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REVIEW ARTICLE

Going beyond books to using e-books in education: a systematic literature review of empirical studies

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ABSTRACT

With the development of educational technologies, electronic books (e-books) have been improved and adapted to cater to new teaching models, as well as to overcome several challenges reported by printed book portability. The literature about the benefits of e-books in education is still fragmented as several studies have reported distinct disadvantages in addition to advantageous of using them. Currently, no prior study has systematically reviewed the research on the ways e-books have been employed in education and the associated benefits and challenges. To address this gap, this study conducts a systematic review of 123 empirical studies on e-books in education. The findings show that the development and adoption of e-books by countries vary, calling for more international collaborations to facilitate the adoption of e-books worldwide. Additionally, several challenges of e-books were identified, such as eye fatigue and lack of knowledge on using e-books in education by both students and teachers. Therefore, it is suggested that more design strategies and training about using e-books can be conducted to enhance both teaching and learning experiences. Finally, it is argued that future research may focus on designing intelligent and open e-books to expand their use in different contexts and provide more personalized learning.

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1. Introduction

As technology has changed and developed, it has played an important role in education (Coll, 2008), incorporating electronic books (e-books), which are a type of technology-enabled publication that allows for easier and higher-quality access to knowledge than traditional media like printed books (Chen et al., 2013; Tang, 2021). E-books have the advantage of greater flexibility and accessibility over printed books, with interactive features, such as multimedia resources, as well as the ability to add supporting materials potentially; they are also more environmentally friendly, less expensive, and more portable when compared to printed books (Doering et al., 2012).

The debate about the effectiveness of e-books, however, still remains intense. Several studies have reported empirical findings showing that e-books can improve students' access to knowledge and revolutionize the reading, evaluating, and analyzing processes (Bozkurt & Bozkaya, 2015 ;

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Rothman, 2006; Zhang et al., 2021). Therefore, e-book technology has acquired widespread adoption , especially in schools and universities, where it is considered to be a standard learning resource (Al-Qatawneh et al., 2019). According to Khalid et al. (2017), e-books are not only economically meaningful for consumers, including students and learning organizations, such as reducing the financial burden; they also have educational implications for general learning, such as allowing learners to easily search for them to support their teaching and learning. On the other hand, some studies have also reported that e-books can negatively affect learners' attention and interfere with learning (Radović et al., 2020), and prolonged reading increases visual fatigue (Lee et al., 2013).

The ongoing discussion of e-books in education also includes the way they should be designed. E-books are text rendered digitally on a screen, according to Cox and Mohammed (2001), and interactive e-books are upgraded versions and enhanced extensions of e-books (Bozkurt & Bozkaya, 2015). Interactive e-books are also seen as a major tool for enhancing the reading experience, including influencing readers' cognitive, sensory, and physical interactions while reading, as well as the publishing industry, the book market, and libraries (Bozkurt et al., 2016). Although learners use e-books to learn simple concepts just like printed books (Worm, 2013), interactive e-books stimulate student motivation, engagement, and learning outcomes more than any other version of books when learning complex concepts (Daniel & Woody, 2013; Dwyer & Davidson, 2013; Hsiao et al., 2016).

Given that the literature about the use and effects of e-books in education, as well as the most effective way of designing them is fragmented, a systematic literature review is needed to provide comprehensive insights to educators, administrators, policymakers, funding agencies, students, researchers, and educational technology entrepreneurs about this topic, as well as identify trends, challenges, and future research possibilities. These stakeholders are many and the potential impact is substantive.

1.1. Previous systematic reviews on e-books in education

Staiger (2012) conducted a literature review from 2006 to 2011, without specifying the number of reviewed studies, which focused on the awareness and popularity of e-books among university and college students with English-speaking backgrounds. Similarly, Blummer and Kenton (2020) conducted a systematic review from 2001 to 2017 about the awareness, understanding, and popularity of e-books among faculty, students, and staff. Their literature review covered 60 studies and focused on English peer-reviewed journals, as well as white papers, technical reports, and conference papers. The findings showed that the USA and the UK contributed the most articles related to e-books in the education field. Additionally, the findings highlighted that a peak time period related to the popularity of e-books among users occurred after 2014.

Prior to that peak, Lee et al. (2013) conducted a literature review, without also specifying the number of reviewed studies. These researchers focused on the technological aspects of e-books, including the selection of hardware or software components. They highlighted that using technologies, such as multi-touch, e-paper, Web 2.0, and cloud computing could solve several problems, including standardizing e-book content format, increasing readability, and protecting copyright associated with e-books.

Similarly, in a more recent study, Rahim et al. (2020) examined the effectiveness of using e-books in learning through a literature review. They considered books, journals, research results, and data about the use of e-books during the learning process. However, the authors did not give details about the adopted literature review steps that they undertook, or the number of reviewed studies that were included in the research corpus. Nevertheless, in their study, the obtained results showed that the use of e-books had positive effects on learning effectiveness.

1.2. Purpose of this study

As shown above, a limited number of systematic reviews has been conducted to investigate e-books in education. Additionally, these review studies provided limited information about their review method, and tackled specific dimensions, such as e-book awareness or technology support.

However, our extensive analyses revealed no systematic literature reviews on e-books in education from a wider perspective to provide trends, research gaps, and future directions in this field. Therefore, this study relies on the technology-enhanced learning model (Hsu et al., 2012) to conduct a systematic literature review of empirical studies on e-books in education. The rationale for using this model is because it provides deep insights into a given educational technology based on several intervening dimensions, such as participants, research method learning design, and challenges (Lin & Hwang, 2019). This model has been used to conduct systematic reviews on several educational technology topics, including blended learning (Ashraf et al., 2021; Yang et al., 2019) and chatbots in education (Hwang & Chang, 2021).

The findings of the current study could facilitate the adoption of e-books in education by highlighting how they can be designed and what advantages and challenges can be expected from using them. Additionally, this study could contribute to the United Nations' Sustainable Development Goals (SDGs), specifically to the Goal 4, which aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." Finally, as noted earlier, the study could serve as a reference for many stakeholders (e.g. publishers, educators, and policymakers) to conduct follow-up studies, activity design, and policy planning about the use of e-books in education. It should be further noted that conducting a meta-analysis review to investigate the effect size of e-books in education was not possible due to the lack of detailed descriptive statistics for the involved groups, such as mean, standard deviation and sample size, in each reviewed study.

2. Method

This study presents a systematic literature review of empirical studies on e-books. Particularly, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed (Moher et al., 2010). PRISMA provides a standard peer-accepted methodology that uses a guideline checklist. This study also follows the recommendations outlined by Kitchenham and Charters (2007) when conducting a systematic review, which includes three phases, namely: (1) planning the review refers to the need of the review and the provided research questions; (2) conducting the review refers to the search for and selection of papers to include in the review, assessing the quality of the selected papers, and selecting the data extraction method; and (3) reporting the review refers to the presentation of the obtained results. Each of these phases is detailed in the subsequent sections of this manuscript.

2.1. Planning the review

To deal with this topic, an extensive search for research papers was conducted based on the following search strings.

Search string: (e-book) AND (education)

E-book substring: electronic books OR e-books OR interactive e-books OR open e-books

Education substring: learning OR education OR educational

Particularly, the search of the literature was undertaken in the Web of Science (WoS), Scopus, Taylor and Francis, IEEE Xplore, and ScienceDirect databases which are considered among the most popular databases for peer-review articles in education. After searching the relevant databases, two of the researchers analyzed the retrieved papers by their titles, abstracts, and if necessary, by full text, based on a pre-defined inclusion and exclusion criteria, as shown in Table 1.

