

Taking Design Thinking to Classroom: A Systematic Literature Review Over a Past Decade

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Abstract : Design thinking (DT) is not only well known in the business field as a user-oriented product design approach. Still, it has also penetrated the field of engineering education as an innovative tool to promote various skills. This paper aims to provide a systematic literature review on the implementation of DT in education that outlines trends and comprehensive content analysis to give more study direction for researchers and educators. A total of 23 papers addressing DT in education published between 2010 and 2021 from Springer were analyzed. The researchers reviewed the distribution of publications in DT by year, journals in which DT studies were published, educational areas of selected papers, the typology of chosen articles, the DT mindsets, and content analysis of DT implication to skills development. The results show that DT publications have fluctuated in number in the last decade and peaked in 2020 with 11 articles. International Journal of Technology and Design Education, Journal of Formative Design in Learning, and TechTrends are the three journals that publish the most studies on DT in education. Teacher education is where DT is most often implemented among the reviewed papers, and educational experiments are identified as the dominant typology. Nine mindsets serve as the basis for implementing DT in education, with human-centeredness being the primary mindset. DT as

innovative learning supported the development of various essential skills such as creativity, collaboration, problem-solving, teacher professional development, self-direction, empathy, communication, decision-making, digital skills, and global and intercultural awareness.

Keywords : Systematic literature review; design thinking; education; research trends.

I. Introduction

Nowdays, integrated approaches to Science, Technology, Engineering, and Mathematics (STEM) education are increasingly attracting attention among educators and researchers worldwide (Irwanto et al., 2022). Given the increasing relevance and interest of integrated approaches to STEM education, educators are expected to adopt this approach to assist students to solve their real-life problems by applying cross-disciplinary concepts (Shernoff et al., 2017; Wahono et al., 2021). In this regard, design thinking is becoming increasingly crucial in STEM education as they are indispensable for promoting creativity, problem-solving, and innovation among students (Arifin & Mahmud, 2021). Historically, Design Thinking (DT) emerged in the early 2000s as an innovative approach for business policymakers (Carlgren, 2013). Basically, DT is rooted in a human-centered approach that is widely applied in the business field to develop products and services that suit the user's needs (Liedtka, 2015). The design was the starting point in a development process—where designers played a very substantive role in producing

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innovative work. The design approach is becoming more popular because it can stimulate market demand growth in many areas by developing new and attractive products and technologies according to user needs and expanding advertising strategies through intelligent communication (Brown, 2008).

DT is basically about the skills needed for creative problem-solving (Simeon et al., 2020). According to Brown (2008), design thinking is an iterative process that provides great potential for turning problems into opportunities. Through this iterative process, DT provides opportunities for creativity development (Hokanson & Kenny, 2020). Therefore, DT is gradually applied in education as a learning by doing method to change students' mindsets that encourage them to be active in learning as creators. According to Eftekhari (2019), DT is an innovative learning method that encourages students to apply their knowledge to actual applications in real-life situations. Thus, DT can be defined as a holistic approach that provides opportunities for students to think outside the box to solve real-life problems innovatively.

DT has been widely developed in pedagogical practices in varied ways (Lor, 2017; Luka, 2020). For example, Goldman and Kabayadondo (2017) argued that process-based is the dominant domain of DT than content-based. Therefore, they concluded DT entwines the learning by doing methodology to shift the learner paradigm from the passive to confident creators. Moreover, Luka (2020) in his previous study pointed out DT as an excellent tool to be applied in the teaching and learning process to develop 21st century skills. In constant, Wrigley and Straker (2017) strongly recommended DT as a pedagogical practice tool in developing effective project development strategies and producing more valuable outputs in order to promote students' future personal and professional skills.

However, the foregoing studies found that the design-based learning approach is still rarely used, but Friesen and Jacobsen (2015) analyze that its application increases learning and practice in teacher education. This finding is in line with research conducted by Zinger et al. (2017), which states that a design-based approach is applied to develop teacher professionalism in preparing to learn, using online content sources, and providing meaningful learning experiences through a process of giving iterative feedback. Therefore, this paper examines research articles to explore trends that integrate DT into

education and investigates DT practices and their impact as findings from the research articles. The information generated from this paper may help researchers and educators understand the development of research in this area and plan for further exploration. The articles involved in writing this paper are published by Springer, one of the largest publishers on a global scale which has issued millions of scientific studies from various scientific disciplines.

