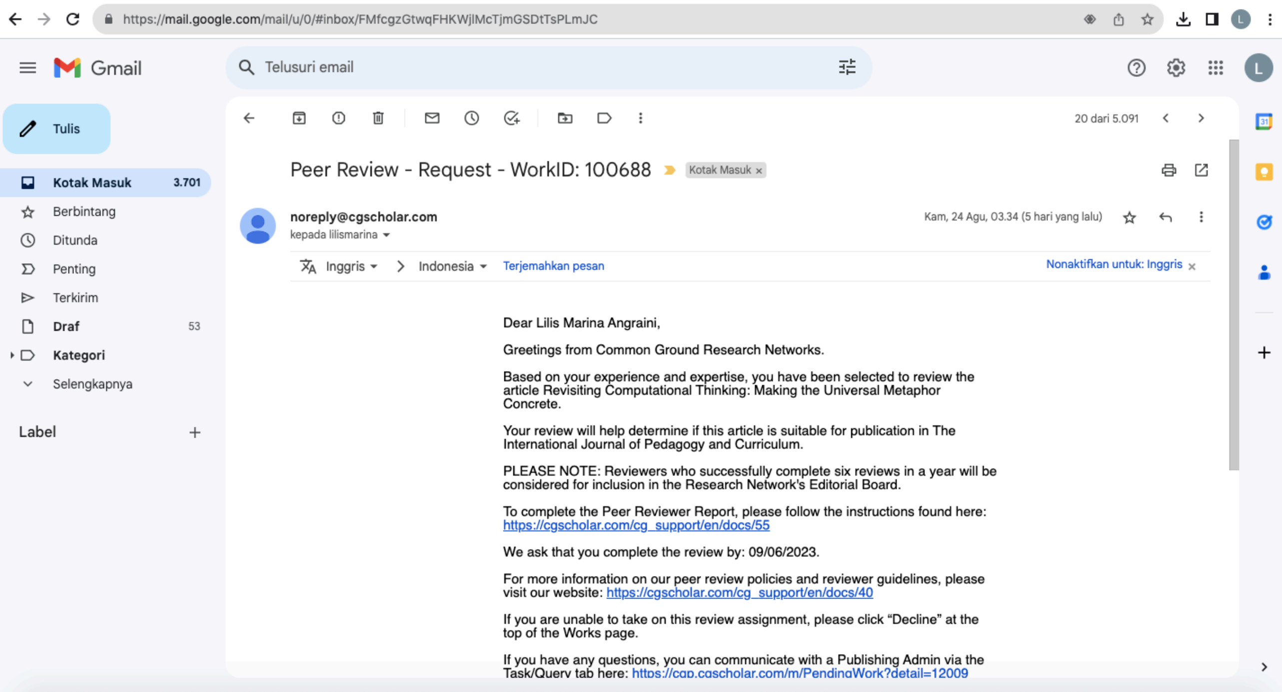
1. Permintaan review (24 Agustus 2023)



Peer Review - Request - WorkID: 100688 Kotak Masuk

noreply@cgscholar.com
kepada lilismarina

Kam, 24 Agu, 03.34 (5 hari yang lalu)

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Dear Lilis Marina Angraini,

Greetings from Common Ground Research Networks.

Based on your experience and expertise, you have been selected to review the article Revisiting Computational Thinking: Making the Universal Metaphor Concrete.

Your review will help determine if this article is suitable for publication in The International Journal of Pedagogy and Curriculum.

PLEASE NOTE: Reviewers who successfully complete six reviews in a year will be considered for inclusion in the Research Network's Editorial Board.