This search yielded a total of 1,991 papers from 2005 to 2021. After removing duplicated papers, 1,796 papers remained. Next, 523 papers were then removed based on the screening process of titles and abstracts. The remaining 1,273 papers were considered and assessed as full texts. In our review of these papers, 1,150 of them did not pass the inclusion criteria. Thus, as a total number, 123 eligible research papers remained for further analysis. Figure 1 presents the study selection process as recommended by the PRISMA group (Moher et al., 2010). Based on the degree of agreement between the choices made by the two independent authors in selecting papers, Cohen's Kappa was

Table 1. Inclusion and exclusion criteria.

Inclusion	Exclusion
Empirical studies discussing e-books in education Peer-reviewed journal papers Studies presenting detailed results (description and discussion) about the impact (positive, no-impact or negative) of e-books in education	The full text is not available online Studies which are not in English Studies discussing e-books in other domains (e.g. economy) Studies which are not peer-reviewed journal papers (e.g. conference papers or book chapters)

calculated to test the inter-rater reliability. According to Cohen (1960), the obtained inter-rater reliability was very good ($\kappa = 0.83$). Importantly, where the assessment score was different between raters, a consensus was reached through discussions.

2.2. Conducting the review

This stage includes the coding scheme for the data extraction process. To reduce the opportunity for bias, an online electronic data extraction form was designed (Kitchenham & Charters, 2007). Two coders worked on this form which they had to fill according to the coding scheme.

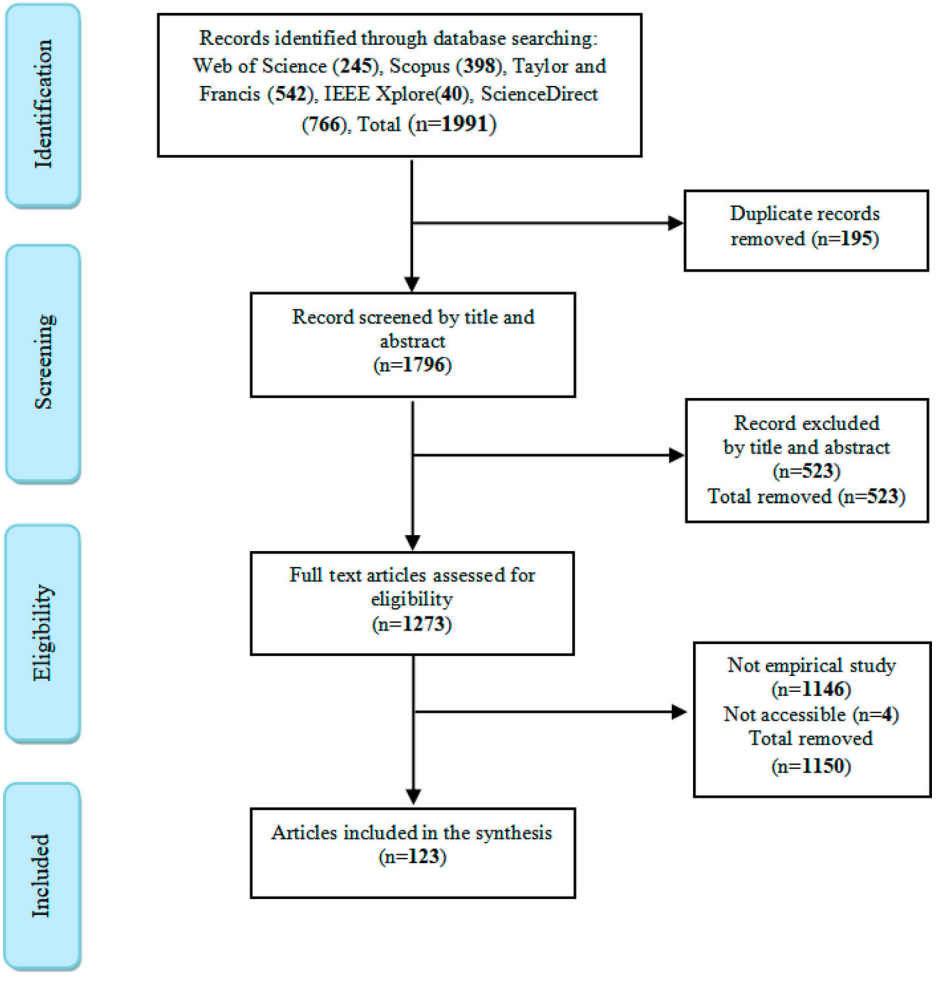


Figure 1. Flowchart of the systematic literature review.

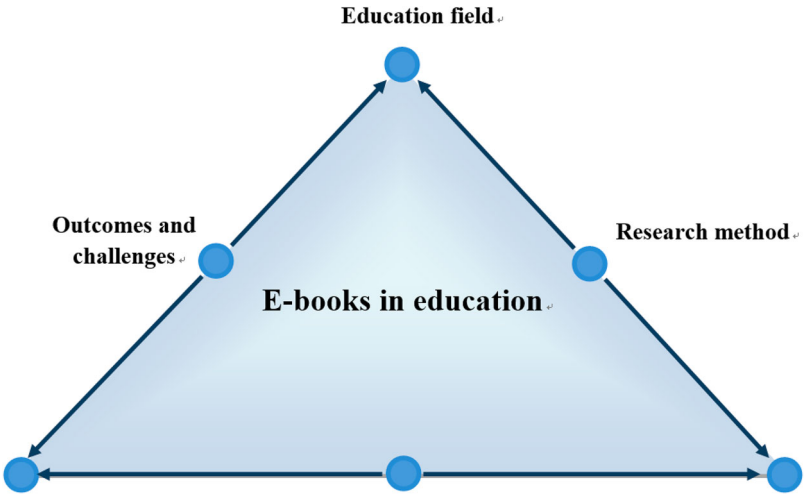


Figure 2. Coding scheme based on the technology-based learning model.

In addition to the descriptive information related to each study (i.e. author list, publication year and venue, etc.), this study adapted the technology-based learning model (Hsu et al., 2012) to better understand the research data, as shown in Figure 2. This model is based on six dimensions, namely: (1) education field, (2) learning scenario, (3) participants, (4) outcomes and challenges, (5) research method, and (6) design. Table 2 presents a detailed description of the coding scheme used in this study.

2.3. Reporting the review

In this stage, the extracted data based on the coding scheme were compared and discussed, as presented in the "Results and discussion" section.

3. Results and discussion

3.1. E-book trends

Figure 3 presents the distribution of studies by publication year. As indicated in that figure, the published research on e-books in education, uncovered in this present study, first appeared in 2005 coinciding with the rise of second-generation Web technologies. As Roha and McGrath (2001) noted, ongoing discussions and pronouncements about the potential of e-books have been salient since 1990. In fact, they predicted that there would be 2.6 million to 28 million e-books in use by 2005 (Roha & McGrath, 2001).

Continued advances in computing and storage technology brought about by the internet revolution combined with and the advent of electronic journals (Long, 2003; Mullin, 2002; Rao, 2003) and the proliferation of open educational resources has brought about increased awareness of e-books. Notably, from 2013 to 2014, research on e-books in education accelerated (see Figure 3). This growth might be related to the high cost of textbooks which catalyzed the research on using e-books in education as a way to reduce educational expenses (McMahon, 2013; Walton, 2014). Additionally, this might be related to the expansion of e-book marketing at that time as companies like Apple and Amazon started providing e-book services on a global scale (Aamoth, 2012; Wischenbart & Licher, 2013).

