	(Chiu, 2017), (Lo et al., 2021), (Lo et al., 2022) *, (Wong et al., 2016)
Korea	(Joo et al., 2017), (Lim et al., 2022), (So et al., 2015)
Germany	(Reinhold et al., 2020), (Reinhold et al., 2021), (Rezat 2021)
Uganda	(Busulwa & Bbuye, 2018), (Kabugo, n.d.)
Morocco	(Moundy et al., 2021), (Moundy et al., 2022)
Sweden	(Grönlund et al., 2018), (Håkansson Lindqvist, 2019)
South Africa	(Masango et al., 2020)
Australia	(Crook & Sharma, n.d.)
Kazakhstan	(Prutko et al., 2020)
Serbia	(Radović et al., 2020)
Portugal	(Lucas, 2020)
Ukraine	(Vorotnykova, 2019)
Taiwan	(Shadiev et al., 2015)
Slovakia	(Zacok et al., 2019)
Tunisia	(Tlili et al., 2022)
Spain	(Grimalt-Álvaro et al., 2019)
Lithuania	(Dudaitė & Prakapas, 2019)

Furthermore, to gain additional insights into the selected papers, a network analysis was conducted using the Gephi tool (Figure 2). All 43 papers, along with their citations, were imported into Gephi for visualization. The network analysis revealed the most influential papers based on the number of citations and links to other papers. Notably, three papers emerged as particularly influential: (Joo et al., 2017), (Shadiev et al., 2015), and (Chiu, 2017). These papers were published in reputable scientific journals and employed survey or experimental approaches in their research. (Joo et al., 2017) focused on Korean middle school students enrolled in an English class that utilized a digital textbook. The study investigated the structural relationships among students' expectations, perceived enjoyment, perceived usefulness, and satisfaction

when using digital textbooks. Their findings shed light on the factors influencing students' experiences with digital textbooks. In the study by (Shadiev et al., 2015), an experimental approach was employed to examine the effects of mobile systems on learning achievement and cognitive load among students in Taiwan. The experimental group, which used digital textbooks and mobile systems, exhibited better performance on tests compared to the control group. Furthermore, the use of technology resulted in reduced cognitive load for the students. A survey conducted by (Chiu, 2017) involved 306 secondary school teachers in Hong Kong. The study explored the acceptance of digital textbooks and identified anxiety as a significant barrier and positive attitude as a key catalyst for their acceptance among teachers.



**Figure 2.** Analyzed papers along with their citations, displayed in the Gephi tool

Out of the 41 papers uploaded to the RR tool, a substantial number of similar papers (15,448) were identified. Further filtering excluded 48 studies published before 2012 and 7 studies published after October 6, 2022. Additionally, 142 studies authored by researchers whose articles were uploaded to RR, as well as 253 suggested articles by other authors, were found. Consequently, a total of 450 articles underwent a two-step selection process. Through searching the titles, 43 articles were initially identified, and by reading the abstracts, 12 papers remained eligible for a detailed analysis. It is worth noting that while RR suggested numerous articles, there was a significant overlap between the authors of the uploaded papers and the suggested authors. Moreover, several articles were excluded due to their focus on entirely different research domains, such as psychology or medicine.

Following a meticulous analysis, only two additional papers, (Fouh et al., 2014) and (Lo et al., 2022), were deemed relevant and were included alongside the articles identified through the classical systematic literature review. Consequently, the final literature analysis comprised a total of 43 articles.

### 3 Results

#### RQ 1. Characteristics of using digital materials in school

A comprehensive analysis of the selected articles revealed that 88% of them addressed aspects related to RQ 1, and their findings were categorized based on the characteristics specified in the research question. While the price of digital materials is recognized as an important factor, teachers also prioritize other considerations. For instance, studies conducted by (Wong et al., 2016), (Busulwa & Bbuye, 2018), and (Lo et al., 2021) emphasized that teachers primarily value the quality and availability of the materials, followed by the necessary hardware and software, with price being of lesser concern. On the other hand, (Vorotnykova, 2019) emphasized the importance of digital materials being freely accessible to students.

