The Synergy between Design Thinking, Artificial Intelligence and Software Engineering

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Abstract. Design Thinking is a human-centered approach to designing with an innovative vision. In Software Engineering, Design Thinking facilitates a deep understanding of user needs, which can significantly impact software development. However, the software industry has not fully adopted Design Thinking to realize its benefits. This may be due to a combination of factors, including the time-consuming nature of Design Thinking. Simultaneously, breakthroughs in the field of Artificial Intelligence foster synergy with Design Thinking, producing both benefits and challenges; one benefit is reduced tasks' time. However, the combination of Design Thinking, Artificial Intelligence and Software Engineering still has unknown aspects. With the purpose of identifying the synergies among these three disciplines, we conducted a scoping review. The process yielded five articles: two from 2024 and three from 2025, even though the search included results from 2022 onward. This could be related to the potential that Artificial Intelligence has achieved in the last two years, which allows for combining the three disciplines. To classify the synergy among the three disciplines, we conducted a Thematic Analysis of the search results. This paper contributes with the analysis of different aspects related to the combination of the three disciplines, and a discussion of some interesting facets of our findings, providing a general overview to allow future research and decision-making.

Keywords: Design Thinking, Artificial Intelligence, Software Engineering.

La Sinergia entre el Pensamiento de Diseño, la Inteligencia Artificial y la Ingeniería de Software

Resumen. El Pensamiento de Diseño es un enfoque centrado en las personas para diseñar con una visión innovadora. En la Ingeniería de Software, facilita una comprensión profunda de las necesidades de los usuarios, lo que puede tener un impacto significativo. Sin embargo, la industria del software no lo ha adoptado en profundidad para aprovechar sus ventajas. Esto puede deberse a una combinación de factores, entre ellos el tiempo que requiere. En simultaneo, los avances en el campo de la Inteligencia Artificial fomentan la sinergia con el

Pensamiento de Diseño, lo que genera tanto beneficios como retos; uno de los beneficios es la reducción del tiempo en las tareas. Sin embargo, la combinación del Pensamiento de Diseño, la Inteligencia Artificial y la Ingeniería de Software sigue presentando aspectos desconocidos. Con el fin de identificar las sinergias entre estas tres disciplinas, hemos llevado a cabo una revisión exploratoria. Del proceso se obtuvieron cinco artículos: dos de 2024 y tres de 2025, a pesar de que la búsqueda incluía resultados a partir de 2022. Esto podría estar relacionado con el potencial que ha alcanzado la Inteligencia Artificial en los últimos años. Para clasificar la sinergia entre las tres disciplinas, llevamos a cabo un Análisis Temático de los resultados de la búsqueda. Este artículo contribuye con el análisis de diversos aspectos relacionados con la combinación de las tres disciplinas, así como también con un debate sobre algunas facetas interesantes de nuestros hallazgos, ofreciendo una visión general que sirva de base para futuras investigaciones.

Palabras clave: Pensamiento de Diseño, Inteligencia Artificial, Ingeniería de Software.

1 Introduction

Design Thinking (DT) is a human-centered approach to design solutions with an innovative vision (Brown, 2008). In Software Engineering (SE), DT facilitates a deep understanding of user needs that is not usually achievable with traditional requirement-gathering methods (Kahan et al., 2024; Challiol et al., 2025). Therefore, DT can significantly impact software development (Dobrigkeit et al., 2019).

In recent years, some research studies have explored different approaches to use DT in software development (Parizi et al., 2022; Hehn et al., 2022). However, the IT (Information Technology) industry has not fully adopted DT to realize its benefits. This may be due to a combination of issues. One of these issues could be the limited specialized DT training courses in the field of Software Engineering (Challiol et al., 2025). This adversely affects how developers choose the resources (or tools) used in DT, based on familiarity or prior experience (Parizi et al., 2022). Selection by familiarity contradicts the recommendation that resources should be chosen aligning with accurate outcomes (Carlgren et al., 2016b), which could impact the success of DT (Brenner et al., 2016). Besides, another issue is the problem-solution preconception mindset among developers, which can hinder the adoption of DT in software development (Butler et al., 2018; Parizi et al., 2022). Apart from that, DT does not have a specific time span, so it could imply days or months (Carlgren et al., 2016a). This could be another issue influencing the adoption of DT in the IT industry, where time is a critical factor.

Lately, breakthroughs in the field of Artificial Intelligence (AI) have enabled other disciplines to take advantage, as is the case with DT; this combination presents both benefits and challenges (Sreenivasan et al., 2024). For example, AI technologies enable performing tedious tasks, such as processing large amounts of data or discovering patterns. Therefore, the time could be improved upon traditional DT when it is enhanced with AI, enabling broader adoption of DT for software development.