It is also apparent in Figure 3 that another spike in e-book research was noted during the past couple of years (i.e. 2019 and 2020) which could be explained by the rapid development of technology that catalyzed research and development of e-books in education (Zokirovna, 2020) and using

Table 2. The coding scheme of the systematic review.

Dimension	Description	Coding
Year of publication	Year of publication	Year of publication
Nationalities of the first authors	Authors names	Authors names
Publication venue	The name of the journal where the study was published	Journal name
Education field	The field of education where the e-book was used	Each study was coded following the classification proposed in the International Standard Classification of Education (UNESCO, 2015). This classification includes 10 broad fields of education: (1) Natural sciences, mathematics and statistics; (2) Arts and humanities; (3) Social sciences, journalism and information; (4) Information and Communication Technologies; (5) Engineering, manufacturing, and construction; (6) Health and welfare; (7) Education; (8) Business, administration and law; (9) Agriculture, forestry, fisheries and veterinary; and (10) Services
Research methods	The applied research method in each study	the research methods were classified as quantitative, qualitative, mixed methods, or other (Grant et al., 1987)
Participants	Participants of the included studies (e.g. students, teachers, health professionals, or institution staff)	The scheme of participants was classified according to today's common education stages
Educational level	The participant educational level (e.g. primary, secondary, and higher education)	The scheme of the educational level was classified according to today's common educational stages
Learning scenarios	The different learning scenarios using e-books.	Describe how e-books were used in each learning scenario
Design	Identify the design features of the used e-books in each study, namely technology, interaction, intelligence, and openness.	Technology describes the technology-based e-book, namely Web or mobile. The interaction was classified according to the four interaction levels that depend on the degree of interactivity of users' involvement in an instructional activity (Bozkurt & Bozkaya, 2015). Intelligence describes the intelligent services provided by each e-book in education. Openness describes whether the used e-book was an Open Educational Resource (OER) or not.
Outcomes and issues	The research issues refer to blended learning outcomes and issues	This study referred to the scheme of Majuri et al. (2018), which categorizes learning outcomes into psychological outcomes (e.g. perception, engagement, etc.) and behavioral outcomes (e.g. academic performance, interaction with the system, etc.).

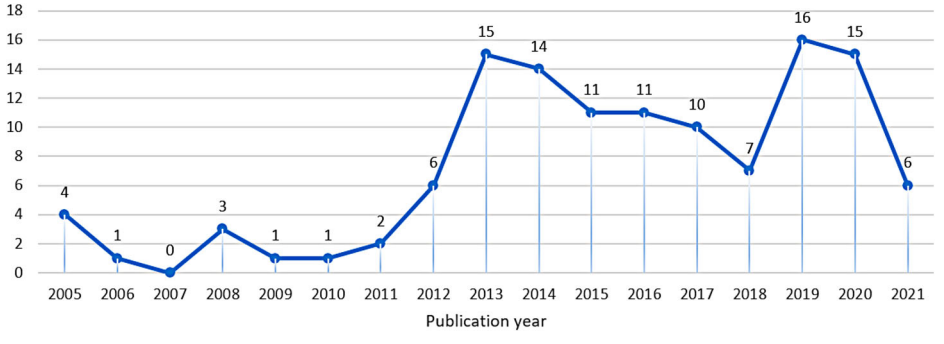


Figure 3. Distribution of studies by publication year.

online learning materials due to requirements imposed by the COVID-19 pandemic (Malaquias et al., 2021) and wide adaptation of online learning processes (Stracke et al., 2022). Another upward trend in e-book research between 2019 and 2020 can be explained, perhaps, by rising awareness related to open educational resources (OER) and the potential of e-books. Due to the associated cost savings on e-books, open textbooks can help in efforts to equalize access to educational resources and play an instrumental role in promoting inclusive education and forms of social justice (Cox et al., 2020; Pitt et al., 2020).

According to the affiliation countries of the authors of the reviewed papers (see Figure 4), the USA has the highest number of publications uncovered by the present study, with 54. In the USA, the price of printed textbooks is rapidly increasing; therefore, educators and researchers have both shifted their attention to e-books to reduce the cost (Bunkell & Dyas-Correia, 2009). Furthermore, several giant US companies, such as Amazon, Apple, and Google, have engaged in e-book development, and have emphasized the popularity and low-cost production of e-books (Sanguo et al., 2012).

Interestingly, the present study indicates that South Africa is leading the research on e-books in the African region. This finding might be because of several governmental initiatives and policies in South Africa, such as the "go green" policy, which aims to digitize several services and reduce the use of paper to protect the environment. However, the rising cost of electricity has limited the usage of e-books in South Africa (Langdown, 2010). Based on different technological development efforts and infrastructure, developed countries, such as the USA, the UK, and Canada, have high technology acceptance, and educators and institutions in those countries are able to adopt e-books; however, regions of the world such as parts of Africa, parts of Asia, and parts of the Middle East have low adoption of e-books due to the lack of technology (Mehana, 2012). As made evident in Figure 4, the stark differences in e-book adoption and use are reflected in the number of published research studies stemming from these regions. These findings suggest that more initiatives and collaborations within and between countries are needed to facilitate the adoption of e-books in education worldwide with a specific emphasize on SDG4, Quality Education.

Currently, there is wide interest in e-books. In fact, the studies reviewed for this research were published in 89 different peer-reviewed journals. In order not to present a fairly long list, the journals that participated with 1% or less of the studies (72 journals) were categorized as other. This analysis is important since it informs stakeholders about the leading journals in the field and where they can find the relevant literature, or where they can aim to publish their research. Figure 5 shows the

Country	Frequency
USA	54
Taiwan	10
UK	7
South Africa	7
China	6
Canada	6
Australia	5
Germany	4
UAE	4
Estonia	2
Indonesia	2
Ukraine	2
Bahrain	2
Columbia	1
Chile	1
Croatia	1
Finland	1
Ghana	1
Greece	1
India	1
Iran	1
Japan	1
Kazakhstan	1
Malaysia	1
New Zealand	1
Singapore	1

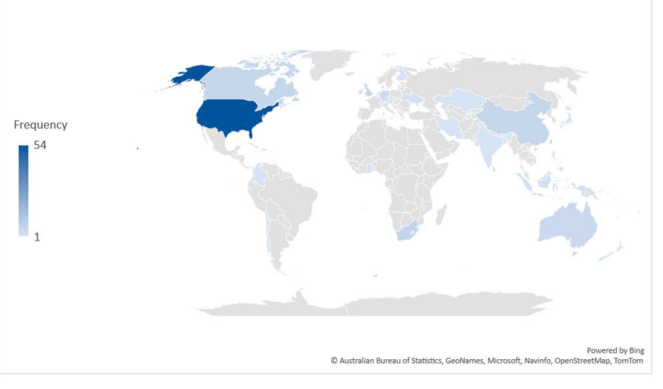


Figure 4. Distribution of studies by country.

distribution of research studies on e-books by journal of publication for the journals that contributed more than 1% of the studies.

3.2. Field of education

Figure 6 presents the distribution of e-book studies according to the education field. The results showed that 61% of the studies were in an educational context, but they did not mention the specific education field (i.e. discipline or research area). This was, most probably, because several studies focused on investigating the perception and attitudes of students towards e-books in educational contexts in general (Clinton-Lisell et al., 2020; D'Ambra et al., 2020; Su, 2021). Figure 6 also shows that most of the e-book studies focused on the natural science, mathematics, and statistics category, followed by courses on health and welfare. In the natural science arena, e-books allow students to have a better understanding of science concepts through a variety of digital mediums, like 3D models, animated videos, and simulations; in this way, learners can more extensively and interactively explore scientific information through e-books (Encheff, 2013). In mathematics, many issues can be addressed by using digital technology since it allows students to develop and apply mathematical knowledge in a variety of ways, as well as integrate subject information in real-world situations and scenarios (Olive et al., 2009). Consequently, several e-book projects have focused on science and mathematics (Lee et al., 2013).