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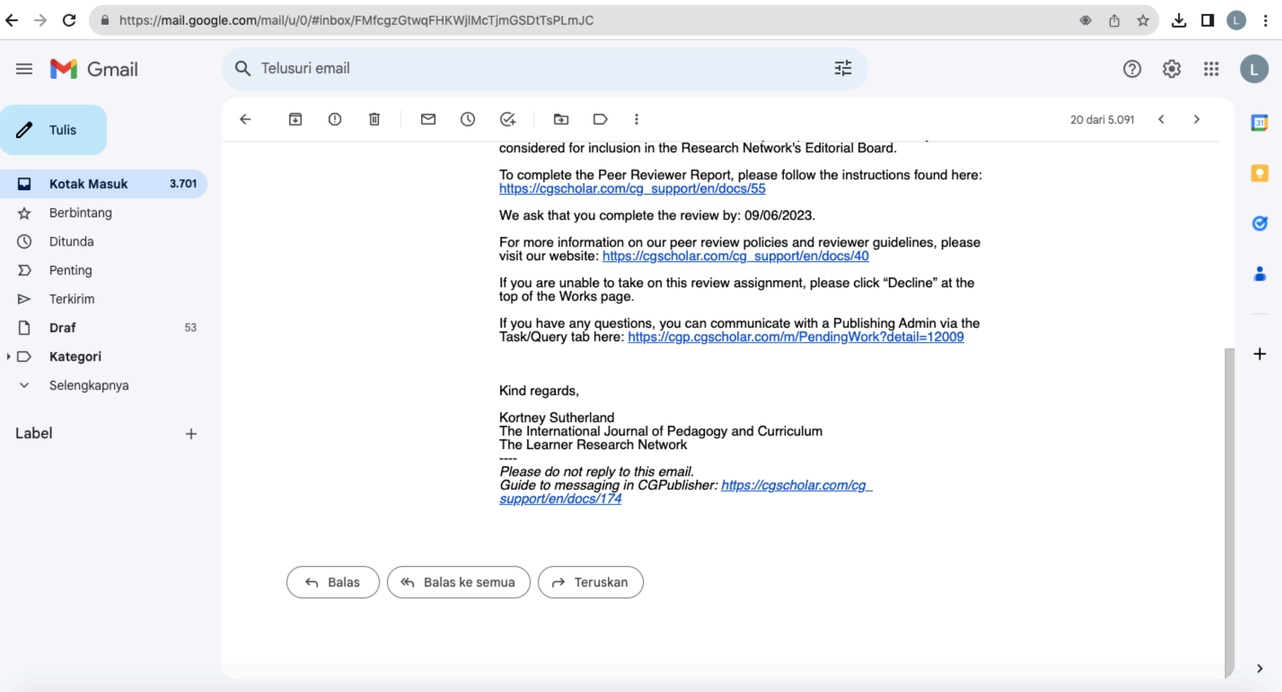

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Kind regards,

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The International Journal of Pedagogy and Curriculum
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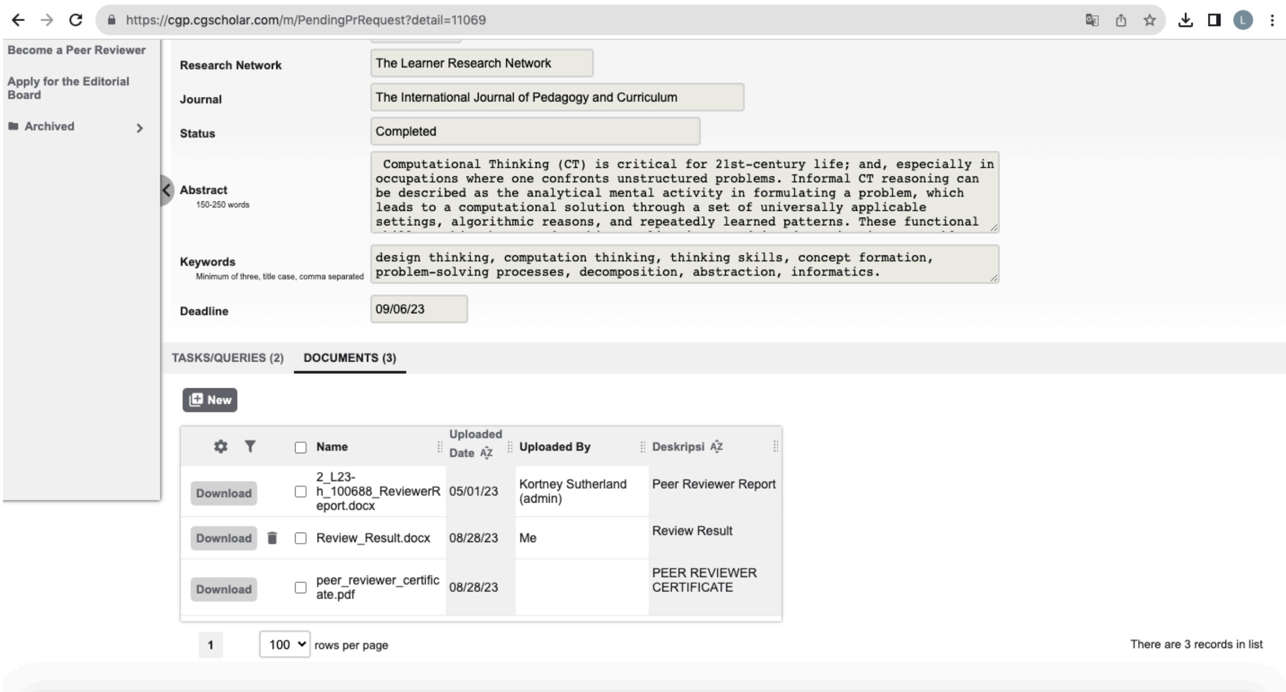