Research trends in design thinking have been documented in previous reviews. For example, Arifin and Mahmud (2021) conducted a systematic literature review of 7209 articles between 2016 and 2020 from six databases. They noted that appropriate learning approaches that apply design thinking are problem-solving, design activities, and collaborative learning. Also, Rusmann and Ejsing-Duun (2021) conducted a literature review of 39 studies up to mid-2018 from four databases. They reported that design thinking in the context of K-12 has the potential to improve students' communication, collaboration, and critical thinking skills. In systematic content analysis, Baker and Moukhliiss (2019) explored the concept of design thinking from 12 academic databases and found that worldwide interest in the term design thinking increased steadily from January 2004 to its peak in November 2018. To the best of our knowledge, no papers explore the application of DT in education, in general, using a systematic literature review with a range of the last ten years until the end of 2021. Whereas, DT has a great potential to develop students' future personal and professional skills endeavors. Therefore, this study provides a comprehensive picture for researchers and educators to conduct further research on the integration of DT in education and publicize their future work. The research questions set out in this study are:

1. What is the trend of DT publications in education during the period 2010-2021?
2. Which journals are published by Springer that regularly publish DT in education between 2010 and 2021?
3. Which education area has the most publications related to DT in the 2010-2021 period?
4. Which type of typology has the highest frequency in DT research in the field of education in the period 2010-2021?

5. What mindsets are used in implementing DT in education in the period 2010-2021?
6. What are the implications of DT in education on developing various skills in the 2010-2021 period?

2. Methodology

This study adapted Systematic Literature Review (SLR) protocols developed by Acebo et al. (2021) to explore design thinking research trends in the education sector. The SLR stage is carried out through three stages: planning of the review, conduct of the review, and reporting and dissemination (Tranfield et al., 2003). In the planning of the review stage, the fundamental questions from the research are prepared, and determine the database will be used as a source of information. Researchers collected journal papers with the theme “Design Thinking in Education” comprehensively from the Springer database (<http://link.springer.com/>) with a publication period of 2010-2021. The keywords “Design Thinking” or “Design-Thinking” were used in conducting searches with the limitations of “article” on the content type, “Education” on the discipline section, and “English” on the language used.

Next, the researchers conducted a review by identifying papers that follow the research objectives. Only articles met the inclusion criteria included in the review process. The researchers selected the specific measures: 1) papers published in English from January 2010 to September 2021 period, 2) containing the concept of “design thinking” in the title and abstract, and 3) publication in the form of books, book chapters, proceedings, editorial, and web pages were excluded from the analysis. Figure 1 is a flowchart of the selection process for the articles reviewed.

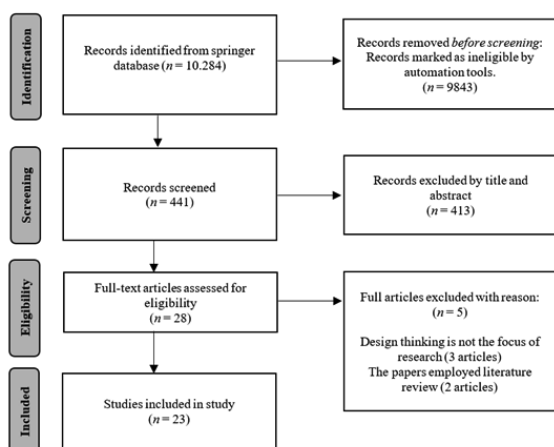


Fig. 1 : Prisma Flow Diagram for SLR

A total of 441 articles spread across 36 educational sub-disciplines were obtained from the search process in the database. Researchers identified titles, abstracts, and keywords to ensure the papers taken are relevant to the research objectives. Furthermore, to select the documents used in the analysis process, the researchers double-checked and read the entire contents of the articles carefully to ensure the accuracy of the selected papers to produce a comprehensive SLR. Based on the selection process, considering the inclusion of the specified criteria, the 23 relevant articles were obtained and selected for review.

In the final stage, researchers synthesized primary papers by identifying the key emerging and research questions to report findings. The variables that will be discussed in this paper are: 1) Distribution of publications in design thinking by year, 2) Journals in which design thinking studies were published, 3) Educational areas of selected papers, 4) The typology of selected papers, 5) The design thinking mindset, and 6) Content analysis of design thinking implication to skills development.