As indicated, the second discipline where e-books were frequently used is related to health and welfare (see Figure 6). One plausible reason for the popularity of e-books in the health and welfare discipline could be due to the searchability features that these types of digital books provide (Bates et al., 2012). In addition, heavy book usage in health and welfare is expensive. As a result, learners spend approximately $1,500 on health textbooks, so using e-books would be cheaper and more convenient (Elias et al., 2012). Based on these findings, it can be argued that there is a need for research on the use of e-books in the less investigated fields such as education and the arts and humanities.

3.3. Participants

Figure 7 shows the distribution of participants in the e-book in education research. It is seen that most studies ($n = 112$) involved students as participants, followed by faculty educators ($n = 8$),

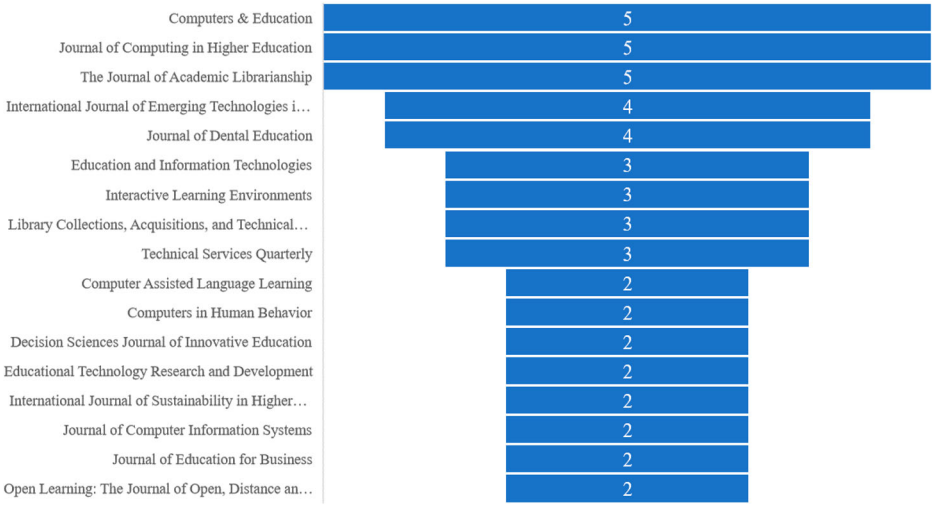


Figure 5. Distribution by journal of publication.

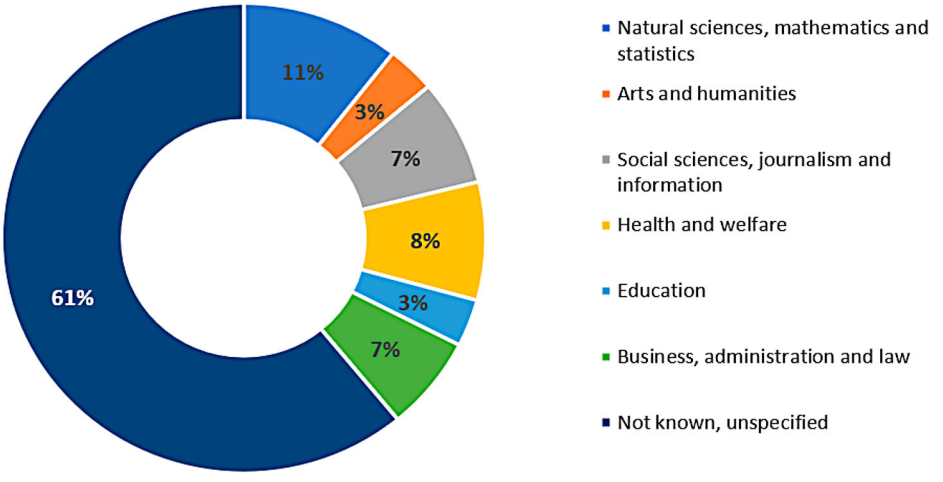


Figure 6. Distribution of studies by disciplinary category.

teachers ($n = 6$), and university librarians ($n = 2$). Specifically, most of the studies investigated how e-books can enhance learning, as well as the perception of students towards this technology (Huang et al., 2014; Sun et al., 2012), which is reflected in the high number of studies involving students. Faculty educators, teachers, and researchers were involved in the e-book research mainly to investigate whether e-books can be effectively used in teaching plans; they were also commonly asked about the challenges they encounter or would encounter when preparing lessons using e-books (Seeley et al., 2018). In addition, university librarians and publishers involved in the e-book research have provided vital insights into the design and organization of e-book management systems (Armstrong & Lonsdale, 2005).

The analysis of participants showed that students were the focus of most research pertaining to e-books, while the participation of other stakeholders in research on e-books is limited, calling for more research in this context. For instance, to use e-books in teaching, more research should be conducted to investigate how teachers and educators can improve their teaching

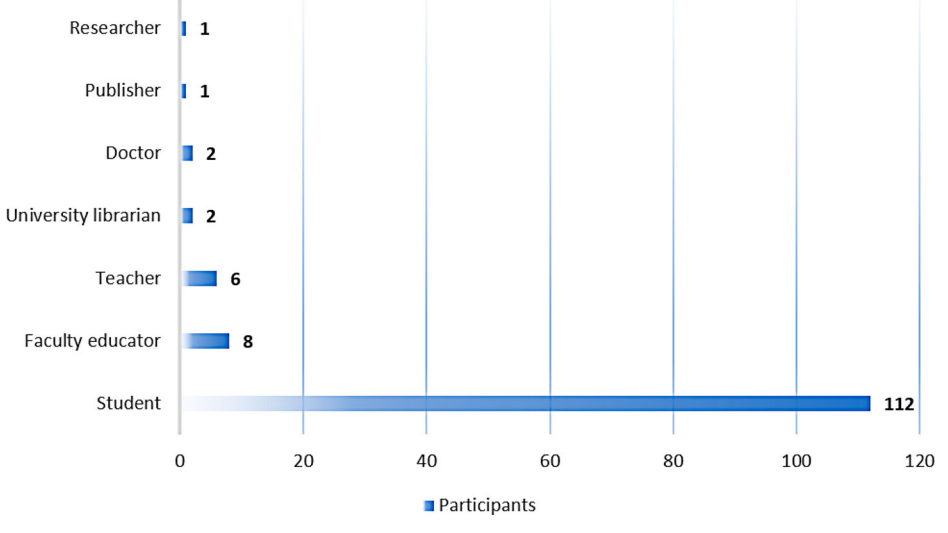


Figure 7. Distribution of studies by participants.

practices and strategies using e-books (deNoyelles & Seilhamer, 2013; Seeley et al., 2018). Additionally, more research should involve participants who are librarians and publishers, as they are important contributors to the process of book digitalization, and their insights can better highlight the advantages and disadvantages of electronic books (Figol et al., 2020); their voices and perspectives could foster higher-quality textbooks which are more satisfying the target audience.

When analyzing the education level of student participants in e-book research (see Figure 8), the findings indicate that 76.2% of the e-book studies focused on higher education, followed by secondary education, elementary school, early childhood education, and others. The focus on higher education could be because college and university students generally maintain a positive attitude towards e-books since they promote cooperative learning and improve student performance and course participation (Dennis et al., 2016). Therefore, future research might investigate the benefits and challenges of e-books in other education levels and in other educational sectors, such as in K-12 education and government and corporate training. In addition to exploring the benefits and challenges of e-books across educational sectors, researchers might also investigate the acceptance and adoption of e-books by both K-12 students and teachers as well as corporate training personnel.

