Exploring The Impact of Design Thinking on the Development of Computational Thinking Skill: Review of the Literature

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Abstract

As an ideal medium for the development of 21st-century skills, Computational Thinking is commonly developed through Computer Science practices such as programming and robotics. Among the vast literature on Computational Thinking, few of them address the strategy to implement Design Thinking to facilitate the development of Computational Thinking. This study investigates whether Design Thinking can facilitate the development of Computational Thinking based on a systematic literature review as a method of this research. The author identifies the literature that can be used as a reference in this study, analyzes the development of Computational Thinking skill, and looks for its correlation with Design Thinking—both Design Thinking and Computational Thinking to support problem-solving skills through a structured thinking approach.

Keywords
Computational Thinking, Design Thinking, Literature Review,

1. Introduction

The Design Thinking model coined by the D-School of the Hasso-Plattner Institute is considered a model in education. The D-School of the Hasso-Plattner Institute of the University of Potsdam is a German university directly connected to Stanford University and IDEO (Tschimmel 2012). The Design Thinking model comprises six steps based on the experience process of IDEO, the six steps in this Design Thinking model are connected to produce a looping process (Tschimmel 2012). Six stages of the Design Thinking model, according to Hasso-Plattner-Institute, include understanding, observing, point of view, ideating, prototyping, and testing.

Ncrel and Metiri Group (Burkhardt et al. 2003) identified four domains in skills needed in the 21st century: digital literacy, inventive thinking, effective communication, and productivity. In the domain of inventive thinking, there are several sub-domains, including the ability to adapt and manage complexity, self-direction, curiosity, creativity, risk-taking, and high-level thinking and reasoning. The sub-domains of inventive thinking intersect with Computational Thinking and Design Thinking. A study by Katalin Harangus and Zoltán Kátai (Harangus & Kátai 2020) showed that computational thinking effectively improves students' problem-solving skills. Design Thinking could be a revolutionary and exciting teaching method because it can support creative thinking processes, teamwork, and communication (Sándorová et al. 2020). Design Thinking and Computational Thinking intersect with the four skill domains needed in the 21st century as described by NCREL and Metiri Group (Burkhardt et al 2003).

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2. Study Design

2.1 Research Questions

The study goal is to investigate whether Design Thinking can facilitate the development of Computational Thinking. The research questions are:
RQ1. What constitutes the influence of Design Thinking on the development of Computational Thinking skills?
RQ2. How does Design Thinking facilitate the development of Computational Thinking?

2.2 Method

This research data is collected by reading articles derived from preferred keywords in scientific databases ScienceDirect, Google Scholar and ResearchGate. The literature review was conducted on journals associated with the topic, especially papers that include keyword design thinking and education. Articles reviewed was undertaken in the period 2010 – 2021. In total, the search resulted in 20 pieces—the distribution of the papers described in the following Table 1.

Table 1. Academic Research Databases Table

	Academic Research Databases		
	Science Direct	**Google Scholar**	**ResearchGate**
Total	14	4	2

3. Result and Discussion

Computational Thinking was first introduced by Wing in March 2006 as a fundamental capability that is a necessity in the middle of the 21st century (Wing 2006). It embraces:

- the confidence to deal with complexity.
- The persistence to work over complex issues.
- The ability to resolve ambiguity.
- The ability to solve open-ended problems.
- Acknowledge the differences of team members while collaborating to achieve a common solution; and
- knowing one’s strengths and weaknesses when working with others (Barr & Stephenson 2011).

As depicted in Table 2, the Computational Thinking Skill is correlated with the skills generated by Design Thinking processes. The findings drawn from the analysis of literature are further elaborated in the next sub-sections.

Table 2. Relation Computational Thinking Skills Table

Computational Thinking Skills	**Study**
Confidence in dealing with complexity	(Rauth et al. 2010), (Albay & Eisma 2021), (Crites & Rye 2020), (Smith et al. 2015).
Persistence in dealing with challenging problems.	(Mouchrek et al. 2016).
The ability to resolve ambiguity.	(Micheli et al. 2019).
The ability to resolve open-ended issues.	(Smith et al. 2015), (Lor 2017), (Greeson et al. 2021), (Shan et al. 2021), (Buhl et al. 2019), (Henriksen et al. 2017), (Csizmadia et al. 2015), (Ewin et al. 2017).
Resolve differences to collaborate with others for a common goal solution.	(Sándorová et al. 2020), (Tschimmel 2012), (Beaird et al. 2018), (Lor 2017), (Greeson et al. 2021), (Chou 2018), (Yalçın & Erden 2021).