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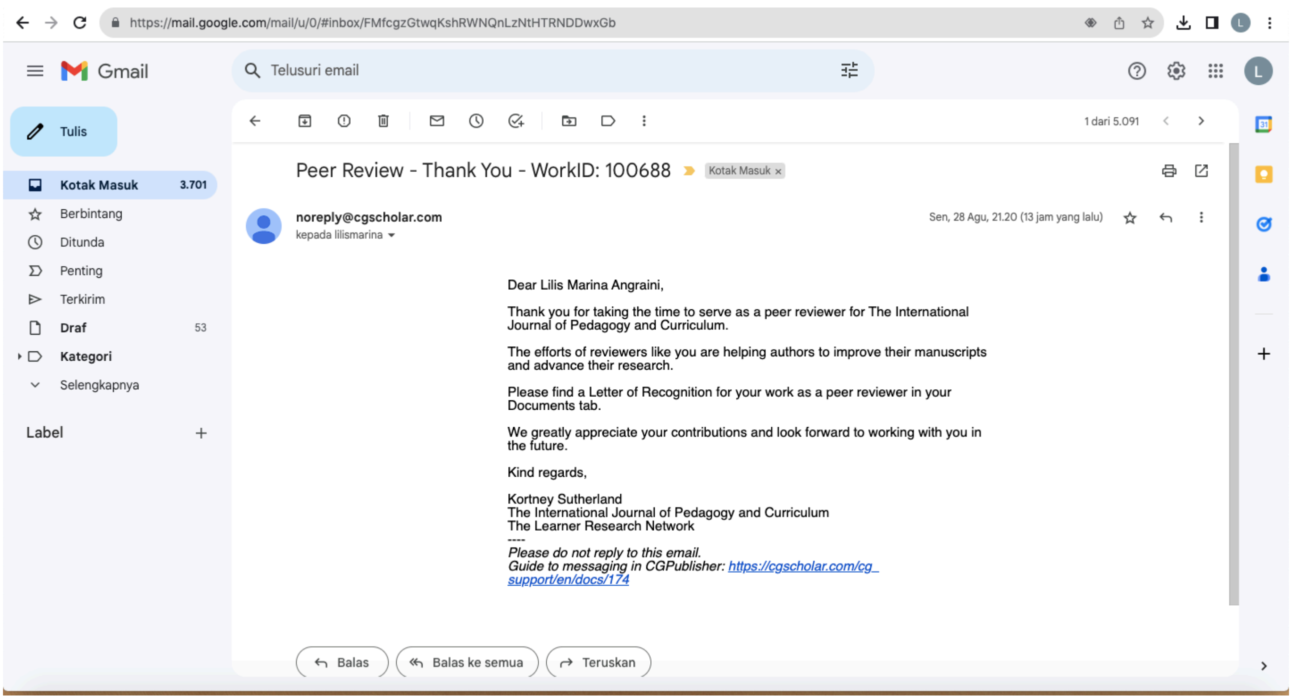