However, some issues could impact DT solutions, such as bias in AI algorithms, which can lead to a loss of sight of the human-centered approach (Sreenivasan et al., 2024). Another issue are hallucinations, which are common in AI recommendations, and could lead to an erroneous interpretation of system requirements. Therefore, the synergy of DT, AI, and SE still has unknown aspects. This motivates our work, which focuses on exploring what kinds of synergy currently happen between the three disciplines.

The paper aims to identify the kinds of synergies among DT, AI, and SE, providing a general overview to allow future decision-making. To do this, we conducted a scoping review (Munn et al., 2022), which is a recommended approach in emerging fields, to synthesize the available evidence on a particular topic. Our findings were obtained through *Thematic Analysis* (Clarke et al., 2017) from the search results. During this analysis, other aspects related to the combination of the three disciplines emerged and were included in the paper. In addition, we discussed some interesting facets of our findings, hoping this would help future research.

The paper is structured as follows. Section 2 describes the method of our scoping review. Section 3 presents the data extraction and findings. Section 4 describes the limitations of our work and discusses some interesting facets of our findings. Conclusions and future work are mentioned in Section 5.

2 Method

In this section, we explain the scoping review that we conducted. The first step is to define the protocol (Munn et al., 2022). In our case, this was specified as follows:

- *Objective:* Exploring the synergy between Design Thinking, Artificial Intelligence and Software Engineering.
- *Research Question*: In scoping reviews, the *Population*, *Concept*, and *Context* are defined to frame the scope (Trapé et al., 2025): the population is the entity being studied, the concept is what is being examined, and the context is the specific settings. In our case, these variables were defined as: population="*research studies*", concept="*the synergy among DT, AI and SE*" and context="*year of publication 2022-2026*". Time constraints allow the review to focus only on the potential that AI has achieved in recent years. According to these variables, our research question is defined as:

  (RQ) *What kind of synergy among DT, AI and SE has been carried out over the recent years in research studies?*

- *Search strategy and study selection*: For our scoping reviews, we sought a general overview of the topic to explore. Therefore, we decided to use *Scopus* (Scopus, n.d.), which covers a wide range of publishers and is a high-quality database. The search criteria were defined as:
  - *Include*: Documents that the title, abstract or keywords include ("Design Thinking" AND "Artificial Intelligence" AND "Software Engineering"), and

the year of publication is between 2022 and 2026 (covering up to February of 2026).
    - *Exclude*: Document types as book reviews, proceeding reviews, editorials, letters, and thesis.
- *Categories:* We were interested in general metadata, such as year of publication, document type and subject area. Furthermore, we aimed at classifying the kinds of synergy among the three disciplines (DT, AI and SE) in the documents.
- *Processing:* The general metadata were provided directly by the *Scopus* search. We used *Thematic Analysis* (Clarke et al., 2017) to extract data for classifying the synergy among the three disciplines. To do this, we acted as experts in our review and worked independently, analyzing the documents' abstracts and each one proposing our own coding. Then, we discussed our insights with each other to reach a consensus. The process continued to elaborate on topics from the codes. In our case, the topics were the kinds of synergies detected. Following this, we analyzed whether a new round was required to classify the documents into the agreed-upon topics; if so, we would use the same process as for the coding round.

3 Data extraction and Findings

We conducted a *Scopus* search following the inclusion criteria detailed in Section 2, yielding seven documents. After applying the exclusion criteria, two documents were discarded (one book review and one proceeding review). The few obtained results evidence that the combination of DT, AI, and SE has been little explored.

As described in Section 2, for these five documents (from now on articles), we extracted the general data provided by *Scopus* (year of publication, document type, and subject area), as shown in Table 1. In addition, for each article, we defined an identification followed by the corresponding reference. Note that the articles are ordered chronologically by the year of publication in the table.

Table 1. General data of the articles extracted of *Scopus*.

Article Identification	Year	Document type	Subject area
AID_1 (Fischer et al., 2024)	2024	Conference paper	Computer Science, Mathematics
AID_2 (Dehbozorgi et al., 2024)	2024	Conference paper	Computer Science. Social Sciences
AID_3 (Lin et al., 2025)	2025	Conference paper	Computer Science, Mathematics
AID_4 (Suresh Babu et al., 2025)	2025	Book chapter	Computer Science
AID_5 (Tariq, 2025)	2025	Book chapter	Computer Science

Table 1 shows two articles from 2024 and three articles from 2025, even though the search included results from 2022 onward. This could be related to the potential that AI has achieved in the last two years, which allows for combining the three disciplines. Besides, the "*Computer Science*" area appeared in the five articles.

