International Journal of Learning, Teaching and Educational Research
Vol. 22, No. 8, pp. 376-390, August 2023
https://doi.org/10.26803/ijlter.22.8.20
Received Jun 28, 2023; Revised Aug 22, 2023; Accepted Aug 28, 2023

Design Thinking and Project-Based Learning (DT-PBL): A Review of the Literature

Li Jia, **Nur Atiqah Jalaludin*** and **Mohamad Sattar Rasul**
Universiti Kebangsaan Malaysia, Bangi, Malaysia

Abstract. Design thinking and project-based learning (DT-PBL) has emerged as an innovative and transformative educational approach, garnering substantial interest in the educational field in recent years. This review delves into existing literature concerning DT-PBL within the realm of education through a systematic literature review. A thorough exploration of academic databases yielded 14 journals that examine this educational paradigm. Within those journals, two distinct models of DT-PBL emerged, signifying the nascent stage of comprehensive research in this area. These models provide conceptual frameworks for teachers and institutions seeking to integrate DT-PBL into their pedagogical strategies. Furthermore, the articles encompassed strategies for student learning outcomes, facilitating teacher professional development, navigating challenges, and acknowledging potential limitations within the DT-PBL context. The synthesis of the findings revealed that the DT-PBL methodology exhibits a discernible impact on students' creativity enhancement and refined problem-solving capabilities. DT-PBL is a program that helps students develop critical skills beyond the traditional classroom setting. Simultaneously, the review revealed that DT-PBL has the potential to reshape teacher professional training paradigms. Engaging teachers in DT-PBL experiences empower them with innovative tools to adapt to evolving educational landscapes. This educational model is ready to undergo progressive refinement, evolving into a mature pedagogical methodology that transcends disciplinary boundaries. The rich insights from this review facilitate continued growth and adaptation of DT-PBL in diverse educational settings, thereby enriching the educational experience for students and teachers alike.

Keywords: design thinking and project-based learning (DT-PBL); creativity; problem-solving skills; innovation ability; critical thinking

1. Introduction

Design thinking and project-based learning (DT-PBL) is an innovative educational approach that combines the problem-solving methodology of design thinking

*Corresponding author: *Nur Atiqah Jalaludin, nuratiqah. jalaludin@ukm.edu.my*

with the project-based learning approach (Lebid & Shevchenko, 2020). The approach of DT-PBL has gained attention recently as an effective teaching method that can enhance students' creativity, empathy, and multiple competencies. Various studies have shown that design thinking is effective in enhancing students' empathy and creativity, while project-based learning is an effective teaching method for developing multiple competencies (Farrar, 2020; Liedtka, 2015; Mahmoud-Jouini et al., 2016; Tu et al., 2018).

An important step in exploring the development of a field is using a systematic literature review to provide a clear and comprehensive overview of the literature related to the topic. However, DT-PBL is a relatively new term, and defining it is challenging and controversial. The literature review reveals that there are few empirical studies on DT-PBL, and the approach is still in the exploration stage (Cummings & Yur-Austin, 2022).

The concept of "design thinking" initially emerged within the design community and was coined by the *Harvard Business Review* (Brown, 2008). Over time, design thinking has found applications in both the design and business domains. Project-based learning traces its origins back to Dewey's empiricist approach to education (Dewey, 1986). At its core, project-based learning emphasizes a student-centered form of instruction (Kokotsaki et al., 2016), making it a highly effective method within the field of education. Integrating both design thinking and project-based learning, as DT-PBL, is an entirely new path in education.
Through a systematic literature research approach, an attempt was made to explore the following issues related to education. The purpose of this study has been to explore the following questions:

1. What is DT-PBL?
2. What are the benefits of the DT-PBL method?
3. What does the DT-PBL method reveal about teacher development strategies?
4. What are the challenges and potential limitations of the DT-PBL method?

2. Materials and Methods

Integrated DT-PBL has received widespread attention from educators and scholars alike for providing a novel pedagogy to enhance students' innovation and problem-solving approaches. However, there is still a paucity of research on its fundamental attributes, applicability and outcomes. To elucidate the current DT-PBL framework and concepts, we conducted a multi-stage study.

This study used a systematic literature review by referring to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, 2020) checklist to carry out the work. The eligibility criteria for the literature were first identified, clearly stating the inclusion and exclusion criteria for the review and how the studies were grouped for the purpose of synthesis. This was followed by identifying the sources of information and registering data, and three commonly used databases were selected. The literature was then screened, and the methods used to collect data from the report, year of publication and citations were specified. At the end of the initial review, a secondary review was conducted to

further specify the inclusion and exclusion criteria and screening the literature was used to answer the research questions of this paper. In addition to this, to further answer the first question, a Google search was applied about the application of DT-PBL.