3. Results and Discussion

This section presents the analysis results of selected papers obtained from the Springer database in the period 2010-2021. The results of the study consist of seven parts: annual publications of DT in the educational field with and without DT included in the papers' title and abstract, journals that regularly publish DT in education, areas of education that are the focus of DT research, research typologies used in the application of DT in the field of education, the DT mindsets, and the implications of DT in developing various skills.

A. Distribution of Publications by Year

This section is pointed out the popularity of design thinking in education publications over the 2010-2021 period. The distribution analysis shows that the number of design thinking publications fluctuated in the last decade (Figure 2).

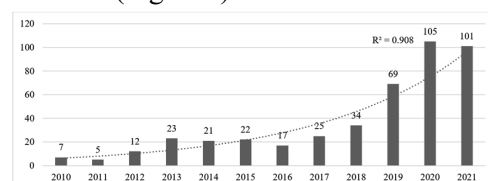


Fig. 2. Design Thinking in Education Research Trends over 2010-2021 (n = 441)

Figure 2 shows that the educational field's annual volume of DT research fluctuates from the period 2010 to 2021. The peak of publications was identified in 2020. However, this number is only four articles different from 2021, which may still experience an increase in the number after this study is carried out. For a more in-depth analysis, all papers obtained from the Springer database are filtered by applying the inclusion and exclusion criteria that have been determined: the date of publication, discipline area, the language used, accommodate the term of DT in the title and abstract, and limited to the type of publication in the form of articles.

The results of the study until September 2021, as many as twenty-three papers, were selected. The selected papers were published in 2013, 2015, 2019, 2020, and 2021; 11 out of 23 were published in 2020 (see Figure 3). In particular, in the last three years, there have been significant developments. In 2019, DT publications only reached 8.69% and experienced their maximum annual volume with a drastic increase up to 550% in 2020.

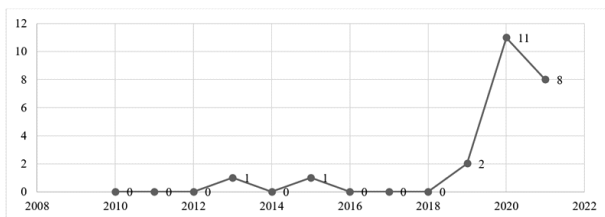


Fig. 3. Distribution of Design Thinking in Education Article Included in Study (n = 23)

The current study provides comprehensive results from the previous literature to provide direction and predictions that the topic of DT will get more attention to be applied in education in future research. It can be seen clearly by the significant increase in publication volume in the last three years. This finding is in line with previous studies (Acebo et al., 2021; Paula & Cormican, 2016). For example, Paula and Cormican (2016) conducted systematic mapping studies of forty-two selected papers from 2000 to 2015 related to DT in the design studies journal published by Elsevier. In the results of their research, they found that the peak volume of DT publications in design studies occurred in the 2009-2011 range with six articles and then decreased, until finally peaking again in 2015. Recently, Acebo et al. (2021) analyzed the implementation of DT in education, especially technical education. A total of 83 articles obtained from the ISI Web of Science database in the period 1987-2018 were analyzed. Their paper shows that

publications with the theme of DT in education began to fluctuate and peaked in 2016 and 2017. Nine journals published by Springer were identified as publishing DT topics in education. The highest percentage of selected papers published in International Journal of Technology and Design Education is 26.09%, followed by TechTrends and Journal of Formative Design in Learning with the same percentage, which is 21.74%. The high number of DT publications in the first and second journals may be possible because the journal titles clearly accommodate the design terms. Meanwhile, TechTrends explicitly explains that the journal aims to provide a means for practitioners to keep up with the latest developments in design. Therefore, these results provide an overview of journals that researchers can address to publish their work on the topic of DT in the field of education.

B. The Number of the Papers in Journals

In order to answer the second research question, Table 1 presents the list of the journals where the DT research in education was published in the 2010-2021 period.

Table 1 : Published Papers By Journals

Journal	N	%
International Journal of Technology and Design Education	6	26.09
Journal of Formative Design in Learning	5	21.74
TechTrends	5	21.74
Perspectives on Medical Education	2	8.70
The Asia-Pacific Education Researcher	1	4.35
Journal for STEM Education Research	1	4.35
Educational Technology Research and Development	1	4.35
Innovative Higher Education	1	4.35
International Journal of STEM Education	1	4.35
Total	23	100

C. Educational Areas of Selected Papers

Aiming to respond to the third research question, Table 2 provides the list of the educational area where DT was integrated during the 2010-2021 period.