The next step was to extract data on the kinds of synergy among the three disciplines (DT, AI, and SE) using the method described in Section 2. The experts worked independently, analyzing the articles' abstract and proposing their own coding. During this process, experts detected other aspects related to the combination of these three disciplines, in addition to the kinds of synergy. Then, they decided to code all aspects to generate a more complete analysis. With this in mind, they continued coding. Following, they discussed their findings to reach a consensus. Regarding the kinds of synergy, they continued elaborating on topics from the codes; in our case, the topics were the kinds of synergy detected. As there were only a few codes, no further iteration was required for this classification. Consensus on the codes related to other aspects happened in the same round: first, the experts agreed on the categories, then on the codes. Following this, they continued to elaborate on and reach consensus on the topics from the codes. In this case, the process required another round. The experts analyzed independently the topics that emerged, followed by a discussion of their findings to reach a consensus.

To help the reader understand the results, Table 2 provides a summary of each article, focusing on relevant aspects for interpreting the extracted data. There is a special column to describe the articles' aims to show that they differ significantly. In addition, Table 2 details the scope of each article: three are for any domain, and two are focused on education.

Table 2. Summary of the articles.

ID	Aim of the research work	Scope
AID_1	The article evaluates the impact of generative artificial intelligence on software design and engineering through a user-centered approach. By conducting a literature review and a preliminary evaluation, the article identifies critical tasks within the software development life cycle where generative AI tools can enhance productivity and creativity.	Any domain
AID_2	The article presents an intervention on integrating computational thinking modules into a software engineering course. The article developed a set of computational thinking modules focusing on higher-level skills used in design thinking. The work is motivated by the fact that artificial intelligence has become increasingly integrated into daily life, and by the growing demand from industries for a workforce and graduates adept at critical thinking and problem-solving.	Education domain
AID_3	The article explores how to apply the concept of design thinking to cultivate software innovation talent, especially in game design. The article developed an artificial intelligence enhanced design thinking tool.	Education domain
AID_4	The article explores integrating AI techniques into design thinking tools for software engineering. To do this, the article reviewed	Any domain

	existing AI applications in design thinking and analyzed their effectiveness in real-world software engineering scenarios.	
AID_5	The article examines how design thinking-based empathy-focused principles are changing software engineering practices. It also explores how empathy is changing in response to new technologies, such as Artificial Intelligence.	Any domain

Table 3 presents the kinds of synergy that emerged from our thematic analysis. The table indicates the frequency with which a specific synergy is used in the articles. Only one kind of synergy ("*DT enhanced with AI in SE*") appeared in two articles.

Table 3. Topics that emerged from the kinds of synergy reflected in the articles.

Emerged kinds of synergy	Frequency
DT enhanced with AI in SE.	2 (AID_3, AID_4)
DT in SE, considering AI as a possible tool used for developers.	1 (AID_5)
Generative AI in SE, from ideation to deployment, with a user-centered viewpoint.	1 (AID_1)
DT skills are embedded as computational thinking modules into a SE course.	1 (AID_2)

Furthermore, Table 3 shows that some disciplines (DT, AI, or SE) were not reflected in the kinds of synergy. This evidences the differences in the level of combination. Each kind of emerging synergy is analyzed in detail below.

- *DT enhanced with AI in SE*. This synergy combines the three disciplines, leveraging the benefits of DT in SE and taking advantage of DT enhanced with AI. Two articles (AID_3 and AID_4) are classified in this synergy. However, they apply this combination for different purposes, depending on their aim, as shown in Table 2. In this sense, the article AID_3 performs an intervention that uses DT enhanced with an ad-hoc AI tool for game design, and the article AID_4 explores DT enhanced with AI techniques in real-world software engineering scenarios. Moreover, the article AID_3 is scoped to the education domain, whereas AID_4 is oriented to any domain. This evidence that the synergy "*DT enhanced with AI in SE*" is general and can be addressed from different perspectives.
- *DT in SE, considering AI as a possible tool used for developers.* This synergy focuses on the combinations between DT and SE, with their benefits. However, the use of AI is in second place as a developer's tool. Therefore, AI is not fully integrated into the DT stages to potentiate them.
- *Generative AI in SE, from ideation to deployment, with a user-centered viewpoint*. This synergy concentrates on generative AI in SE. The DT is considered a concept to take into account the user-centered viewpoint. Moreover, this synergy considered the stages from ideation to deployment, omitting the first stage of empathizing, a characteristic of DT.