Next, content analysis was used to delve into more details about DT-PBL. Content analysis is a powerful data reduction technique. Its main benefit comes from the fact that it is a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit coding rules. It has beneficial features that are unobtrusive and useful when dealing with large amounts of data (Stemler, 2000).

3. Data Collection

The data collection consisted of three main steps (see Figure 1). The study began with a comprehensive search in three common databases: Web of Science (WOS), Scopus, and Google Scholar (GS). The search was extended to "design thinking" emergence (Brown, 2008) in order to gain a comprehensive understanding of the application of DT-PBL in the educational field. Therefore, the search focused on titles, abstracts and keywords published between 2008 and 2023. To ensure comprehensiveness, an extensive search strategy was employed to encompass a wide range of terms (searching the "design thinking" and "project-based learning") that might be associated with "DT-PBL". The results gave an initial search of 1,492 documents published between 2008 and 2023.

To streamline the review process, an assessment of titles and abstracts was performed. This step involved excluding articles that were not directly relevant to the research objective, such as those discussing design thinking-based learning, project-based learning aimed at developing design thinking skills, or articles emphasizing the enhancement of creative thinking. Furthermore, non-education-related articles, such as those relating to design thinking in business skills and business strategies, were also excluded. By employing these exclusion criteria, the study focused on articles specifically related to research in the field of education, ensuring a more targeted analysis.

At the end of this phase, 14 articles remained. As is common in systematic literature reviews, these articles were complemented by other sources (mainly the introduction of DT-PBL) that provided further insights into the DT-PBL definition. Spencer (2020), whose theory "PBL by Design", selected the source on his personal website in April 2022.

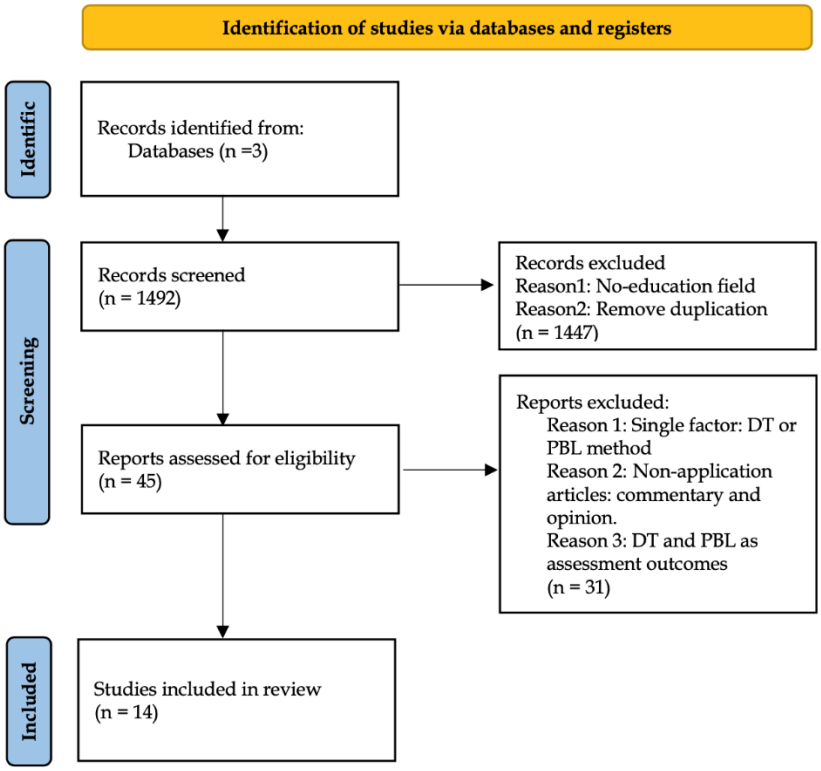

Figure 1: The procedures of data collection

4. Results and Discussion

In this systematic literature review, 14 publications related to the theoretical and pedagogical applications of DT-PBL were identified. Table 1 shows the eight articles that mentioned the search term in the title and abstract; no keywords from the literature appear as search terms, but were separate mentions of DT-PBL; and three articles did not have it in the title, abstract or keywords, but it was reflected in the article. Furthermore, as shown in Figure 2, these articles were published in the last decade, because the concept of design thinking was introduced in 2008. In particular, five of them were published by the Institute of Electrical and Electronics Engineers (IEEE). The most discussed was the application of the DT-PBL pedagogy to the field of engineering.