Based on the results of a study of twenty-three selected papers, it reveals the essential characteristics of DT applied to teacher education (30.43%), followed by higher education (17.39%) and multidisciplinary learning (13.04%). The study obtained surprising results that design education was one of the minor areas where DT was implemented (4.35%). In addition, it was identified that in the 2010-

Table 2 : Educational Area of Selected Papers

Educational Area	<i>N</i>	%
Teacher Education	7	30.43
Higher Education	4	17.39
Multidisciplinary	3	13.04
Educational Technology	2	8.70
Medical Education	2	8.70
Interdisciplinary	1	4.35
Science Education	1	4.35
Primary Education	1	4.35
Secondary Education	1	4.35
Design Education	1	4.35
Total	23	100

2021 period, DT began to be applied in medical education (8.70%). This phenomenon can be explained based on the fact that DT is rooted in a human-oriented approach.

Current educational demands are pushing for expanding students' learning experiences to prepare them for complex global challenges (Henriksen et al., 2020). Thus, pedagogical practice must be directed towards a human-centered framework in the context of the challenges of contemporary society. Therefore, DT is more popularly implemented in teacher education to build a framework for overcoming the challenging problems educators tackle in their pedagogical practice (Friesen & Jacobsen, 2015; Henriksen et al., 2020). Besides being useful as a pedagogical tool for students, DT provides excellent potential for teacher professional development (Zinger et al., 2017). If teachers want to cultivate a design-oriented epistemic view, they must have firsthand experience by engaging in design practice (Chai et al., 2013). One of the frameworks that are a means to encourage DT in educators is TPACK (Technological, Pedagogical, and Content Knowledge) (Mishra & Koehler, 2006).

D. The Typology of Selected Paper

Aiming to identify the research typology of the selected papers, the researchers refer to the typology categories used in research conducted by Acebo et al.

Table 3 : Typology Categories Of Selected Papers

Typology	<i>N</i>	%
Educational Experiments	18	78.26
Theoretical	3	13.04
Real Experiences	2	8.70
Total	23	100

(2021). The twenty-three selected papers were classified into three research typology categories as shown in Table 3.

Of the three categories, it is identified that the educational category of experiments has the highest frequency compared to the theoretical and real experiences categories. Educational experiment typology refers to articles that analyze the application of DT in controlled environments and make students research subjects (18 of 23 articles). The frequency of the theoretical category (3 out of 23 articles) is related to research that studies the DT framework and its contribution and application in the field of education. In comparison, the real experiences category has the lowest frequency (2 out of 23 articles) containing best practices in implementing DT involving students and real social agents.

Returning to the definition of education in the 21st century to cultivate the whole human beings (Yang & McKenzie, 2018). Thus, the pedagogical practice needs to be directed not only to achieve cognitive abilities but also to support competency development through opportunities to gain hands-on learning experiences (Hernandez-de-Menendez et al., 2020; Hero & Lindfors, 2019). This statement is in line with John Dewey's thinking that learning needs to be done as an authentic activity that allows students to act as community members to grow future abilities (Dewey, 1985). Therefore, DT in education needs to be applied directly to provide authentic learning experiences through an iterative process to build valuable skills for students. It is not going to be thunderstruck that educational experiment typology has the highest percentage in DT publications. This finding provides a direction for educators and researchers to expand access to learning experiences by implementing DT in their innovative pedagogical practices.

E. The Design Thinking Mindset

In order to answer the fifth research question, researchers have identified nine mindsets that are the basis of DT implementation in the field of education presented in Table 4.

DT mindset that focuses on modifying, changing, or improving students' mentality or even teachers to build a mindset of thinking about complex concepts in the classroom (Noh & Karim, 2021). Cognitive psychology is the basis for the DT mindset that

provides guidelines for achieving learning goals through a culture of thinking (Lisa Carlgren et al., 2016). Human-centeredness is the mindset that is most widely applied in the implementation of DT. It contains a philosophy that DT requires clear understanding, and empathy and motivates students to innovate in solving challenges (Carroll et al., 2010). Innovations in human-centered design methodologies encourage students to consider human behavior, needs, and preferences in developing designs (Brown, 2008). Therefore, empathy is one of the DT mindsets. It refers to the ability to step into other people's shoes, understand their lives (the pain points and needs), and solve problems from their point of view (IDEO, 2015). Empathy is essential to understanding and translating the perspectives of various parties to realize a meaningful empathetic approach (Guanes et al., 2021).