3.4. Research method

Figure 9 presents the research methods that were adopted by researchers in the e-book in education research reviewed in this study. Of the 123 published articles meeting our criteria, 53.6% of them used quantitative analyses, followed by qualitative (16.3%) and mixed method (30.1%) analyses. When analyzing the instruments used for data collection (see Table 3), the results showed that questionnaires ($n = 97$) were the most used instruments to collect data, followed by interviews ($n = 26$).

Of course, both questionnaire and interview data are easier to collect than changes in behavior or learner performance data and can be quickly administered to obtain participant feedback. However, questionnaires are limited to obtaining subjective perceptions of students, which can be biased or easily faked (Tlili et al., 2021). In other words, using a data collection tool that mainly relies on self-

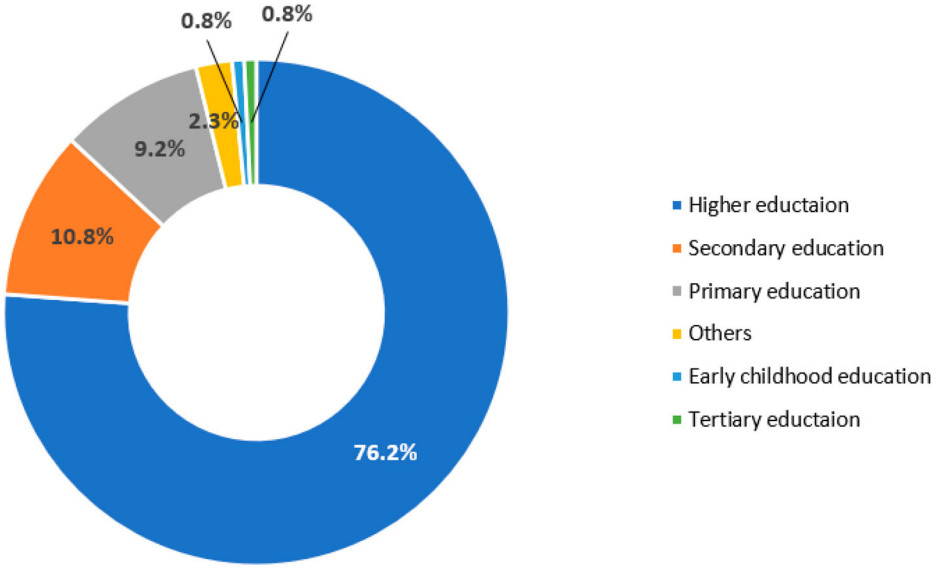


Figure 8. Distribution of students by education level.

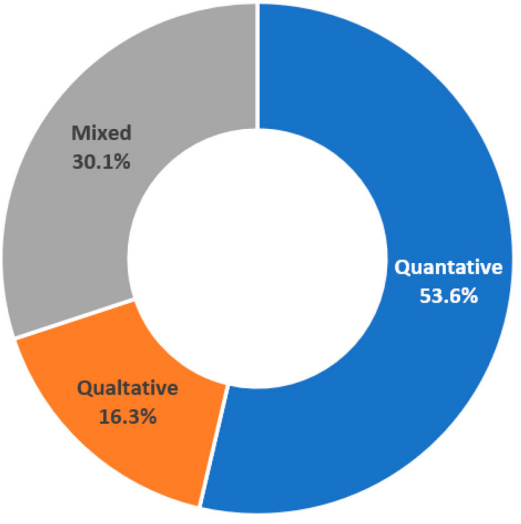


Figure 9. Research methods used in the e-book in education studies.

reports is considered as a limitation (Brenner & DeLamater, 2016). An additional problem or constraint with questionnaires is that they cannot reflect deep insights into the learning process, such as the students' learning behaviors and learning paths while they are using an educational system (i.e. e-books in this study). In this case, big data and learning analytics can be an alternative approach to overcome this challenge by collecting students' log data related to e-book usage and analyzing it to provide additional insights. Notably, as shown in Table 3, only nine studies relied on learning analytics for their research on e-books in education. Such low usage of big data and learning analytics could be because designing intelligent e-books that use learning analytics systems can be complicated. Therefore, future research might focus on investigating how to incorporate learning analytics to design e-books that can be intelligent and support the learning process in different ways (e.g. personalization, assessment, etc.).

3.5. Learning scenario

Table 4 presents the distribution of learning scenarios using e-books. The findings showed that there are four learning scenarios of using e-books in education. Most research studies to date have focused on using e-books *during class* ($n = 32$); followed by studies focusing on using e-books *before, during,*

Table 3. Distribution of the instruments used in the reviewed studies (Note: some studies used multiple methods).

Instrument	N	%
Case studies	4	2.5
Focus groups	7	4.4
Test	8	5.0
Observation	9	5.6
Log data analysis	9	5.6
Interview	26	16.3
Questionnaire	97	60.6
Total	*160*	*100*

Table 4. The distribution of learning scenarios using e-books in the reviewed studies.

Learning Scenario	N	%
Use e-books during class	32	26
Use e-books before class	2	1.6
Use e-books during and after class	2	1.6
Use e-book before, during, and after class	16	13
Use e-books in experiments	27	22
Did not use e-books in any learning scenario	44	35.8
Total	*123*	*100*

and after class ($n = 16$); *before class* ($n = 2$); and, *during and after class* ($n = 2$). The adaptation of e-books through different scenarios (e.g. before, during, and after the classes) can be related to trending blended and hybrid pedagogies (EDUCAUSE, 2021) which requires using learning materials, more specifically digital ones such as e-books, in different sequences of the classes.

When using e-books before class, the main goal was to allow students to familiarize themselves with the e-book materials and learn before the course starts (Brooks & Taylor, 2016). Using e-books before class can encourage students to be more active and involved in the learning process, including warm-up exercises and a brief preview of some of the new content available via Web-based multimedia (Wang, 2009). For example, Oi et al. (2015) allowed students in an information science course to use e-books before class. Their results showed that by previewing e-books in advance, students spent more time participating in the learning process. Despite the importance of using e-books before class, only two studies adopted this learning approach. Clearly, there is a pivotal gap in the research in terms of understanding the effects of using e-books before class in a flipped learning mode.

As indicated, in contrast to the use of e-books before class, most studies to date have used e-books during class ($n = 32$) as the main reading material for students (Shin, 2014). For example, in a language class, students used an e-book to search for words with interactive dictionaries, and make sentences with the new words that they have learned (Lin, 2017). In science lessons, the students also have the possibility to use the note functions of the e-book by highlighting key sentences and vocabulary, sharing notes, and participating in exercises such as quizzes and tests with multiple-choice questions (So et al., 2019).

Considering the portable feature of e-books, which allowed them to be used in assorted locations, such as schools and homes , several studies ($n = 16$) used e-books before, during, and after class. For example, in a psychology course, students had to go through several reading materials before class. During class, while interacting with the teacher, the students took notes while browsing the e-book content and highlighting or underlining key information. Finally, after class, students utilized the e-book resources to revisit the learning materials and prepare for exams (Clinton-Lisell et al., 2020).

Few studies ($n = 2$) used e-books during and after class. During class, students can complete different reading tasks, while after class, students can complete the homework assigned by the teacher on the e-book to strengthen their memory of the learning materials (Lin, 2014). For example, in a political science course, the students can interact with the e-book in a timely manner in class to take notes online. After class, they can deepen their understanding and recall of materials through notes and assorted review activities (Slocum-Schaffer, 2021).