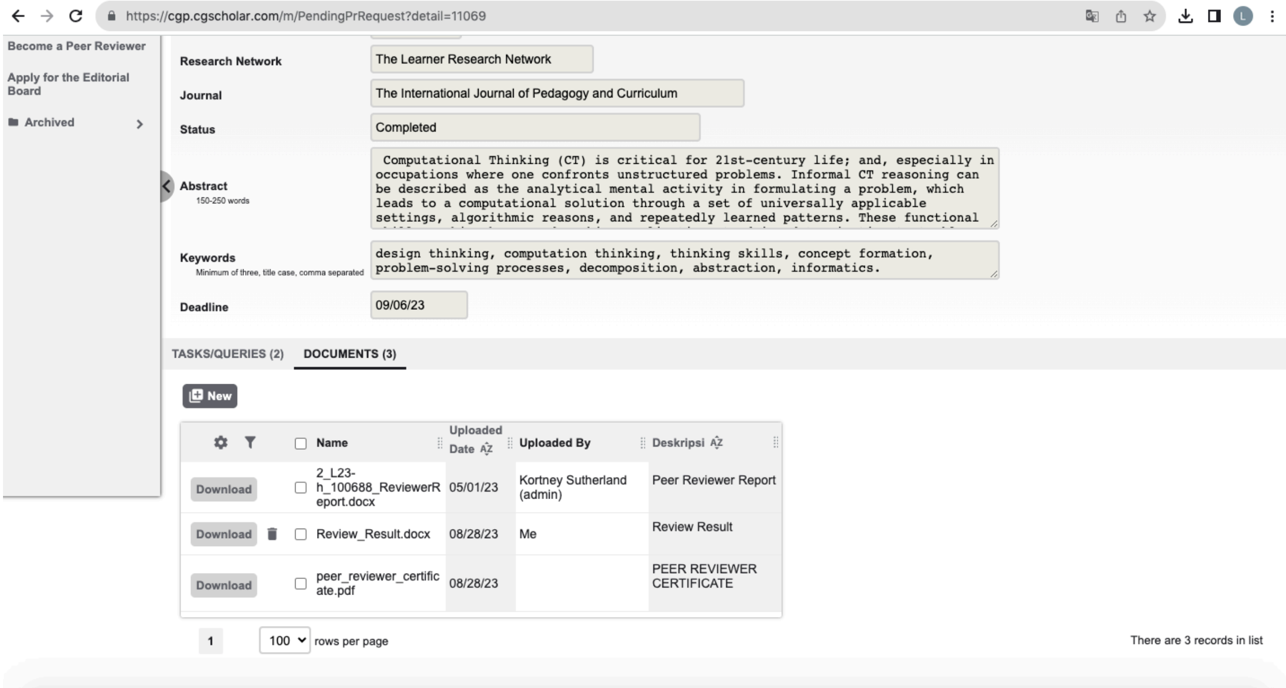

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Research Network	The Learner Research Network
Journal	The International Journal of Pedagogy and Curriculum
Status	Completed
Abstract (150-250 words)	Computational Thinking (CT) is critical for 21st-century life; and, especially in occupations where one confronts unstructured problems. Informal CT reasoning can be described as the analytical mental activity in formulating a problem, which leads to a computational solution through a set of universally applicable settings, algorithmic reasons, and repeatedly learned patterns. These functional
Keywords (Minimum of three, title case, comma separated)	design thinking, computation thinking, thinking skills, concept formation, problem-solving processes, decomposition, abstraction, informatics.
Deadline	09/06/23

TASKS/QUERIES (2) DOCUMENTS (3)