- *DT skills are embedded as computational thinking modules into a SE course*. In this case, the synergy is very limited because it is centered only on SE. In this synergy, from DT is extracted are high-level skills, and the AI is seen as current technology in use; both disciplines are in second place.

In summary, the synergy "*DT enhanced with AI in SE*" is the only one that combines the three disciplines, maximizing the benefits of each. Besides, the following two kinds of synergy combine only two disciplines (DT in SE, or AI in SE), relegating the other to a secondary place. The last synergy of Table 3 is not really a combination because it is centered in SE.

Besides, in our thematic analysis, three categories emerged, associated with aspects of the combination of the three disciplines, such as benefits, challenges, and techniques. Table 4 presents the topics that emerged for each category. In addition, the table shows the frequency with which each topic appeared in the articles.

Table 4. Topics that emerged related to the other aspects.

Categories	Topics	Frecuency
Benefits	Improving the way to perform problem-solving.	3 (AID_3, AID_4, AID_5)
	Fostering creativity.	3 (AID_1, AID_3, AID_5)
	Enhancing user-centered development.	2 (AID_4, AID_5)
	Improving innovation.	2 (AID_3, AID_5)
	Optimizing software workflows through AI-powered design thinking.	1 (AID_4)
	Enhancing user experience modelling.	1 (AID_4)
	Improving decision-making.	1 (AID_4)
	AI integration fosters a more adaptive approach for software design.	1 (AID_4)
	AI integration fosters an efficient approach for software design.	1 (AID_4)
	Integrating empathy into the software lifecycle	1 (AID_5)
	Enhancing productivity.	1 (AID_1)
	Optimize software workflows through AI-powered.	1 (AID_1)
Challenges	Generative AI required human oversight.	1 (AID_1)
	Critical evaluation of AI-generated outputs.	1 (AID_1)
Techniques	AI-enhanced prototyping.	2 (AID_1, AID_4)
	AI-enhanced ideation.	1 (AID_4)
	Collaborative prototyping.	1 (AID_5)
	Sympathetic user testing.	1 (AID_5)
	Human-AI collaboration.	1 (AID_1)
	Generative AI to speed requirements validation.	1 (AID_1)
	Generative AI to accelerate documentation.	1 (AID_1)

By comparing Tables 3 and 4, the benefits, challenges, and techniques are closely linked to the kinds of synergy of each article. In this regard, the following is worth noting.

- From the two articles that combine the three disciplines, seven benefits emerged in one and two benefits in the other. Besides, their abstracts do not depict any challenges; this may be due to the aims of these articles, as detailed in Table 2.
- In the case of the article that focuses on DT in SE, its benefits are aligned with DT such as fostering creativity, improving innovation or enhancing user-centered development.
- There is only one article that focuses on generative AI in SE; its benefits align with AI. Moreover, it is the only one that identifies challenges.
- The only article not included in Table 4 is AID_2; this is the same one that, in Table 3, evidences a lack of synergy among the three disciplines.

Regarding the techniques, in Table 4, two versions of prototyping emerged: one related to the traditional approach of DT as "*Collaborative prototyping*"; and, with DT enhanced with AI, the "*AI-enhanced prototyping*". Besides, other techniques are entirely AI-related. Furthermore, the "*Sympathetic user testing*" appears in article AID_5, which focuses on DT in SE, reinforces the empathic feature shown in Table 2, and aligns with the benefit "*Integrating empathy into the software lifecycle* " listed in Table 4.

To conclude, the analysis conducted provides an answer to the research question raised in Section 2. Regarding this, Table 3 presents the kinds of synergies identified; these were also analyzed, demonstrating that synergy occurs with different levels of combination. Furthermore, Table 4 provides a more in-depth examination of other aspects, including their benefits, challenges, and techniques. It is important to note that these aspects are closely linked to the kinds of synergy.

4 Limitation and Discussion

In this section, we first describe the limitations of our work. Next, we discuss some interesting facets of our findings.

Regarding limitations, Trapé et al. (2025) mention that in scoping reviews, methodological quality is not assessed beforehand, as it does not evaluate the risk of bias for the exploratory nature. In this sense, our scoping review provides a general overview to support future decision-making that may lead to more exhaustive reviews. For the *Thematic Analysis* (Clarke et al., 2017), we may have introduced biases into the analysis and reporting. In this sense, the coding and thematic analysis could be influenced by the experts' cognitive biases.