Our study also found that there are correlations between the different learning scenarios of using e-books and students' educational levels. For instance, in the *use of* e-books *during class* learning scenario, most of the students are from high education ($n = 25$), followed by primary education ($n = 6$), and secondary education ($n = 1$). In terms of students from higher education, it is can be said that they usually interact directly with e-books in the classroom by, for instance, sharing their own notes and reading materials with classmates (Shin, 2014), taking quiz, and interacting with

multimedia (So et al., 2019). For students from primary education, they are more likely to use e-books to play games. By presenting the content of e-books in the form of images and simulations, they combine knowledge with gameplay for better learning attention and engagement (Chen et al., 2019). In the learning scenarios of *before class, during class and after class*, most of the participants' education levels are students of higher education ($n = 14$), and only two participants' education levels are from students of secondary education. This is because self-directed learning is a core component of university teaching methods , which provides higher education students more freedom in learning. For instance, they can preview, highlight, search, and mark content before class according to their needs (Clinton-Lisell et al., 2020; Hendrix et al., 2016). During class, they can quickly navigate based on notes marked before class or shared with peers (Dobler, 2015). After class, the students can take a quiz to review what they learned and complete course-related assignments (Slocum-Schaffer, 2021). Although there were only two students from secondary education, their use of e-books in this learning scenario showed similarities with students from higher education. In a study by Gelderblom et al. (2019), allowing high school students to use e-books, it was found that students performed similar tasks before, during, and after class, including searching for specific sections, highlighting text, and creating summaries, add notes, and open resources added by educators.

3.6. Design

Table 5 shows the distribution of the reviewed studies related to each design dimension. In terms of technology access, most e-books were Web-based ($n = 82$), whereas only a dozen studies were dedicated to mobile devices ($n = 12$). It is plausible that the preference for Web-based technology allows for more flexible access by different devices, and users are allowed to choose their preferred devices based on their different skills and knowledge (Hilbert & Trevor, 2004). However, this is not the case for mobile devices where some applications or platforms are designed for a specific mobile operating system (e.g. Android, iOS, etc.) and cannot work on all mobile devices.

In terms of interaction, Table 5 shows that 21% of e-books were designed with only Level-1 interaction, while 26.8% of the studies were with only Level-2 interaction. Level-1 implies that users are passive, where they act solely as information receivers, whereas Level-2 implies that users have limited participation, such as making simple responses to instructional cues (Bozkurt & Bozkaya, 2015). In effect, the researchers considered that simple reading of e-books does not provide highly useful functionalities for students, such as highlighting, bookmarking, or writing notes (Bidarra et al., 2015). Additionally, as displayed in Table 5, only 24% of the designed e-books in education have high levels of interactivity (Level 3 and Level 4 interaction). Level-3 interaction implies that users have complex participation and make a variety of responses to instructional cues. In contrast, while Level-4 interaction implies that users can experience real-time participation, including being involved in a life-like set of complex cues (Bozkurt & Bozkaya, 2015).

The low level of interactivity within e-books revealed in this study might be due to designers and publishers lacking the financial resources or technology skills to enhance the e-book experience. For instance, Gu et al. (2015) reported that in some cases, e-books were simply an electronic copy of the paper version. Additionally, poor copyright rules, writers' concerns about co-creation, and a lack of competence in developing interactive narrative and multimedia content all hampered the production of interactive e-books (Fahimnia et al., 2021). Therefore, in future research, educators and e-book designers can promote experiential learning and multi-modal learning methods through innovative functions, and use richer interaction design in e-books to solve this problem. Furthermore, the present systematic literature review did not find enough data that could be analyzed to reveal if there is any relationship between the electronic devices used for learning and e-book interaction functionalities. Therefore, future research directions could also focus on this topic.

Additionally, when discussing the design dimension in e-books, it is found that e-books have a significant positive impact on students' learning outcomes. The timely feedback function of

Table 5. Distribution of studies according to the design features of e-books.

Category	Design	N	%
Technology	Web-based	82	66.7
	Mobile-based	12	9.8
	Web & Mobile-based	1	0.8
	Not mentioned	28	22.8
Interaction	Level 1	26	21.1
	Level 2	33	26.8
	Level 3	19	15.4
	Level 4	12	9.8
	Not mentioned	33	26.8
Intelligence	Assessment & Feedback	8	6.5
	Recommendations	2	1.6
	Learning analytics & Visualizations	5	4
	Not mentioned	108	87.8
Openness	Not open	35	28.5
	Provide only open access	11	8.9
	Use open license	4	3.3
	Not mentioned	73	59.3

the device, interactive mini-programs, and learning materials can form a good interaction with students, thereby motivating them to learn more things, whether it is at home or school (Radović et al., 2020). E-books are designed to meet the teaching and learning needs of learning, allowing for a high degree of interaction and feedback during the learning process (Radović et al., 2020). It is seen that the e-book device itself and its interaction design can create a positive relationship and enjoyment between the learner and the material. The relationship between interactive e-books and devices was found in a study by Allred and Murphy (2019). MindTap's program was used in the study to automatically collect analytical data from each student user and aggregate the data online for teachers to observe and analyze. The research has shown a significant positive correlation between student engagement in the device and the interactive activities accessed (Allred & Murphy, 2019).

From an intelligence perspective, Table 5 shows that most of the studies did not discuss smartness in their e-books, while only few focused on this perspective. This systematic review of the research indicates that intelligent e-books in education were used to achieve three key objectives:

(1) Automatic assessment and feedback ($n = 8$). The design of automatic assessment and feedback provides support for students' learning in the form of graded assistance according to students' learning needs. By providing automatic feedback and assessment, students have opportunities for autonomous learning in e-books (Lin, 2014; Reinhold et al., 2021). For example, when a student makes a mistake in a math problem, the e-book can directly point out the mistake and provide tips for solving steps (Hoch et al., 2018);
(2) Student supervision through learning analytics and dashboards ($n = 5$). E-books in education were used to collect and analyze students' log data to provide insights for teachers about the learning process (Allred & Murphy, 2019). Teachers can then, for instance, consider the relationship between students' time spent on e-books and the outcomes of new concepts in the course based on log data (Hoch et al., 2018). E-books also provide learning dashboards for students to enhance their interactivity with the system (Fouh et al., 2014); and

(3) Automatic recommendations for students in terms of the most suitable exercises or books based on their learning data. For instance, Fouh et al. (2014) showed that e-books can recommend personalized exercises for students based on their participation in the system and allow students to repeat the exercises. This review of the research indicates that there is a need for more research on how to harness the power of artificial intelligence (AI) and big data to design intelligent e-books that could enhance the learning process for students and the overall learning outcomes.

As displayed in Table 5, most studies in this systematic review did not mention the openness feature ($n = 73$) within e-books or the e-books were not open ($n = 35$). For those open e-books in education, the degree of openness varies from one study to another. For instance, 11 studies focused only on providing open-access to e-books, allowing students and instructors to have access to the entire course materials and modules for free (e.g. Kinskey et al., 2018). For students with financial difficulties, open-access can reduce the burden of buying textbooks (Johnston et al., 2015). Four studies, on the other hand, provided e-books as open educational resources (OER) under an open license.