Table 1: Reference to DT-PBL

Location	No.	Citation
Title	8	Collins and Chiaramonte (2017); Taratukhin and Pulyavina (2018); Lebid and Shevchenko (2020); De Queiroz-Neto et al. (2021); Cummings and Yur-Austin (2022); Indrianti and Kurniawan (2022); Kuo et al. (2022); Jiang and Pang (2023).
Abstract	8	Collins and Chiaramonte (2017); de la Fuente et al. (2019); Lebid and Shevchenko (2020); De Queiroz-Neto et al. (2021); Kuo et al. (2022); Indrianti and Kurniawan (2022); Cummings and Yur-Austin (2022); Jiang and Pang (2023).
Keywords	0	/
None	3	Chandrasekaran et al. (2013); Isa et al. (2019); Gupta (2022).

Figure 2: Year of publication of the selected articles

The researchers then created a table to find more elaboration in the articles (Table 2). The authors, nationalities, source, discipline, research methods, student learning outcomes, faculty development strategies, and challenges were organized in chronological order of publication. Of the 14 articles, two articles were from the WOS, seven articles were taken from WOS and Scopus, three from Scopus and GS, and the remaining two articles were found on GS. In addition, the articles were identified as quantitative research methods (five articles), qualitative research methods (two articles), and mixed research methods (three articles), and the rest were reviews (four articles).

Further analysis of the results showed that 29 points for learning outcomes, two for teacher development strategies, and three for possible challenges were explicitly mentioned in the literature. Further in-depth analyses followed to explore additional factors that may be evident.

In addition, in order to better understand the learning outcomes and benefits of DT-PBL, the selected 14 papers were divided into seven topics (Table 2):

1. Engineering education (seven articles).
2. Vocational education (one article).
3. Design education (two articles).
4. MBA (Master's in Business Administration) education (one article).
5. High school education (one article).
6. Higher education (one article).
7. Military service education (one article).

The selected literature was thoroughly evaluated and analyzed and, to improve ease of interpretation, the collected data were carefully organized into a table to facilitate generalization. In summary, the selected literature was subjected to rigorous evaluation and in-depth analysis. To facilitate straightforward interpretation and generalization, the collated data were organized into a table format, enhancing the accessibility and usability of the amassed insights. We can see a clear upward trend in the adoption of the DT-PBL model. This implies research interest and recognition of the application of the DT-PBL method in education.

Table 2: The elaboration of findings

Author/ Country/ Year	Source	Discipline	Main Study Design	Student Learning Outcome	Teacher Development Strategy	Challenge of DT-PBL
Chandrasekaran et al./ Australia/2013	WOS/ Scopus	Engineering	MM	Co CT Cr IA PS		
Parmar/India/2014	Scopus /GS	Engineering	/	/		
Collins & Chiaramonte/ USA/2017	WOS/ Scopus	Military Service	/	PS		
Taratukhin & Pulyavina/USA/2018	Scopus /GS	Engineering	/	PE HoS		
de la Fuente et al./ USA/2019	GS	Design	/	IA PS		Class Scale
Isa et al /Malaysia/2019	WOS	Engineering	QN	PS		
Liu et al./ China/2019	Scopus /GS	High School	QN	IA S-S Re Em		
Lebid & Shevchenko/ Ukraine/2020	WOS/S copus	Higher Education	QN			
De Queiroz-Neto et al /Brazil/2021	WOS	Vocational Education	QN	SS		
Kuo et al./ China/2022	WOS/ Scopus	Engineering	MM	FT Cr		Availability of Resources & Technology Assessment
Cummings & Yur-Austin/ USA/2022	WOS/ Scopus	MBA	QL	CT PS	Reflective	
Gupta/ India/2022	WOS/ Scopus	Engineering	QN	Cr CT	Assessment	
Indrianti & Kurniawan /Indonesia/2022	GS	Design	QL	Re CT Cr		
Jiang & Pang/China/2023	WOS/ Scopus	Engineering	MM	DT EA IA Cr		

WOS=Web of Science
Scopus=Scopus
GS=Google Scholar
QN=quantitative research
QL=qualitative research
MM=mixed method
Co=collaboration
CT=critical thinking
Cr=creativity
IA=innovation abilities
PS=problem-solving
PE=practical experience
HoS=hands-on skills
S-S=self-satisfaction
Re=responsibility
Em=empathy
SS=soft skills
FT=faster thinking
DT=design thinking
EA=engineering application