Interestingly, over 80% of the articles did not discuss the price of digital materials or the publisher. However, the available data indicated that the initiative for digital materials primarily originated from national or regional authorities. Among the analyzed articles, seven highlighted that digital materials were provided through private initiatives or private publishers, while nine articles described the significant influence of entities such as ministries of education, public open educational resource (OER) initiatives, UNICEF, and K-12 foundations in the creation and availability of digital materials. Only five papers specifically addressed the use of open educational content, while the remaining articles predominantly focused on digital textbooks.

It is worth noting that two-thirds of the analyzed articles were published after the onset of the Covid-19 pandemic. As anticipated, teachers increasingly relied on OER during the pandemic compared to before (Lo et al., 2022), which aligns with the findings of (Divjak et al., 2022).

Furthermore, findings from (Pratama & Firmansyah, 2021) and (Chiu, 2017) highlighted that students who are enthusiastic about adopting the latest mobile technology tend to prefer digital content. Additionally, (Shadiev et al., 2015) emphasized the positive impact of multimedia tools in enabling students to effectively utilize authentic contextual resources for learning (e.g. language learning).

In the majority of the analyzed articles, it was observed that students enjoy working with interactive teaching aids in the classroom and find such activities interesting and engaging. Moreover, (Wang & Xing, 2019) pointed out that students perceive digital materials as easy to use. Teachers also noted various benefits associated with the use of digital materials, such as promoting active student participation, offering practical and effective learning experiences, fostering increased student motivation to learn, and leading to improved learning outcomes compared to traditional teaching methods. These findings were supported by studies conducted by (Moundy et al., 2022), (Radović

et al., 2020), (Chiu, 2017), (Lim et al., 2022), and (Dudaitė & Prakapas, 2019).

Furthermore, it was found that increased student engagement when using digital materials can result in better academic performance, as highlighted by the research of (Moundy et al., 2021) and (So et al., 2015).

On the other hand, (Fouh et al., 2014) pointed out that the limited adoption of mobile devices in the classroom is attributed to device-specific characteristics and usability issues, such as small screens. Teachers also acknowledged several challenges and negative aspects associated with the use of digital materials. For instance, difficulties in maintaining student discipline, observed a decline in students' interest and enthusiasm for using interactive tools as the school year progresses, and encountered occasional technical issues (Dudaitė & Prakapas, 2019). Additionally, older studies pointed out that inadequate technology infrastructure, characterized by slow response times and frequent technical difficulties, may discourage students from fully embracing digital textbooks (Shen et al., 2015). Furthermore, a three-year study conducted by (Lim et al., 2022) emphasized the importance of continuously updating the user interface and user experience of digital textbooks to meet students' preferences and demands. This ensures that students perceive digital textbooks as attractive and engaging learning tools. Figure 3 presents a SWOT analysis of the use of digital textbooks in schools, based on the insights gathered from the analyzed literature.

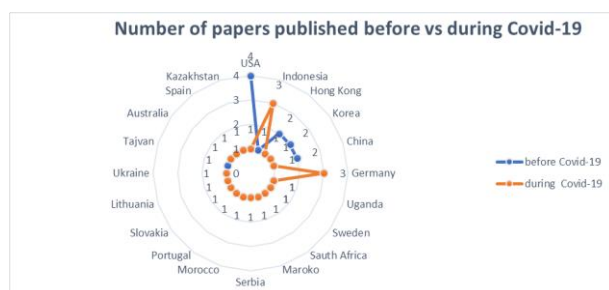
Regarding the medium of digital materials used in schools, it is challenging to make a definitive assessment since almost half of the analyzed articles did not provide specific information on this aspect. Furthermore, it is important to note that drawing conclusions about the current situation in a particular country based solely on research articles may not be comprehensive, and it is necessary to examine available international and national reports. However, it is evident that the use of digital devices has increased in the aftermath of the Covid-19 pandemic (OECD, 2022). This observation is supported by the analyzed articles, as only one article mentioning the use of tablets was published prior to the pandemic, while the rest were published after its onset.

Interestingly, most teachers expressed concerns about utilizing mobile phones for learning and teaching purposes (Busulwa & Bbuye, 2018). A similar finding was reported in a study conducted by (So et al., 2015), which revealed that teachers tend to be more conservative compared to students and parents when it comes to implementing mobile devices in classrooms. However, it is important to note that these studies were conducted before the pandemic, and the current situation regarding the use of mobile devices may have evolved.