Furthermore, integrative thinking as a DT mindset refers to a thinking process that encourages students to look at all aspects comprehensively even though it is sometimes contradictory (Brown, 2008). From various opposing ideas that emerged from team members, students were encouraged to create solutions that were out of the box. Therefore, the DT mindset that is also important is collaboration. It refers to the process of collaborating to combine various thoughts to solve problems in innovative ways, encourage enthusiasm, and enable interdisciplinary collaboration (Brown, 2008). Working in a team requires an awareness of the process and mindset to do work (Schweitzer et al., 2016). Mindfulness of process refers to awareness about involving divergent and convergent thinking at different times to make choices and make choices (Brown & Katz, 2011).

The main principle of DT is to develop students' skills through exploration, discovery, experimentation, testing, and collecting feedback from various parties (Plattner et al., 2012). Experimentalism is one of the DT mindsets that refers to trying new ideas to turn intangible ideas into a tangible form (Clark & Smith, 2010), and it can be tested (Schweitzer et al., 2016). An exploratory approach to obstacles through creative avenues to open new directions (Brown, 2008). So, in the iterative cycle, prototype development becomes very important. The prototype is a simple model of the idea developed and involves people getting feedback as to material for improvement (Carroll et al., 2010). In the process, students will be faced with obstacles that test

their optimism to complete the design. Optimism becomes a DT mindset that encourages them to try hard to solve complex problems and survive despite the many obstacles that come their way (Brown, 2008; Schweitzer et al., 2016). One of the ways to understand and answer complex problems, students as designers, are encouraged to ask questions and explore constraints in a creative way (Brown, 2008). It aims to open up opportunities for the creation of innovative solutions.

An interesting phenomenon is that researchers identified uncertainty and risk as mindsets in implementing DT. It is possible to face the VUCA era (volatility, uncertainty, complexity, and ambiguity), where user requirements become more convoluted (Schweitzer et al., 2016). Therefore, in the context of DT practice in learning, students must make decisions that have great potential in the future by considering the worst risk of failure (Goldschmidt & Rodgers, 2013; Kelley & Kelley, 2013). The findings of this study provide information to researchers and educators adopting various mindsets in implementing DT in learning and give directions for opportunities to test the implications of DT applications empirically.

F. Content Analysis of Design Thinking Implication to Skills Development

To respond to the last research question, the researchers have analyzed the ten skills that appear as the implications of the implementation of DT in education, as presented in Table 5.

Table 4 : Nine Mindsets Of Design Thinking

Skills	Analyzed in Selected Paper(s)
Creativity	(Balakrishnan, 2021; Kijima et al., 2021; Ladachart et al., 2021; M. -F. G. Lin & Eichelberger, 2020; McDonald et al., 2019; Naghshbandi, 2020)
Collaboration	(Arrington & Willox, 2021; Boakes, 2020a; Ladachart et al., 2021; M. -F. G. Lin & Eichelberger, 2020; McDonald et al., 2019; Naghshbandi, 2020)
Problem-Solving	(Arrington & Willox, 2021; Naghshbandi, 2020; Simeon et al., 2020; Sung & K elley, 2019)
Teacher Professional Development (TPD)	(Azukas & Gaudelli, 2020)
Self-Direction	(Lake et al., 2021; MacKinnon et al., 2020)
Empathy	(M.-F. G. Lin & Eichelberger, 2020)
Communication	(Arrington & Willox, 2021; M. F. G. Lin & Eichelberger, 2020)
Decision-making	(M. F. G. Lin & Eichelberger, 2020)
Digital Skills	(Gleason & Jaramillo Cherez, 2021)
Global and intercultural awareness	(Gleason & Jaramillo Cherez, 2021; Naghshbandi, 2020)

Evaluation of the implications of DT shows that there are direct learning experiences that positively impact the development of various skills. Creativity and the ability to collaborate are the most outputs generated from the analysis of twenty-three selected papers. This finding is in line with the philosophy of DT as a creative process to solve complex problems that require students to collect ideas and make prototypes to be tested (Naghshbandi, 2020). Balakrishnan (2021) in his study, argues that DT helps students in the creative thinking process as a catalyst in increasing motivation to be more creative by being actively involved in designing solutions to problems faced by stakeholders. It is in line with the results of a study conducted by Kijima et al. (2021) that students experienced an increase in their sense of creative confidence. In the DT iterative process, creative confidence implies working in uncertain conditions and being open to criticism and feedback on their developed ideas (Kelley & Kelley, 2013).