Acknowledge team members' strengths and weaknesses during teamwork.	(Lor 2017), (Greeson et al. 2021), (Lahiri et al. 2021).

3.1 Confidence in dealing with complexity

Table 3. Specific Ability Table: Confidence in dealing with complexity

Author	Confidence in dealing with complexity
(Rauth et al. 2010)	Some teachers (4 out of 18) have reported creative reliance on design thinking activities.
(Albay & Eisma 2021)	Teachers can create creative, interactive, engaging, and learner-centered classrooms by implementing a design thinking process.
(Panke 2019)	Possible Motivations for Integrating Design Thinking into Educational Experience: Implicit Experience, Improved Empathy, Mitigated Cognitive Bias, Playful Learning, Flow, Collaboration, Productive Failure, Amazing Solutions, Creative Confidence: Is diverse.
(Crites & Rye 2020)	It has also been suggested that Design Thinking may be an approach that could be employed for future policy reforms in Latin America, especially within the Social Innovation area.

As shown in Table 3, Design Thinking is supported to provide an ability to confidence in dealing with complexity. It was presented in previous research through Design Thinking teachers could be confident to create creative classrooms (Albay & Eisma 2021).

3.2 Persistence in working with challenging problems

Table 4. Specific Ability Table: Persistence in working with challenging problems

Author	Persistence in working with challenging problems
(Mouchrek et al. 2016)	Design Thinking-based activities give more insight into important moments during the semester. At this moment, individual students and the entire group overcame the points of battle and realized a way to master this task.

The persistence to deal with complex problems is underscored in the research reported in Table 4 (Mouchrek et al. 2016). Students were challenged by the tasks to be overcome during the assignment. It supported one of the abilities in Computational Thinking.

3.3 The ability to resolve ambiguity

Table 5. Specific Ability Table: The ability to resolve ambiguity

Author	The ability to resolve ambiguity

(Micheli et al. 2019)	The literature suggests that design thinking should be able to embrace ambiguity and engage in defining and resolving problems.

As detailed in Table 5, The ability to handle ambiguity is mentioned as an ability of Computational Thinking (Barr & Stephenson 2011). Handle ambiguity is relevant with a part of Design Thinking: define. Define is a process to define the problem to solve in the next part, ideate.

3.4 The ability to resolve open-ended problems

Table 6. Specific Ability Table: The ability to resolve open-ended problems

Author	**The ability to resolve open-ended problems**
(Smith et al. 2015)	Design thinking supports children's ability to work in a "wicked" solution space, where failures, iterative processes, and continual reflections on materials of manufacture are integral parts of the process.
(Lor 2017)	A deeper analysis of the application of the framework for all studies, resulting in common themes: (1) Building empathy and user-centeredness; (2) creativity and innovation; (3) rapid prototyping and experimentation mindset; and (4) open-minded interdisciplinary collaboration across disciplines.
(Greeson et al. 2021)	The results indicate that design thinking potentially facilitates change in child welfare systems. It effectively addresses the suffering of the people for whom solutions have been developed.
(Shan et al. 2021)	The findings showed the feasibility and influence of the solution to promote recycling in developed countries.
(Buhl et al. 2019)	In sum, Design Thinking`s approach to problem-solving appears to be helpful to determine the suitable innovation scope for SOI.
(Henriksen et al. 2017)	The results suggest that design thinking abilities can instil thinking habits that educators can use to solve problems creatively.
(Simon & Cox 2019)	Inquiry is central to introducing students to prototyping or design thinking, and one of the key aspects of the PLTW curriculum is for students to find unique solutions to open design problems.
(Ewin et al. 2017)	Design thinking can address bad relationship issues that have been reported to be critical to project failure by developing soft skills for project management practitioners and incorporating them specifically into the project management curriculum.