While the frequency of digital materials usage is not explicitly defined in over half of the analyzed articles, some insights can still be gleaned.

Approximately 37% of the articles discuss the continuous use of digital materials in schools, highlighting their consistent integration into the learning process. On the other hand, occasional use of digital materials is mentioned in 11% of the articles, typically for activities related to the learning of new content.

The majority of the analyzed articles (62%) were published after the onset of the Covid-19 pandemic (Figure 3), indicating a significant shift in the use of digital devices in schools in line with (OECD, 2022). It was found that 45% of the articles explicitly mentioned the use of devices in schools, while no information was provided in 45% of the articles. This data is particularly noteworthy because studies such as (Lo et al., 2021) and (Moundy et al., 2022) reported increased utilization of digital devices by students for remote learning, especially during the Covid-19 period. These studies also highlighted the use of flipped classroom approaches for teaching and learning, which were only mentioned in a limited number of articles (compared to 45% of articles that explicitly stated the absence of flipped classroom usage).



**Figure 3.** Number of papers published before and during pandemic caused by Covid-19

Furthermore, research by (Joo et al., 2017) revealed that students with high expectations regarding the usefulness of digital materials tend to be more satisfied users. However, this does not necessarily guarantee their continued usage. These findings align with the research conducted by (Reinhold et al., 2020), which emphasized the connection between students' active engagement in classroom activities and their academic success, regardless of the type of textbook utilized. While many teachers considered the use of digital materials as a crucial educational practice (Roskos & Neuman, 2014), it was noted by (Crook & Sharma, n.d.) that teachers still tended to employ teacher-centered approaches in their instruction, irrespective of whether digital technologies were incorporated or not.

### **RQ 2. Use of digital materials for TL in schools related to the digital competences of teachers**

Regarding the second research question on the use of digital materials for teaching and learning (TL) in schools in relation to teachers' digital competences, insights were obtained from 11 (23%) of the papers.

One study by (Masango et al., 2020) investigated the competences of teachers in integrating digital textbooks in 356 South African schools, with complete questionnaire responses received from 51 schools. The research indicated that 47.1% of teachers believed they possessed the necessary competences for using digital textbooks. However, 35.3% of teachers expressed neutrality, suggesting doubts about the obtained results. Furthermore, (Wijaya et al., 2022) found in their research that some teachers used digital textbooks because they believed such materials helped improve the quality of learning.

Moreover, (Grimalt-Álvaro et al., 2019) and (Masango et al., 2020) stated that teachers with basic digital knowledge did not require additional training in the use of digital textbooks. Among the articles providing insights on the second research question, half of them emphasized the need for continuous professional development for teachers. Noteworthy papers highlighting this aspect include (Grönlund et al., 2018), (Håkansson Lindqvist, 2019), (Hermita et al., 2023), (Gerard et al., 2022), and (Crook & Sharma, n.d.). Additionally, (Gerard et al., 2022) emphasized that experienced teachers who have used digital textbooks can provide valuable professional development support to their colleagues. Teachers expressed the need for quality support to effectively implement digital content in teaching and learning, as mentioned in studies by (Masango, 2022), (Crook & Sharma, n.d.), (Gerard et al., 2022), and (Håkansson Lindqvist, 2019).

Digital textbooks were primarily used when introducing new material, as indicated by (Grimalt-Álvaro et al., 2019). Furthermore, (Wijaya et al., 2022) highlighted that mathematics teachers used digital textbooks to enhance the quality of learning in their classrooms. Another important aspect emphasized by (Richardson & Roebuck Sakh, 2022) was the significance of developing new curricula that incorporate advanced technologies such as virtual and augmented reality, algorithmic learning, and artificial intelligence. They emphasized the advantage of integrating these technologies into the curriculum and learning design to improve interaction between students and teachers and better prepare students for their future professional work.

A particularly interesting finding from the research conducted by (Håkansson Lindqvist, 2019) was teachers' perception of the substantial time spent on reviewing and selecting digital textbooks to adapt them to individual students' needs to support their learning.