4.1 The Introduction of DT-PBL

As the application of design thinking shifts from design to education, by incorporating design thinking into project-based learning courses, we can bridge the gap between education and industry (Farrar, 2020). Many scholars have constructed the DT-PBL model. For example, De Queiroz-Neto et al. (2021) argued that DT-PBL is used as a method for organizing the development of innovative products, through which the soft skills of vocational education students can be developed. In the context of project-based learning, design thinking is integrated into the internal organization of the project, which defines the stages in the context of the project development itself, continuing between inspiration, conception and prototyping, without being disconnected from the project-based learning organization. This allows opportunities for students to develop skills such as management, responsibility, collaboration, communication and critical thinking. Indrianti and Kurniawan (2022), based on de la Fuente et al. (2019) and Traifeh et al. (2019), outlined the stages of DT-PBL as research, opportunity (problem) identification, concept exploration, concept refinement, and final concept. Jiang and Pang (2023) for a course named Introduction to Artificial Intelligence and Basic Algorithm Training (IAIBAT) pointed out that the engineering education teaching model is divided into the five stages of empathy or project perception; information integration or definition of a project; creative design or formulating scheme; prototype; project testing and communication.

In addition, a Google search turned up sites that could be used to answer the DT-PBL introduction. Spencer (2022) demonstrated a student-friendly design thinking framework tailored specifically for K-12 settings called the Launch Cycle. He later studied overlapping this design thinking framework with project-based learning to propose seven stages of DT-PBL.

In the initial stage of DT-PBL, students begin with a challenge or question centered on a specific community. The questioning stage is where students are expected to answer questions to begin the inquiry process. The initial content understanding phase focuses on student inquiry and helps students build knowledge internally. As a teacher, this stage can be improved by embedding moments of self-reflection. The deeper understanding stage is where students have the option of brainstorming and project planning. This is the beginning of a deeper project management process. The create prototype phase tends to be highly self-directed at the small group and individual levels. The feedback and revision phase focuses on improving the product while students self-reflect on the process. The public phase is where students should take the product to the public. Table 3 describes the principles underlying DT-PBL. The table articulates the core of DT-PBL which is a student-centered pedagogical paradigm where the student is the focus of the teaching and learning experience. Despite the varied perspectives of researchers, the essence of DT-PBL as a student-centered approach remains consistent. The different insights offered by different scholars highlight the dynamic nature of DT-PBL, which can be adapted to different educational contexts. Notably, the DT-PBL model furnishes educators with a meticulously crafted and structured framework that empowers them to curate immersive and impactful learning encounters for students across diverse educational contexts.

Table 3: The introduction of DT-PBL

Indrianti and Kurniawan	Spencer
Empathy / Project perception	Challenge / Question-centered
Information integration / Definition of project	Questioning
Creative Design / Formulating scheme	Content understanding
Prototype	Deeper understanding
Project testing & communication	Create prototype
	Feedback & revision
	Public

4.2 Learning Outcomes and Benefit of DT-PBL

Design thinking and project-based learning integration has proven to be an effective teaching method (Lebid and Shevchenko, 2020). This study used content analysis to obtain information about the benefits of DT-PBL in education. Content analysis is a widely used qualitative research technique. The current application of content analysis is not a single methodology; all methods are used to interpret the meaning of the content of textual data and, therefore, follow the naturalistic paradigm (Hsieh & Shannon, 2005). Project-oriented design-based learning (PODBL) will have a positive impact on students' content knowledge and the development of skills such as collaboration, critical thinking, creativity, innovation and problem-solving. It is an interesting task for researchers to implement a combination of projects and design thinking (Chandrasekaran et al., 2013). What follows is a detailed description of the learning outcomes and benefits of the DT-PBL educational approach in the six existing majors.

4.2.1 DT-PBL in Engineering Education

Parmar (2014) emphasized the significance of design thinking in creating a new generation of engineers who can address real-world problems through innovative products and services, to highlight the significance of a project-based approach in the domains of engineering and management. According to Taratukhin and Pulyavina (2018), through the incorporation of the DT-PBL approach, students are provided with opportunities to develop practical skills and gain valuable practical experience. This methodology facilitates a seamless integration of theoretical knowledge with real-world application, equipping students with the necessary skills and capabilities to excel in their future careers.