We discuss some facets of our findings below. An important aspect of *Thematic Analysis* (Clarke et al., 2017) is that the topics are defined to emphasize discovery. In our case, we aimed at classifying the kinds of synergies, highlighting each synergy's potential in its assigned name. Thus, some other implicit cooperations occurring between disciplines may not be evident in the synergy's name. Since AI is general-purpose, combining it with another discipline directs its use by utilizing the specific knowledge of that discipline. and focuses its application. For example, in the synergy "*DT enhanced with AI in SE*", AI is implicitly applied from a DT perspective. Therefore, the prompts are enhanced by a person-centered vision; so, DT enhances AI. In addition, in this synergy, AI is used in line with SE principles, meaning that SE also cooperates with AI. Apart from that, in the case of the synergy "*Generative AI in SE, from ideation to deployment, with a user-centered viewpoint*", AI is implicitly applied from a person-centered perspective; in this sense, DT cooperates with AI. However, it does not work the other way around because AI does not enhance DT. Therefore, in this kind of combination is only synergy between AI and SE.

Furthermore, regarding the kinds of synergy, "*DT enhanced with AI in SE*" is the only one that emerged in our analysis that combines the three disciplines. This synergy leverages the benefits of DT in SE (Do-brigkeit et al., 2019; Parizi et al., 2022). In this context, this kind of combination facilitates a deep understanding of user needs (Kahan et al., 2024; Challiol et al., 2025). Besides, this synergy leverages DT enhanced with AI (Sreenivasan et al., 2024). Furthermore, the synergy "*DT enhanced with AI in SE*" could help address the time issue related to DT (Carlgren et al., 2016a). As mentioned in Section 1, the time factor could impact the adoption of DT for software development. Therefore, this kind of synergy is worth exploring in future research.

From Table 4, the benefits of combining the three disciplines are worth highlighting, such as: "*Optimizing software workflows through AI-powered design thinking*", "*Enhancing user-centered development*", and "*Integrating empathy into the software lifecycle*". This last benefit highlights empathy as a relevant aspect in software development (Tariq, 2025). Moreover, empathy is a critical skill in DT (Brown, 2008). However, empathy training in Software Engineering has been underexplored (Gunatilake et al., 2023). This is an open area to explore.

Besides, in Table 4, challenges emerged, such as "*Generative AI required human oversight*" and "*Critical evaluation of AI-generated outputs*" from article AID_1. These challenges are directly related to the bias in AI algorithms (Sreenivasan et al., 2024) or hallucinations, as mentioned in Section 1. Therefore, these issues should be exhaustively explored in future research due to their direct impact on the synergy among the three disciplines.

Moreover, as mentioned in Section 1, the challenges of DT in SE (Dobrigkeit et al., 2019; Parizi et al., 2022; Dobrigkeit et al., 2019) could impact its adoption in the IT industry. Related to this, one issue is the limited number of specialized DT training courses in Software Engineering. Aligned with this, the article AID_3 explores how to apply the concept of DT to cultivate software innovation talent, especially in game design, using an ad-hoc AI-enhanced DT tool. This work could serve as inspiration for generalizing the strategy to other software domains. To do this, it is critical to learn DT as a thought process (Challiol et al., 2025).

Another issue, mentioned in Section 1 that impacts the adoption of DT in the IT industry, is the problem-solution preconception mindset among developers (Butler et al., 2018; Parizi et al., 2022). Related to this, the article AID_5 examines how DT-based empathy-focused principles are changing SE practices. This approach to applying DT could help change developers' mindsets and serve as inspiration for conducting the synergy "*DT enhanced with AI in SE*".

In summary, our discussion identified areas for further research based on our scoping review's findings. We hope our work will help researchers in future studies.

5 Conclusion and Future Work

The results of our scoping review showed that the synergy among the DT, AI, and SE is underexplored. Related to this, we provide a general overview of how DT, AI, and SE are combined, identifying existing forms of synergy. Only the synergy "*DT enhanced with AI in SE*" leverages the benefits of DT in SE and DT enhanced with AI. In addition, we identified benefits, challenges and techniques related to the combination of the three disciplines. Furthermore, our findings are discussed in Section 4 to highlight open research areas.

As future work, we will explore in more detail the synergy "*DT enhanced with AI in SE*". We will focus on handling the synergy, considering the DT-based empathy-focused vision, in order to identify ways to effectively apply a wholesome balance between AI-enhanced tasks with correct human supervision. For example, it could use AI to analyze interviews to empathize and discover relevant aspects of the software being designed. Then, these findings should be supervised by humans to ensure there is no AI cultural bias. Thus, questions arise: Does this human supervision require listening to all the interviews? Who does this supervision? How many people verified this basis?. Therefore, it is critical to investigate how to achieve a wholesome balance between AI and human intervention, without losing sight of the critical factor of time.

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