### **RQ 3. Is there a relationship between the use of digital materials for TL and the maturity level of the school or educational system?**

Our study did not identify any scientific papers that comprehensively address all three research areas of digital maturity, school education, and the utilization of digital textbooks.

## 4 Discussion

The analyzed articles predominantly discuss the implementation of digital materials, including digital textbooks, in teaching and learning. In order to present a comprehensive perspective, we have included a SWOT analysis table (Table 2) that summarizes the strengths, weaknesses, opportunities, and threats associated with their utilization, based on the findings of the analyzed articles.

**Table 2.** SWOT analysis

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>- digital material (DM) is practical and effective</li> <li>- students use DM without training</li> <li>- use of DM increase student activity within the class</li> <li>- DM is particularly efficient in introducing new content</li> <li>- improved learning outcomes through systemic use of DM</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>- student discipline issues arise with DM usage</li> <li>- waning student interest in interactive tools over time</li> <li>- students employ mobile gadgets in unintended ways during class</li> <li>- teachers lack sufficient familiarity and efficient use of DM</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>- enhance out of the class activity (learning at home)</li> <li>- availability of DM</li> <li>- availability of authentic context for learning</li> <li>- education authorities support purchase of digital textbooks</li> <li>- preparing collaborative digital textbooks</li> <li>- positive attitude towards technology among students</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>- poor technology</li> <li>- lack of access to suitable technology</li> <li>- technology-related anxiety</li> <li>- continuous updates to user interface and user experience</li> <li>- DM use not always student-centered</li> <li>- variation in digital material quality</li> <li>- limited availability of teacher training for effective DM use</li> </ul>

As previously mentioned, digital textbooks are predominantly used for introducing new content (Grimalt-Álvaro et al., 2019). However, concerns persist regarding teachers' familiarity with digital textbooks (Wong et al., 2016), (Busulwa & Bbuye, 2018), (Lo et al., 2021), and their ability to integrate them with innovative teaching and learning strategies that support student-centered approaches. Teachers expressed the need for substantial time to review and select quality digital materials (Håkansson Lindqvist, 2019), showing less concern about the price.

While additional training in the use of digital materials may not be necessary for teachers with basic digital knowledge, possessing basic IT skills and

access to digital materials does not guarantee their effective use (Grimalt-Álvaro et al., 2019) and (Masango et al., 2020), particularly in terms of implementing pedagogically effective approaches. Notably, despite the utilization of digital materials, teaching still tends to be teacher-centered, without the incorporation of innovative methods (Crook & Sharma, n.d.), which is consistent with the findings of the analyzed studies. Specifically, 45% of the analyzed articles indicated the absence of innovative teaching and learning methods, while only 5% confirmed the use of the flipped classroom approach.

The need for continuous professional development for teachers was emphasized by (Grönlund et al., 2018), (Håkansson Lindqvist, 2019), (Hermita et al., 2023), (Gerard et al., 2022), and (Crook & Sharma, n.d.). This need was also recognized by local authorities and teachers themselves (OECD, 2022). Moreover, teachers who have effectively utilized digital textbooks can assist in training their peers and identifying the best forms of professional development support (Gerard et al., 2022).

Furthermore, (Wong et al., 2016) and (Grönlund et al., 2018) highlighted the insufficient familiarity of teachers with digital textbooks. (Grönlund et al., 2018) expressed doubts about whether teachers have fully incorporated the new collaborative design of digital textbooks into their teaching practices or if they still perceive them as static books. This suggests that making full use of digital tools necessitates new learning designs that take advantage of rich collaborative digital materials. The need for modern textbooks that teachers and students can creatively utilize was recognized in previous research (Hajdin & Divjak, 2016). To conclude, quality digital materials may enhance student activity and have a positive impact on achieving learning outcomes, but only when paired with sound learning design. Despite students' enthusiasm for adopting the latest mobile technology and digital content (Pratama & Firmansyah, 2021) and (Chiu, 2017), most teachers have concerns about using mobile phones in classrooms (Busulwa & Bbuye, 2018) due to the difficulties in restricting their use solely to learning purposes.