Isa et al. (2019) implemented the conceive-design-implement-operate (CDIO) standard in the field of civil engineering, along with the integration of the DT-PBL model. The study conducted in this context concluded that this combined approach is highly effective in enhancing the cognitive learning domain. Furthermore, students who were exposed to the CDIO-DT-PBL approach exhibited an enhanced ability to tackle complicated engineering problems.

Kuo et al. (2022) conducted a study to assess the effectiveness of the DT-PBL model in a robot course. The experimental findings provided validation for the efficacy of the DT-PBL model, indicating that the students in the experimental group outperformed the control group in various aspects of learning motivation, including overall motivation, task value, and self-efficacy. The implementation of the DT-PBL model enabled students to critically reflect on their existing

knowledge and skills, identifying areas for improvement. This reflective process contributed significantly to their enhanced learning effectiveness. Moreover, students in the experimental group demonstrated improved cognitive abilities, such as faster thinking, the ability to approach problems from multiple perspectives, and increased idea generation.

Gupta (2022) examined the influence of information and communication technology (ICT) on the teaching of software engineering (SE) courses using design-based learning and project-based learning approaches. The findings revealed that integrating ICT in these pedagogical methods resulted in increased interest, motivation, and conceptual understanding among students, thereby facilitating the development of creative and critical thinking skills. Moreover, the combination of project-based learning activities with traditional classroom instruction was found to enhance student engagement, motivation, comprehension, satisfaction, and overall learning experience.

More recently, Jiang and Pang (2023) conducted a detailed exploration of the teaching methodology and implementation of DT-PBL in an integrated software training project. DT-PBL offers four points of benefit: (1) project-based learning and design thinking are human-centered at their core and can help develop students' empathy to better understand user needs; (2) using DT-PBL can give full scope to their respective strengths and help solve complex problems effectively; (3) DT-PBL helps students to complete the design process, iteratively modify and improve the design, and develop their innovation abilities; and (4) both project-based learning and design thinking emphasize innovation and initiative. Finally, the study found that the experimental group, which was taught using DT-PBL, outperformed the control group in terms of creativity, including risk-taking, curiosity, imagination, and challenge. Students in the experimental group were also able to generate more ideas quickly from the perspective of user needs (Jiang and Pang, 2023).

4.2.2 DT-PBL in Vocational Education

Brazil seeks alternatives to improve its vocational education system; vocational education also seeks complete human formation that prepares students for real life. De Queiroz-Neto et al. (2021) described the integration of two methods aimed at developing soft skills, combining project-based learning approach with design thinking approach. This integration was carried out within the framework of an international exchange project with teams of students from different countries, and the results showed that the methods used in an integrated way have great potential and met the project's objectives.

4.2.3 DT-PBL in Design Education

Research has demonstrated that the DT-PBL approach has been instrumental in enhancing innovation among packaging engineering students. The survey findings indicated that DT-PBL projects stood out in design competitions, consistently earning higher rankings. This suggests that students who underwent the DT-PBL approach were able to develop innovative and well-executed solutions that captured the attention and recognition of competition judges. Their ability to apply their knowledge and skills in a real-world design context

showcased their innovation and problem-solving capabilities (de la Fuente et al., 2019). In addition, research by Indrianti and Kurniawan (2022) has suggested that the DT-PBL model can be a pedagogical approach for fashion studio subjects. This learning approach gives students more responsibility and involvement in the learning process to strengthen their critical and creative thinking.

4.2.4 DT-PBL in MBA Education

Cummings and Yur-Austin (2022) recognized the effectiveness of design thinking methods in promoting student project development as a productive pedagogical approach. They argued that this approach can transform students' academic practice into a creative force that can have a positive and impactful effect on stakeholders.

4.2.5 DT-PBL in High School Education

Liu et al. (2019) demonstrated the effectiveness of integrating the DT-PBL model into the high school information curriculum. The implementation led to improvements in student learning outcomes, including heightened innovation, motivation, self-satisfaction, social responsibility, and empathy. These findings underscore the potential of the DT-PBL model to positively transform the educational experience for high school students in the realm of information studies.

4.2.6 DT-PBL in Higher School Education

Lebid and Shevchenko (2020) noted that the use of design thinking in project and research work develops teamwork skills, fosters emotional intelligence and develops critical and creative thinking skills. These skills derive from experiential learning gained in problem-solving. They also pointed to a modern shift in education to a model that prioritizes the development of essential skills and competencies that are highly valued in the modern world.

4.2.7 DT-PBL in Military Service Education

Design thinking can also be applied to the military field. For example, Collins and Chiaramonte (2017) suggested that a design thinking approach should be integrated into the training of military officers to help them develop the necessary skills to identify and solve problems by focusing on the needs of the people they serve.