Ability to solve open problems in Computational Thinking as described in Table 6 enables students to deal with problems, separate them down into resolvable blocks, and develop algorithms to solve them (Simon & Cox 2019). Design Thinking also supported problem-solving skills through its structure: (1) Building empathy and user-

centeredness; (2) creativity and innovation; (3) rapid prototyping and experimentation mindset; and (4) openness are diverse (Crites & Rye, 2020). Mentioned that problem-solving skills in Design Thinking are supported by the empathize process (Buhl et al. 2019). Both Design Thinking and Computational Thinking support problem-solving skills through a structured thinking approach.

3.4 Resolve differences to work with others for a common goal solution

Table 7. Specific Ability Table: Resolve differences to work with others for a common goal solution

Author	**Resolve differences to work with others for a common goal solution**
(Sándorová et al. 2020)	DT can be not only be seen as an efficient and creative problem-solving approach in the development of tourism products, but it also has the potential as a revolutionary and fascinating real-life teaching method, as it can animate teaching and encourage learning. Creative thinking, teamwork and communication.
(Tschimmel 2012)	The students have repeatedly confirmed to me that knowledge and awareness about the dynamics of processes, their characteristics and models, and the use of associated DT tools help them participate more effectively in innovation processes and give new impulses to your employees.
(Beaird et al. 2018)	Design thinking is also collaborative in nature and can help develop skills that are useful to practice as part of a team.
(Lor 2017)	A deeper analysis of the application of the Design Thinking Framework for all studies, resulting in common themes: (1) Building empathy and user-centeredness; (2) creativity and innovation; (3) rapid prototyping and experimentation mindset; and (4) open-minded interdisciplinary collaboration across disciplines.
(Greeson et al. 2021)	The analysis indicates that the change in child welfare systems can be facilitated and effectively addressed the issues of the community whose solutions have been developed.
(Chou 2018)	We believe that using design thinking skills such as empathy with clients can help alleviate some of these problems.
(Yalçın & Erden 2021)	In summary, preschool STEM education based on design thinking models has been found to sustainably improve children's creativity and problem-solving abilities.
(Mouchrek et al. 2016)	Looking back on her personal role in the group, another student infers that her class provided her with the opportunity to get a good look at her role in the group. She realized that each group member should take the initiative and be actively engaged.

As mentioned in Table 7, teamwork literacy is associated with the fundamental individual's knowledge, skills, and abilities to be more productive and effective in contributing to the team (Awuor et al. 2021). It is important to take the

initiative in group work in order to develop the ability to work as a team as part of the ability of Computational Thinking. In Design Thinking, the ability to work as a team is defined in various research.

3.5 Acknowledge team members' strengths and weaknesses during teamwork

Table 8. Specific Ability Table: Acknowledge team members' strengths and weaknesses during teamwork

Author	**Acknowledge team members' strengths and weaknesses during teamwork**
(Lor 2017)	A deeper analysis of the application of the Design Thinking Framework for all studies, resulting in common themes: (1) Building empathy and user-centeredness; (2) creativity and innovation; (3) rapid prototyping and experimentation mindset; and (4) open-minded interdisciplinary collaboration across disciplines.
(Greeson et al. 2021)	The analysis indicates that the change in child welfare systems can be facilitated and effectively address the pain points of the people whom solutions have been developed.
(Lahiri et al. 2021)	We believe that using design thinking skills such as empathy with clients can help alleviate some of these problems.

Computational Thinking gives the ability to know each other's strengths and weaknesses (Barr & Stephenson 2011), it correlates with the point of "empathize" on Design Thinking that is mentioned in Table 8. Empathizing processes can also help to know each other when working together.

4. Conclusion.

From the twenty manuscripts examined, all of the research reports provide evidence for all the abilities. It can be concluded that design thinking affects individual ability in Computational Thinking. It is apparent that Design Thinking influences the ability of Computational Thinking through the process of Design Thinking: (1) empathize, (2) define, (3) ideate, (4) prototype, (5) test. Those steps generate creativity, problem-solving, collaboration, and empathy that also intersect with the abilities of Computational Thinking. Design thinking enhances students' confidence to deal with complexity and persistence to work over complex issues. The critical and technical aspect of the skill enables students to resolve ambiguity and gears them to solve open-ended problems. The social ability aspect of design thinking aspires students to acknowledge team members' differences while collaborating to achieve a standard solution. They are also introduced to the ability to recognize team members' strengths and weaknesses when collaborating with others.

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Biography

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