Certain studies highlighted the effectiveness of continuous use of digital materials in schools tied to school and educational system resilience and readiness. This readiness was a prerequisite for successfully transitioning to predominantly digital learning and teaching, as demanded by unprecedented challenges such as those triggered by the COVID-19 pandemic (Svetic & Divjak, 2021).

It is particularly interesting to note that no studies connecting the use of digital textbooks with the digital maturity of schools, or the education system were found, indicating a potential avenue for future research.

In conclusion, there is a need for systematic investigation into the implementation of digital textbooks in schools and its connection to teachers' digital competences and, indirectly, the digital maturity

of the school. This will ensure greater incorporation of innovative forms of teaching and learning, ultimately preparing students for the jobs of the future.

One limitation of this study is that only papers written in the last ten years, in English, and indexed in the WoS or Scopus databases or accessible through the Research Rabbit tool were analyzed.

Finally, recognizing Research Rabbit's limitations is important. Despite its potential, there are constraints. Since the SLR was conducted in a traditional manner, the utility of the RR tool was limited. Additionally, as with many machine learning applications, researchers have limited control over the selection and ranking of outputs, making the research process less reproducible and difficult to explain. The RR tool did not provide information on how its algorithms work or the dataset on which the search relies (Krzton, 2023).

## 5 Conclusion

This paper offers a literature review via SLR and an AI tool to examine the implementation of digital materials, particularly digital textbooks, in schools. The review identifies positive/negative effects, opportunities and challenges. Out of the 43 papers analyzed, the majority focused on the use of digital materials in schools, but only a quarter of them specifically examined the relationship between digital materials and teachers' digital skills. Surprisingly, none of the papers investigated the link between the use of digital materials and the digital maturity of schools. The use of digital materials was found to encourage active student participation and positively impact learning outcomes, particularly when integrated into innovative learning designs. Negative effects include technical issues, discipline maintenance, and a decrease in student interest and enthusiasm over time. Teachers' lack of familiarity with digital textbooks and efficient utilization was identified as a challenge. Having basic digital skills was considered a necessary but insufficient condition for successful use of digital materials. For meaningful use, continuous teacher training is vital, integrating digital materials into innovative teaching and learning strategies. Future research should explore the connection between the use of digital textbooks, the digital readiness of the educational system, and the digital maturity of schools.

## References

Bouck, E. C., Weng, P.-L., & Satsangi, R. (2016). Digital versus Traditional: Secondary Students with Visual Impairments' Perceptions of a Digital Algebra Textbook. *Journal of Visual Impairment & Blindness*, 110(1), 41–52. <https://doi.org/10.1177/0145482X1611000105>

- Bruhn, A. L., & Hasselbring, T. S. (2013). Increasing Student Access to Content Area Textbooks. *Intervention in School and Clinic*, 49(1), 30–38. <https://doi.org/10.1177/1053451213480030>
- Busulwa, H. S., & Bbuye, J. (2018). Attitudes and coping practices of using mobile phones for teaching and learning in a Uganda secondary school. *Open Learning: The Journal of Open, Distance and e-Learning*, 33(1), 34–45. <https://doi.org/10.1080/02680513.2017.1414588>
- Chen, X. (2017). A comparative study of visual representations in conventional, digitized and interactive high school science textbooks. *Journal of Visual Literacy*, 36(2), 104–122. <https://doi.org/10.1080/1051144X.2017.1386388>
- Chiu, T. K. F. (2017). Introducing electronic textbooks as daily-use technology in schools: A top-down adoption process. *British Journal of Educational Technology*, 48(2), 524–537. <https://doi.org/10.1111/bjet.12432>
- Crook, S. J., & Sharma, M. D. (n.d.). Bloom-ing Heck! The Activities of Australian Science Teachers and Students Two Years into a 1:1 Laptop Program Across 14 High Schools. 16.
- Divjak, B., Rienties, B., Iniesto, F., Vondra, P., & Žizak, M. (2022). Flipped classrooms in higher education during the COVID-19 pandemic: Findings and future research recommendations. *International Journal of Educational Technology in Higher Education*, 19(1), 9. <https://doi.org/10.1186/s41239-021-00316-4>
- Dudaitè, J., & Prakapas, R. (2019). Influence of use of Activinspire interactive whiteboards in classroom on students' learning. *Digital Education Review*, 299–308. <https://doi.org/10.1344/der.2019.35.299-308>
- Farisi, M. I. (2014). Bhinneka Tunggal Ika [Unity in Diversity]: From Dynastic Policy to Classroom Practice. *JSSE - Journal of Social Science Education*, 12014 Insights into Citizenship Classrooms: The Art of Documentation & Description. <https://doi.org/10.4119/JSSE-687>
- Fouh, E., Breakiron, D.A., Hamouda, S., Farghally, M.F., Shaffer, C.A., (2014) Exploring students learning behavior with an interactive etextbook in computer science courses. *Computers in Human Behavior*, 41. 478-485. <https://doi.org/10.1016/j.chb.2014.09.061>.
- Gerard, L., Wiley, K., Debarger, A. H., Bichler, S., Bradford, A., & Linn, M. C. (2022). Self-directed Science Learning During COVID-19 and Beyond. *Journal of Science Education and Technology*, 31(2), 258–271. <https://doi.org/10.1007/s10956-021-09953-w>
- Grimalt-Álvaro, C., Ametller, J., & Pintó, R. (2019). Factors Shaping the Uptake of ICT in Science