4.2.8 DT-PBL in Education

The results of the studies show that DT-PBL pedagogy has a great potential for future education; the method increases classroom motivation and students' self-satisfaction. Furthermore, DT-PBL is an effective teaching method that enhances students' cognitive level, solves real and complex problems in an empathetic way, and enables students to critically reflect on their existing knowledge and skills, thus promoting the development of creative and critical thinking skills. In addition, the DT-PBL model fosters social responsibility and teamwork skills, providing students with opportunities for practical experience for their future careers.

A systematic literature review helped to identify the benefits of combining DT-PBL, found gaps in existing research, summarized current knowledge, and informed future research on the in-depth development of the DT-PBL model.

4.3. Implications on Teachers' Development Strategies

The integration of the DT-PBL method has a transformative impact on a teacher's role by empowering students with greater autonomy and initiative in their learning. In this approach, students actively engage in discussions with the instructor to collaboratively determine the most suitable workflow for project completion. This student-centered learning style encourages a sense of ownership and responsibility among students (Indrianti & Kurniawan, 2022; Liu et al., 2019), while the teacher assumes a more advisory role as facilitator, coach, and mentor (Cummings & Yur-Austin, 2022).

Based on this, as a teacher, there are several important implications to consider in a DT-PBL teaching class. The following are four key points:

1. Real-world problem-solving: Teachers need to create learning experiences that allow students to tackle authentic challenges, apply their knowledge and skills, and develop innovative solutions. This requires framing projects around meaningful problems that students can relate to and providing opportunities for practical, experiential learning (Taratukhin & Pulyavina, 2018).
2. Multiple disciplines: DT-PBL often involves interdisciplinary approaches. Teachers should encourage students to draw from various disciplines and perspectives to solve complex problems. Teachers may need to collaborate with colleagues from different disciplines to create interdisciplinary projects and ensure a well-rounded learning experience (Farrar, 2020).
3. Reflective: Teachers should guide students through these iterative cycles, helping them learn from failures, make improvements, and develop a growth mindset (Cummings & Yur-Austin, 2022).
4. Assessment: Teachers need to explore alternative forms of assessment that focus on process, collaboration, creativity, and critical thinking. This could include portfolios, presentations, exhibitions, and self-assessments that showcase students' abilities to apply knowledge and skills in real-world contexts (Gupta, 2022).

4.4 The Challenges in Implementing DT-PBL

The DT-PBL educational approach has many benefits which are based on existing research suggesting the DT-PBL model. While the challenge of this learning approach is particularly evident, it also poses certain challenges that teachers must address (Figure 3).

Figure 3: The challenges of DT-PBL

DT-PBL faces some challenges. First, the DT-PBL models often involve open-ended questions and real-world design problems with no clear solutions. This uncertainty can be challenging for both students and teachers. Students need to develop the ability to embrace ambiguity, take risks, and persist in finding innovative solutions. Teachers must navigate this uncertainty by providing guidance and support, while fostering a culture of experimentation and resilience. Second, assessing student learning in the context of DT-PBL can be complex. Traditional assessment methods may not fully capture the multidimensional skills and competencies developed through these approaches. Teachers must develop alternative assessment strategies that go beyond evaluating the final product. Assessments should focus on assessing the process, collaboration, critical thinking, creativity, and reflection demonstrated by students (Kuo et al., 2022). Formative assessment and ongoing feedback are essential for tracking progress and providing guidance for improvement.

Third, the application of DT-PBL often requires access to a variety of resources, materials, and tools to support student exploration and project implementation (Kuo et al., 2022). Limited availability of resources can hinder the full potential of these approaches. Teachers should be ingenious in seeking alternative resources, leveraging technology, and collaborating with external organizations or community partners to provide students with the necessary support and materials. Additionally, integrating technology effectively into the learning process requires teachers to stay current with the latest tools and strategies.
Fourth, class scale is the final challenge in the DT-PBL framework is its suitability for large classes (de la Fuente et al., 2019). When dealing with a large number of students, it can be more challenging for teaching staff to provide individualized attention and support to each student. The sheer volume of students can lead to difficulties in effectively facilitating the learning process and providing timely feedback.