The inclusion of an open license in an e-book means allowing others to use or re-use the teaching, learning, and research resources released under the intellectual property license for free (Fischer et al., 2015). The findings revealed that most e-books with open licenses can be used and modified for free. In addition, the electronic versions of these books can be accessed on multiple types of devices and reused in various environments (Fischer et al., 2015; Hilton III et al., 2013). Open license can also save a lot of money for students and teachers in the learning environment. For example, Hilton III et al. (2013) mentioned that if all 2,043 students in their study buy a textbook for $125 and use publicly licensed free online materials, over $255,000 USD would have been saved. On the other hand, open licensed e-books have limited interactive functionalities. For instance, Wong et al. (2016) showed that the functionalities given to teachers when using open e-books were limited to editing images, videos, and web pages. This made them less interested in using open e-books (Wong et al., 2016). On top of the technical issues, there are also huge barriers to the development and maintenance of open e-books . Although open license brings many benefits to students and teachers, the current findings make apparent that open e-books in education under open license are still scarce, calling for more research in this context. Therefore, future research could investigate how open e-books should be designed especially in terms of their interactive functionalities, and how they could contribute to the quality and inclusive education, which is one of the main goals of SDG4 by the United Nations.

3.7. Outcomes and challenges

Figure 10 analyzes the psychological and behavioral outcomes of using e-books in education. In terms of psychological outcomes, participants' attitudes towards e-books are the most investigated outcome ($n = 85$), followed by engagement ($n = 34$), and motivation ($n = 17$). Five studies discussed e-books and their impact on students' self-regulation and autonomy and two studies mentioned how the use of e-book can improve students' critical thinking. As for behavioral outcomes, 45 studies examined the impact of using e-books on academic performance, followed by seven studies on skill acquisition, six on social interaction, and six on participation in the e-book system. It should be noted that several studies investigated more than one outcome.

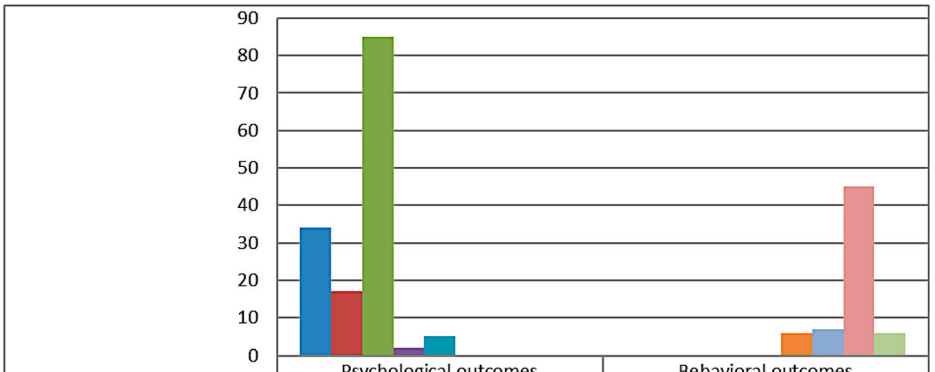
In terms of psychological outcomes, 85 studies discussed the different attitudes towards the use of e-books by students and teachers. Notably, 35 papers are mixed with students showing both positive and negative attitudes. In addition, 37 studies have positive attitudes only and 13 studies have negative attitudes only. Positive attitude is mostly connected with the different functionalities offered by e-books in education, such as searching and navigating (D'Ambra et al., 2020), note-taking or text highlighting (Johnston & Ferguson, 2020), bookmarking (Al-Qatawneh et al., 2019), and sharing (Cuillier & Dewland, 2014; Dobler, 2015), resulting in interactive reading and learning

experience. Using e-books can make the reading material more engaging, resulting in more effective learning outcomes (Johnston & Ferguson, 2020; Slocum-Schaffer, 2021).

Importantly, one reason for favoring e-books over printed books is their portability and accessibility. E-books are considered lightweight and convenient to bring along. Therefore, it is very convenient for students to get access to the learning material without the constraint of time and location (Al-Qatawneh et al., 2019; Broadhurst, 2017; Hendrix et al., 2016; Millar & Schrier, 2015; Muir & Hawes, 2013; Mulholland & Bates, 2014; Shelburne, 2009; Tang & Barnett-Ellis, 2016).

As revealed in Table 6, negative attitudes toward e-book technology can be explained by several pressing factors including functionality problems, inconvenience of accessibility, physical and psychological burden caused by electronic devices, negative impact on learning outcomes, privacy and copyright problems, and concern of the cost. Functional problems are mentioned most frequently by participants. For instance, students have problems in downloading the learning materials, searching and navigating problems, and annotating and highlighting the text, as well as flipping through pages and switching from one window to another (Gelderblom et al., 2019; Jamali et al., 2009; Shelburne, 2009). Moreover, technical problems such as lack of stable internet access and compatibility can hinder the accessibility of the e-book (Pratt et al., 2019).

Electronic devices have burdens on learners physically and psychologically: some participants reported tired eyes, fatigue, and headaches due to being exposed constantly to screen lights while using e-books in education (Anuardi et al., 2020; Dwyer & Davidson, 2013). Some teachers also have a high level of anxiety when using e-books because of a possible increase in their working load (Chiu, 2017). E-books can have negative impacts on learning by causing distraction. The distraction can come from the electronic devices itself or from the large number of Web pages incorporated in the e-book (Dobler, 2015). Another concern related to e-books is that it reduces the control over plagiarism (Shelburne, 2009). Besides, while e-books often enable students to obtain access to many free learning resources, some learning resources can be expensive. Adding to such concerns is the fact that compared with printed books, which can be resold after use,



	Psychological outcomes	Behavioral outcomes
Engagement	34	
Motivation	17	
Attitude	85	
Critical thinking	2	
Self regulation/Autonomy	5	
Social interaction		6
Skill acquisition		7
Academic performance		45
Participation in system		6

Figure 10. Distribution of learning outcomes based on the number of studies addressing them.

Table 6. Challenges identified in e-books in education studies.

Category	Challenge	N	%
Students	Increase reading time	8	5.4
	Increase academic anxiety	2	1.4
	Unfamiliar the e-textbooks use	29	19.7
	Visual fatigue	13	8.8
	Distracts students	7	4.8
Teachers	Unfamiliar the e-textbook use	19	12.9
	Visual fatigue	2	1.4
	Time consuming	4	2.7
	Increase teaching anxiety	1	0.7
Technologies	Cost	8	5.4
	Storage capacity	4	2.7
	Battery life	3	2
	Screen size and resolution	4	2.7
	Internet connectivity	5	3.4
Design	Poorly designed	19	12.9
	Accessibility	4	2.7
	Usability	6	4
License	Copyright and ownership	9	6.1

purchasing e-books is often a one-time, nonrefundable investment (Pratt et al., 2019; Terpend et al., 2014).

Student engagement in e-book-related learning activities is evaluated in 34 studies. Most studies suggest that using e-books can increase students' engagement in learning by increasing the time spent on e-book activities and resources deepening students' understanding of the learning materials (Abuloum et al., 2019; Alhammad & Ku, 2019; Daniel & Woody, 2013; Sheen & Luximon, 2021). There are also opposite outcomes. For instance, Dobler (2015) found that using e-books can negatively impact students' cognitive engagement. Students tend to skim more and to skip around within the text, and are easier to be distracted more easily when using e-book.

Seventeen studies discussed the influence of e-books on students' learning motivation. Generally, it is reported that using e-books can increase students' learning motivation (Al-Qatawneh et al., 2019; Alsalhi et al., 2020; Kirk et al., 2012; Radović et al., 2020). According to Kirk et al. (2012), the interactive interface of e-books will help learners to retrieve information more quickly and easily improve learners' attentiveness and comprehension, as well as make learning more pleasurable. Moreover, Rockinson-Szapkiw et al. (2013) suggest that students who used e-books in class had significantly higher perceived affective learning and psychomotor learning than students who used print books. However, a contrary finding comes from Chen et al. (2019) who suggest that only game-based e-books can improve students' comprehension and learning motivation whereas conventional e-books can reduce students' learning motivation.