- Classrooms. A Study of a Large-Scale Introduction of Interactive Whiteboards and Computers. *International Journal of Innovation in Science and Mathematics Education*, 27(1). <https://doi.org/10.30722/IJISME.27.01.002>
- Grönlund, Å., Wiklund, M., & Böö, R. (2018). No name, no game: Challenges to use of collaborative digital textbooks. *Education and Information Technologies*, 23(3), 1359–1375. <https://doi.org/10.1007/s10639-017-9669-z>
- Hajdin, G. & Divjak, B. (2016) Use of informatics textbooks in school classroom. *Journal of information and organizational sciences*, 40 (1), 21-44.
- Håkansson Lindqvist, M. (2019). Talking about digital textbooks. The teacher perspective. *The International Journal of Information and Learning Technology*, 36(3), 254–265. <https://doi.org/10.1108/IJILT-11-2018-0132>
- Hermita, N., Wijaya, T. T., Yusron, E., Abidin, Y., Alim, J. A., & Putra, Z. H. (2023). Extending unified theory of acceptance and use of technology to understand the acceptance of digital textbook for elementary School in Indonesia. *Frontiers in Education*, 8, 958800. <https://doi.org/10.3389/educ.2023.958800>
- Joo, Y. J., Park, S., & Shin, E. K. (2017). Students' expectation, satisfaction, and continuance intention to use digital textbooks. *Computers in Human Behavior*, 69, 83–90. <https://doi.org/10.1016/j.chb.2016.12.025>
- Kabugo, D. (n.d.). *Utilizing Open Education Resources to Enhance Students' Learning Outcomes during the COVID-19 Schools Lockdown: A Case of Using Kolibri by Selected Government Schools in Uganda*. 12.
- Kim, P., & Yu, J.-S. (2019). A Study on Online Delivery of Digital Textbooks in Korea. *Universal Journal of Educational Research*, 7(5A), 92–102. <https://doi.org/10.13189/ujer.2019.071511>
- Krzton, A. (2023, March 21). Welcome to the Machine: Ir/Responsible Use of Machine Learning in Research Recommendation Tools. *ACRL 2023 Proceedings*. ACRL 2023 Conference Proceedings, American Library Association.
- Lee, S., Lee, J.-H., & Jeong, Y. (n.d.). *The Effects of Digital Textbooks on Students' Academic Performance, Academic Interest, and Learning Skills*.
- Lim, K., Go, J., Kim, J., Son, J., Jang, Y., & Joo, M.-H. (2022). Sustainable Effect of the Usefulness of and Preference for Digital Textbooks on Perceived Achievements in Elementary Education Environments. *Sustainability*, 14(11), 6636. <https://doi.org/10.3390/su14116636>
- Lo, C. K., Cheung, K. L., Chan, H. R., & Chau, C. L. E. (2021). Developing flipped learning resources to support secondary school mathematics teaching during the COVID-19 pandemic. *Interactive Learning Environments*, 1–19. <https://doi.org/10.1080/10494820.2021.1981397>
- Lo C.K., Tlili A, Huang X. (2022). The Use of Open Educational Resources during the COVID-19 Pandemic: A Qualitative Study of Primary School Mathematics Teachers in Hong Kong. *Education Sciences*. 12(11):744. <https://doi.org/10.3390/educsci12110744>
- Lucas, M. (2020). External barriers affecting the successful implementation of mobile educational interventions. *Computers in Human Behavior*, 107, 105509. <https://doi.org/10.1016/j.chb.2018.05.001>
- Masango, M. M. (2022). A Paperless Classroom: Importance of Training and Support in the Implementation of Electronic Textbooks in Gauteng Public Schools. 20(3), 15.
- Masango, M. M., Van Ryneveld, L., & Graham, M. A. (2020). Barriers to the Implementation of Electronic Textbooks in Rural and Township Schools in South Africa. *Africa Education Review*, 17(6), 86–118. <https://doi.org/10.1080/18146627.2022.2064310>
- Milić, M. & Divjak, B. (2022). Digital Maturity of Schools - Explanation, Literature Review and Analysis, *Central European Conference on Information and Intelligent Systems*
- Moundy, K., Chafiq, N., & Talbi, M. (2021). Comparative Analysis of Student Engagement in Digital Textbook Use during Quarantine. *Education Sciences*, 11(7), 352. <https://doi.org/10.3390/educsci11070352>
- Moundy, K., Chafiq, N., & Talbi, M. (2022). Digital Textbook and Flipped Classroom: Experimentation of the Self-Learning Method Based on the Development of Soft Skills and Disciplinary Knowledge. *International Journal of Emerging Technologies in Learning (IJET)*, 17(07), 240–259. <https://doi.org/10.3991/ijet.v17i07.28933>
- OECD. (2022). *Education at a Glance 2022: OECD Indicators*. Organisation for Economic Co-operation and Development. [https://www.oecd-ilibrary.org/education/education-at-a-glance-2022\\_3197152b-en;jsessionid=oktyOPo37201BNrtdqOoNnU13gQXJkfdnbeR18Le.ip-10-240-5-190](https://www.oecd-ilibrary.org/education/education-at-a-glance-2022_3197152b-en;jsessionid=oktyOPo37201BNrtdqOoNnU13gQXJkfdnbeR18Le.ip-10-240-5-190)
- Pratama, A. R., & Firmansyah, F. M. (2021). How can governments nudge students to become ebook readers? Evidence from Indonesia. *Digital Library Perspectives*, 37(3), 275–288. <https://doi.org/10.1108/DLP-07-2020-0066>