4.5 The Limitations of DT-PBL

The existing literature shows that DT-PBL has some limitations in the field of education and needs to be improved in the future. These limitations include the

four challenges mentioned: uncertainty, assessment, resources and technology, as well as the scale of class. The model of teachers' development is also a significant factor in further research. The most impactful strategies for preparing and supporting teachers to effectively use DT-PBL, including ongoing training, coaching, collaboration and communication opportunities, should be explored.
Moreover, based on the DT-PBL model, we need to consider interdisciplinary approaches to further explore the potential of interdisciplinary approaches during the teaching. How multiple disciplines can be effectively integrated to address complex, interdisciplinary problems and foster a holistic understanding of subject matter should be investigated. Teachers can develop robust DT-PBL curricula with interdisciplinary approaches that foster creativity, critical thinking, collaboration, and problem-solving skills in students (Parmar, 2014).

Finally, longitudinal studies to investigate the long-term impact of DT-PBL on students' academic achievement, the acquisition of 21st-century skills, and their motivation and engagement in learning may be conducted (Silva, 2009). Such studies can provide insights into the sustainability and transferability of these approaches beyond immediate project outcomes. Moreover, the impact of DT-PBL on the development of employability skills in students, such as communication, teamwork, and adaptability, may be explored. Further studies may research how these approaches align with the workforce's needs and prepare students for future careers. By conducting research in these areas, teachers, policymakers, and researchers can deepen their understanding of the impact of DT-PBL on student learning and identify ways to enhance and optimize these approaches in educational settings.

5. Conclusion

Through a systematic literature review, 14 articles matching the theme and DT-PBL were screened, which shows that DT-PBL is less researched in education. The study revealed that the use of the DT-PBL model in teaching can lead to many positive outcomes and benefits: 17% each for creative and problem-solving skills, 14% each for critical thinking and innovative abilities, 7% for responsibility, and the remaining nine items, only mentioned once, accounted for a total of 31%. The data show that DT-PBL mainly develops creativity, problem-solving, critical thinking and creative skills. Therefore, this method can be used in all fields where the teaching objective is to develop these competencies.

Moreover, effective teacher facilitation is critical in DT-PBL. Teachers serve as guides, providing support, feedback, and scaffolding throughout the process. The four implications for teacher development strategies were identified from the available articles as real-world problem-solving, multiple disciplines, reflection, and assessment. In addition, this study analyzed the articles regarding the challenges of DT-PBL: uncertainty, assessment, technology and the scale of classes. Based on this, the possible limitations of DT-PBL in pedagogical applications were summarized.

In conclusion, according to the systematic literature review, it was revealed that DT-PBL has been used less in education, but it still revealed an objective outlook

for future research in this area. In addition, the DT-PBL model demonstrated its potential to develop the critical skills needed for success in the 21st century. By adopting the DT-PBL model, teachers can create dynamic learning experiences that engage students, develop their creativity and problem-solving skills, and prepare them for future challenges.

6. References

Brown, T. (2008). Design thinking. *Harvard business review*, *86*(6), 84. https://www.researchgate.net/publication/5248069_Design_Thinking

Chandrasekaran, S., Stojcevski, A., Littlefair, G., & Joordens, M. (2013). Project-oriented design-based learning: aligning students' views with industry needs. *International Journal of Engineering Education*, *29*(5), 1109-1118. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84885665988&partnerID=40&md5=7263e054d51d4baeb502383cdba8c084

Collins, J. A., & Chiaramonte, M. W. (2017). Project-based learning and design thinking: Fomenting agility and innovation in government. *2017 IEEE International Professional Communication Conference (ProComm)*. https://doi.org/10.1109/ipcc.2017.8013938

Cummings, C., & Yur-Austin, J. (2022). Design thinking and community impact: A case study o project-based learning in an MBA capstone course [Article]. *Journal of Education for Business*, *97*(2), 126-132. https://doi.org/10.1080/08832323.2021.1887795

de la Fuente, J., Carbonell, I., & LaPorte, M. (2019). Design thinking as a framework for teaching packaging innovation. *Journal of Applied Packaging Research*, *11*(1), 4. https://scholarworks.rit.edu/japr/vol11/iss1/4

De Queiroz-Neto, J. P., De Farias, M. S. F., & Chagas, E. L. T. (2021). Project based learning and design thinking in an exchange project. *Revista Ibero-Americana De Estudos Em Educacao*, *16*(3), 1791-1806. https://doi.org/10.21723/riaee.v16i3.14557

Dewey, J. (1986). *Experience and education*. The educational forum,. https://doi.org/10.1080/00131728609335764