The DT process is simply known as iterative problem solving to engage students in exploring various topics in a learner-centered format. As they work through a specific problem, students are encouraged to be creative and reflective in their practice (Arrington & Willox, 2021). They must consider each team member's thoughts in the perspective of designing the solutions that will be offered. Therefore, DT has substantial implications for the development of collaboration skills. Balakrishnan (2021) argues that DT promotes collaboration to take inventory of a wide variety of ideas. Collaboration between team members supports student learning experiences and produces better design outputs (Arrington & Willox, 2021). In line with collaboration skills, there is also the enhancement of communication as a medium for delivering messages. DT encourages students to obtain information related to the difficulties and needs of stakeholders, exchange ideas and information with fellow team members to generate ideas, and convey back the results of teamwork to obtain feedback (Arrington & Willox, 2021). In addition, a study conducted by M. F. G. Lin and Eichelberger (2020) found that the DT application played an essential role in resolving faculty communication issues, thus having a positive impact on their work efficiency.

One of the essential results in this paper shows that the implementation of DT in the field of education is mainly carried out in teacher education. It turns out

not without any reason. Reviewing that teaching challenges occur in an ambiguous pedagogical realm so that the solutions needed and the consequences resulting from these various choices cannot be ascertained from one teacher to another. Therefore, teachers must have professional development to understand problems, needs, and thinking solutions to their practice (Azukas & Gaudelli, 2020). Implementing the DT process encourages teachers to shift their paradigm of thinking not only as learning facilitators but also actively involved in self-reflection based on the principles of DT. The results of this study are consistent with a study conducted by Zinger et al. (2017) that the design approach involves teachers directly to provide meaningful learning opportunities through feedback in the PD iteration process. In addition, the design approach is a bridge between theory and practice (Kyza & Constantinou, 2008) to improve teacher professionalism in teaching and learning activities (Friesen & Jacobsen, 2015).

In line with that, Naghshbandi (2020) used a design-based approach in teacher education and analyzed that DT plays a vital role in improving various valuable competencies such as critical thinking and problem-solving, global awareness, communication, and collaboration. In addition, the integration of digital tools in DT facilitates the development of deep technological competencies through collaborative decision-making to solve a challenge (Gleason & Jaramillo Cherez, 2021). In their study, Gleason and Jaramillo Cherez (2021) showed that DT is used in virtual exchanges involving prospective teachers in global collaboration and empowered their learning through technology. They stated that DT principles are aligned with educational goals to expand cultural practice networks and metacognitive abilities through international partnerships and problem-solving strategies utilizing educational technology to achieve learning objectives (Gleason & Jaramillo Cherez, 2021).

4. Conclusion

The analysis uttered that few publications related to DT in the education sector in the 2010-2021 period, but have dramatically improved in number in the last three years. The journal that publishes the most DT in education is the International Journal of Technology and Design Education, followed by a different of one paper by the Journal of Formative Design in Learning and TechTrends with the same volume of publication. Teacher education is becoming the subdiscipline in

which DT is popularly implemented. Interestingly, design education is one of the areas with the lowest percentage. Of the twenty-three selected papers analyzed, 78.26% are typological types of educational experiments. While the other two typologies only contributed 13.04% and 8.70% of the total DT publications in the field of education in the last decade.

In conclusion, the systematic review of literature has revealed that DT is proper to implement in any field, including education. In exposure to DT, at least nine mindsets are used that might expand students' opportunities to get meaningful learning experiences and encourage the development of various skills. Analysis of practical experience concludes that DT promotes creativity, collaboration, problem-solving, Teacher Professional Development (TPD), self-direction, empathy, communication, decision-making, digital skills, and global and intercultural awareness. It predicts that DT will grow in the educational environment as the best pedagogical technique for encouraging students to solve complex problems focused on fulfilling human needs.

5. Limitations and Recommendations

Although the results of a thorough review of the previous literature are considered to have provided deep insights and potentially provided directions for further research, there are still limitations that must be acknowledged. First, the DT in education publications reviewed were limited to journal articles published in the Springer database. Thus, different results may be obtained if using other scientific databases. Second, the studies were limited to a specific time frame and focused on publications in the form of journal articles only; editorial, book chapters, etc. are omitted.

Based on the research limitations mentioned above, further literature review studies need to expand the database sources used with a longer time span to produce a more comprehensive view of the implementation of DT in education.

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