- Prutko, A. S., Kodussov, A. S., Mussenova, E. K., & Kambarova, Zh. T. (2020). Development of the electronic physics textbook for students of secondary school. *Bulletin of the Karaganda University. 'Physics' Series*, 100(4), 87–94. <https://doi.org/10.31489/2020Ph4/87-94>
- Radović, S., Radojičić, M., Veljković, K., & Marić, M. (2020). Examining the effects of Geogebra applets on mathematics learning using interactive mathematics textbook. *Interactive Learning Environments*, 28(1), 32–49. <https://doi.org/10.1080/10494820.2018.1512001>
- Reinhold, F., Hoch, S., Schiepe-Tiska, A., Strohmaier, A. R., & Reiss, K. (2021). Motivational and Emotional Orientation, Engagement, and Achievement in Mathematics. A Case Study With One Sixth-Grade Classroom Working With an Electronic Textbook on Fractions. *Frontiers in Education*, 6, 588472. <https://doi.org/10.3389/educ.2021.588472>
- Reinhold, F., Strohmaier, A., Hoch, S., Reiss, K., Böheim, R., & Seidel, T. (2020). Process data from electronic textbooks indicate students' classroom engagement. *Learning and Individual Differences*, 83–84, 101934. <https://doi.org/10.1016/j.lindif.2020.101934>
- Rezat, S. (2021). How automated feedback from a digital mathematics textbook affects primary students' conceptual development: Two case studies. *ZDM – Mathematics Education*, 53(6), 1433–1445. <https://doi.org/10.1007/s11858-021-01263-0>
- Richardson, S., & Roebuck Sakho, J. (2022). Creating equitable access: Using OER for socially just educational leaders. *Journal for Multicultural Education*, 16(5), 443–455. <https://doi.org/10.1108/JME-12-2021-0224>
- Roskos, K., & Neuman, S. B. (2014). Best Practices in Reading: A 21st Century Skill Update. *The Reading Teacher*, 67(7), 507–511. <https://doi.org/10.1002/trtr.1248>
- Shadiev, R., Hwang, W.-Y., Huang, Y.-M., & Liu, T.-Y. (2015). The Impact of Supported and Annotated Mobile Learning on Achievement and Cognitive Load. The Impact of Supported and Annotated Mobile Learning on Achievement and Cognitive Load. *Educational Technology & Society*, 18(4), 53–69.
- Shen, H., Luo, L., & Sun, Z. (2015). What Affect Lower Grade Learner's Perceived Usefulness and Perceived Ease of Use of Mobile Digital Textbook Learning System? An Empirical Factor Analyses Investigation in China. *International Journal of Multimedia and Ubiquitous Engineering*, 10(1), 33–46. <https://doi.org/10.14257/ijmue.2015.10.1.4>