The results of these studies imply that type (e.g. plain, multimedia enriched, etc.) and design (e.g. interactive, game-based, conventional, etc.) of the e-books are significant factors to investigate and understand the influence of e-books on students' learning motivation. Other studies are in line with this view. For instance, it is reported that e-books can encourage students to use learning strategies such as learning planning, monitoring, and self-regulation because e-books allow students to interact, browse additional resources, videos, and animations, and explore materials (Rockinson-Szapkiw et al., 2013). Similarly, research from So et al. (2019) suggests that students who are given more autonomy during e-learning can conduct more effective and meaningful self-regulated learning.

In terms of behavioral outcomes, 45 studies discussed the influence of e-books on students' academic performance. For instance, Slocum-Schaffer (2021) and Rockinson-Szapkiw et al. (2013) found no differences in students' academic performance between using printed books and electronic books. Similarly, Marie Johnson (2016) suggests that the association between e-books and achievement may not be well established. There are also studies reporting that the use of e-books can improve learning outcomes (Broadhurst, 2017; Dobler, 2015; Hung et al., 2018). Rockinson-Szapkiw et al. (2013) suggest that e-books can provide scaffolding, allowing students to use cognitive tools when needed, thereby improving their achievement. Alhammad and Ku (2019) suggest that searching functions help students to learn more efficiently.

Since many e-books are used in reading classes, there is no surprise that using e-books improves students' reading and writing skills (Huang, 2013; Lin, 2014). The interactive function of e-books enables students to develop the skill of information searching. Students learn to get access to new learning materials and discover new tools (Chou, 2016; Tang & Barnett-Ellis, 2016). Moreover, the experience of using e-books enables students to be more proficient in handling electronic materials.

E-books can increase the social interaction between peers by developing a sense of community and ongoing interaction with peers (Huang, 2013). For example, Dobler (2015) suggests that using e-books can create connections among group members who share the experience of reading the same digital text. Often, when this occurs, group members can pose a question about the text and receive a reply in the small group.

E-books can also enhance the interaction between students and teachers as it can prompt feedback, collaboration, and interaction between educators and students (Armstrong & Lonsdale, 2005; Wiese & Du Plessis, 2017). The widely used annotation feature of e-books facilitates social interaction and collaboration (Kalir, 2020) which means that e-books can be considered more than just tools to deliver information; instead, they are a learning space where students can socially interact, communicate, and collaborate. While several studies investigated the impact of e-books on students, limited studies have investigated how students with different individual differences (e.g. personality, cognitive load, etc.) might perceive e-books in education. Luik and Mikk (2008) suggest that the use of e-books can have different influences on different types of students. Therefore, future research studies could focus on this topic, which can contribute to developing personalized e-books in education.

Table 6 presents the identified issues and challenges in the e-book in education studies. The findings show that several key challenge categories should be considered when developing e-books in education. For instance, for teachers and students, their unfamiliarity with the features and functionalities of e-books (19.7% of the studies reported this challenge for students and 12.9% of the studies reported this challenge for teachers) is one of the common concerns. Eltahir et al. (2019) indicated that teachers and students may be accustomed to using printed books instead of e-books, and, therefore, do not have enough experience in using them. In addition, students and teachers may also lack previous e-book use training, resulting in an insufficient understanding of e-book functions (Eltahir et al., 2019; Wong et al., 2016). Additionally, another major challenge faced by students and teachers is visual fatigue, with ratios of 8.8% and 1.4% respectively (see Table 5). Verkuyl et al. (2020) reported that students and teachers had many difficulties after using e-books for a long time, such as eye strain.

The findings also show that technology and the poor design of e-books can hinder their use in education. For instance, research on students and teachers has found that e-books are difficult to use because the interface is poorly designed, which leads to an uncomfortable online reading experience or tiredness (Muir & Hawes, 2013). From the technology perspective, the size and resolution of electronic screens can also cause headaches or poor visual experiences for students and teachers, due to screen freshness, contrast level, and screen light fluctuations (Brown et al., 2016; Gunawan, 2018). Finally, copyright and ownership of e-books are among the key challenges reported by teachers and students (Delimont et al., 2016), as described in 6.1% of the studies reviewed. Students and teachers worry about whether e-books could be used for a long time and whether they can be

reused or sold to others again due to copyright issues (Terpend et al., 2014). In order to avoid the challenges that licenses bring to teachers and students, future research can explore whether the use of open e-books will face the same difficulties.

In sum, it was seen that most of the outcomes and challenges have already been continuously reported in several studies thus far, implying a bottleneck in research on e-books in education. This observation is also linked to the tendency to use the same research methodologies (see Figure 9) and data collection tools (see Table 3) which signal that there is a need to focus on uncovered issues such as user experience design, interaction design, and financial impacts of the use of e-books in educational settings. However, considering the scope of this systematic review is the analyze of the current state of the art of e-books in educational settings, discussing these issues is beyond the purpose of this study and can be considered as a call for future research directions.

4. Conclusion and implications

This study presents a systematic literature review of empirical papers on e-books in education from multiple dimensions, including research methods, participants, education field, the design of e-books, the extent and timing of use (i.e. learning scenarios), and the advantages and challenges of using e-books in education. Despite the myriad advantages of e-books in education, several challenges and issues are also identified that need to be considered for a better teaching and learning experience. Additionally, different outcomes were identified when investigating the use of e-books.

The findings of this study can promote the use of e-books in education and help to understand how students interact with e-books from a psychological and behavioral perspective. The effectiveness of e-books can provide teachers and students with many learning resources and paths. The current research emphasizes the challenges that students and teachers encountered when using e-books in the 123 reviewed studies. For instance, the study found that students and teachers need to conduct e-book training before using e-books in order to improve students' learning efficiency and motivation, and to enable teachers to understand how to combine e-books and teaching methods to create a richer and more effective learning environment.

In the future, more intelligent e-books in education should be designed and tested to enhance the overall learning experience. The openness of e-books has also brought insight into the learning process as well as hope for more equal access to education.

Based on the findings of this study and identified gaps in the related literature, the following suggestions can be considered for future research implications. In terms of a macro (national or international) level, the financial aspects and outcomes of e-books in education can be researched. The results of the study show the benefits of open e-books, such as lowering student financial burdens and the availability of learning from e-books in a variety of educational settings (Fischer et al., 2015; Johnston et al., 2015). Additionally, it is considered that such a research direction contributes to the United Nations Sustainable Development Goals (SDG), more specifically Goal 4 which covers issues such as equity, social justice and promotion of lifelong learning as they are highly related to financial dimensions. Furthermore, as the obtained results show that the adoption of e-books in education is still fragmented. Cross-country collaborations related to launching policies and initiatives about designing and adopting e-books in education should be established. This might catalyze the adoption of e-books worldwide. In terms of micro (individual) level, future research can focus on issues such as motivation and perception of using e-books in educational settings by employing theoretical lenses (e.g. Technology Acceptance Model – Davis, 1989; Theory of Multimedia Learning – Mayer, 2002) which would help us to get deeper insights and go beyond technological aspects of using e-books in educational settings. Besides, considering that many stakeholders are involved in regarding the use of e-books in educational settings (e.g. authors, users/readers, libraries and educational institutions, publishers and retailers), there is a need for multilayered and multidimensional studies that examine the e-books in situ.

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