Farrar, E. J. (2020). Implementing a Design Thinking Project in a Biomedical Instrumentation Course. *IEEE Transactions on Education*, *63*(4), 240-245. https://doi.org/10.1109/te.2020.2975558

Gupta, C. (2022). The Impact and Measurement of Today's Learning Technologies in Teaching Software Engineering Course Using Design-Based Learning and Project-Based Learning. *IEEE Transactions on Education*, *65*(4), 703-712. https://doi.org/10.1109/te.2022.3169532

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qual Health Res*, *15*(9), 1277-1288. https://doi.org/10.1177/1049732305276687

Indrianti, P., & Kurniawan, O. (2022). Design Thinking-Project Based Learning (DTPjBL): Modelling Studio Teaching Material in Fashion Design Program. *4th Vocational Education International Conference* (VEIC 2022). https://doi.org/10.2991/978-2-494069-47-3_15

Isa, C. M. M., Mustaffa, N. K., Preece, C. N., & Lee, W.-K. (2019). Enhancing Conceive-Design-Implement-Operate and Design Thinking (CDIO-DT) Skills Through Problem-Based Learning Innovation Projects. *2019 IEEE 11th International Conference on Engineering Education (ICEED)*. https://doi.org/10.1109/iceed47294.2019.8994935

Jiang, C., & Pang, Y. (2023). Enhancing design thinking in engineering students with project-based learning. *Computer Applications in Engineering Education*. https://doi.org/10.1002/cae.22608

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving schools*, *19*(3), 267-277. https://doi.org/10.1177/1365480216659733

Kuo, H. C., Yang, Y. T. C., Chen, J. S., Hou, T. W., & Ho, M. T. (2022). The Impact of Design Thinking PBL Robot Course on College Students' Learning Motivation and Creative Thinking [Article]. *IEEE Transactions on Education*, *65*(2), 124-131. https://doi.org/10.1109/te.2021.3098295

Lebid, A. E., & Shevchenko, N. A. (2020). Cultivation of the Skills of Design Thinking via the Project-Based Method as a Component of the Dual Model of Learning. *European Journal of Contemporary Education*, *9*(3), 572-583. https://doi.org/10.13187/ejced.2020.3.572

Liedtka, J. (2015). Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction. *Journal of product innovation management*, *32*(6), 925-938. https://doi.org/10.1111/jpim.12163

Liu, Y., Wei, X., & Li, Z. (2019). Improving Design and Creative Ability of High School Students through Project Based Learning. *2019 International Joint Conference on Information, Media and Engineering (IJCIME)*. https://doi.org/10.1109/ijcime49369.2019.00074

Mahmoud-Jouini, S. B., Midler, C., & Silberzahn, P. (2016). Contributions of design thinking to project management in an innovation context. *Project management journal*, *47*(2), 144-156. https://doi.org/10.1002/pmj.21577

Parmar, A. J. (2014). Bridging gaps in engineering education: Design thinking a critical factor for project based learning. *2014 IEEE frontiers in education conference (FIE) proceedings*. https://doi.org/10.1109/fie.2014.7044081

PRISMA. (2020). *PRISMA 2020 Checklist*. http://prisma-statement.org/documents/PRISMA_2020_checklist.pdf

Silva, E. (2009). Measuring Skills for 21st-Century Learning. *Phi delta kappan*, *90*(9), 630-634. https://doi.org/10.1177/003172170909000905

Spencer, J. (2022). *PBL by Design-Exploring the Overlap of Project-Based Learning and Design Thinking*. https://spencerauthor.com/pbl-by-design#:~:text=PBL%20Elements-PBL%20by%20Design,centered%20on%20a%20specific%20community

Stemler, S. (2000). An overview of content analysis. *Practical assessment, research, and evaluation*, *7*(1), 17. https://doi.org/https://doi.org/10.7275/z6fm-2e34

Taratukhin, V., & Pulyavina, N. (2018). The future of project-based learning for engineering and management students: towards an advanced design thinking approach. *2018 ASEE Annual Conference & Exposition*. https://doi.org/10.18260/1-2--31102

Traifeh, H., Staubitz, T., & Meinel, C. (2019). Improving learner experience and participation in MOOCs: A design thinking approach. *2019 IEEE Learning With MOOCS (LWMOOCS)*. https://doi.org/10.1109/lwmoocs47620.2019.8939623

Tu, J.-C., Liu, L.-X., & Wu, K.-Y. (2018). Study on the Learning Effectiveness of Stanford Design Thinking in Integrated Design Education. *Sustainability*, *10*(8). https://doi.org/10.3390/su10082649