- Sinaga, P., Setiawan, W., & Iliana, M. (2022). The impact of electronic interactive teaching materials (EITMs) in e-learning on junior high school students' critical thinking skills. *Thinking Skills and Creativity*, 46, 101066. <https://doi.org/10.1016/j.tsc.2022.101066>
- So, H. J., Choi, H., & Yoon, H. G. (2015). Understanding users' perceived needs and concerns toward mobile application integration in primary science education in Korea. *International Journal of Mobile Learning and Organisation*, 9(4), 315. <https://doi.org/10.1504/IJMLO.2015.074515>
- Sun, Z., & Jiang, Y. (2015). How the young generation uses digital textbooks via mobile learning terminals: Measurement of elementary school students in China: How the young generation uses digital textbooks. *British Journal of Educational Technology*, 46(5), 961–964. <https://doi.org/10.1111/bjet.12299>
- Svetec, B., & Divjak, B. (2021). Emergency Responses to the COVID-19 Crisis in Education: A Shift from Chaos to Complexity. *EDEN Conference Proceedings*, 1, 513–523. <https://doi.org/10.38069/edenconf-2021-ac0051>
- Tlili, A., Zhao, J., Yang, K., Wang, Y., Bozkurt, A., Huang, R., Bonk, C. J., & Ashraf, M. A. (2022). Going beyond books to using e-books in education: A systematic literature review of empirical studies. *Interactive Learning Environments*, 1–25. <https://doi.org/10.1080/10494820.2022.2141786>
- Vorotnykova, I. (2019). Organizational, Psychological and Pedagogical Conditions for the Use of E-Books and e-Textbooks at School. *Turkish Online Journal of Distance Education*, 89–102. <https://doi.org/10.17718/tojde.598227>
- Wang, X., & Xing, W. (2019). Understanding Elementary Students' Use of Digital Textbooks on Mobile Devices: A Structural Equation Modeling Approach. *Journal of Educational Computing Research*, 57(3), 755–776. <https://doi.org/10.1177/0735633118758643>
- Wijaya, T. T., Zhou, Y., Houghton, T., Weinhandl, R., Lavicza, Z., & Yusop, F. D. (2022). Factors Affecting the Use of Digital Mathematics Textbooks in Indonesia. *Mathematics*, 10(11), 1808. <https://doi.org/10.3390/math10111808>
- Wong, B. T. M., Li, K. C., Yuen, K. S., & Wu, J. W. S. (2016). Adopting and adapting open textbooks: School teachers' readiness and expectations. *International Journal of Services and Standards*, 11(2), 160. <https://doi.org/10.1504/IJSS.2016.077954>
- Zacok, L., Bernat, M., & Bernatova, R. (2019). Verification of New Electronic Technical Textbooks In The Current School. *Ad Alta-Journal Of Interdisciplinary Research*, 9(2), 371–375.