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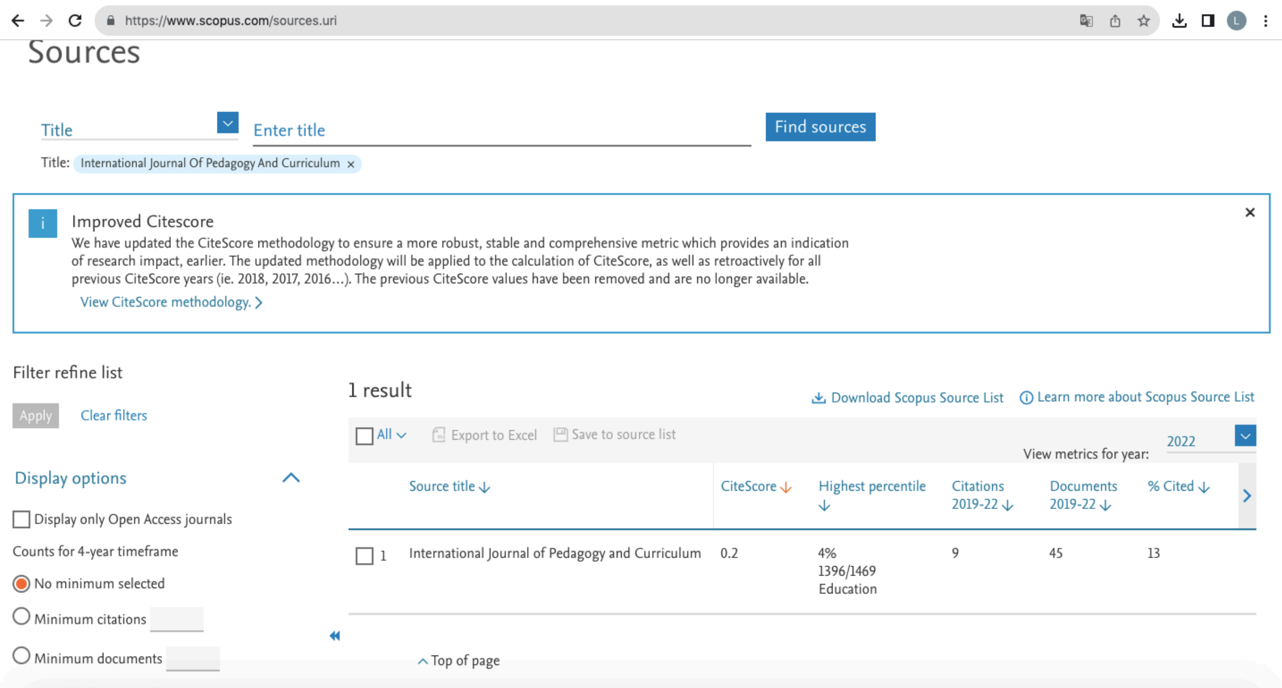

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Top of page

08/28/23

To Whom It May Concern,

This letter certifies that Lilis Marina Angraini has successfully completed a peer-review report for an article under publication consideration by Common Ground Research Networks. We express gratitude for their contribution and expertise as a reviewer. Their feedback has enriched the value of *The International Journal of Pedagogy and Curriculum.*

This peer-review report was verified on 08/28/23. We have certified that Lilis Marina Angraini's report is complete and that it satisfies the requirements of our evaluation rubric. Our approach to peer review seeks to be inclusive, founded on a rigorous, merit-based, two-way anonymous peer-review processes. Common Ground Research Networks takes intellectual integrity seriously. The publisher, editors, reviewers, and authors all agree upon a standard of expected ethical behavior, which is based on the Committee on Publication Ethics (COPE) Core Practices.

Yours Sincerely,

Dr. Phillip Kalantzis-Cope
Chief Social Scientist, Common Ground Research Networks

Common Ground Research Networks

Address: University of Illinois Research Park 2001 South First St, Suite 201L Champaign, IL 61820

Email: support@cgnetworks.org

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Dear Reviewer,

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Please be mindful that you belong to a community of scholars, educators, and practitioners who devote their energy to sharing knowledge. Always be respectful and professional when providing feedback. Reviewers are encouraged to be critical, constructive, and, above all, respectful.

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If you have any questions about the peer-review process, please contact us for assistance.

Sincerely,

CG Journal Publishing Team
Common Ground Research Networks
University of Illinois Research Park
60 Hazelwood Drive
Champaign, IL 61820 USA
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Reviewer Report

Article for Review:	REVISITING COMPUTATIONAL THINKING: MAKING THE UNIVERSAL METAPHOR CONCRETE
Research Network:	Learner

Instructions

- Provide a response and score for each of the five sections.
- Kindly use concrete examples when offering criticism and feedback.
- Please do not offer advice or criticism regarding styles or formatting.
- This file contains the manuscript for review. When returning reports, the manuscript must remain attached to verify the report appropriately matches the correct manuscript.
- Each category is scored on a range of 0 to 5 points.

0	1	2	3	4	5
Very Poor	Poor	Below Average	Above Average	Good	Very Good

Scoring Summary

After providing a written response for each the five evaluation criteria, please total your scores below.

EVALUATION CRITERIA	SCORE
1. Empirical Grounding	2 of 5
2. Conceptual Modeling	1 of 5
3. Explanatory Logic	2 of 5
4. Implications and Applications	2 of 5
5. Quality of Communication	1 of 5
TOTAL SCORE	8 of 25

1. Thematic Focus and Empirical Grounding

When considering the Thematic Focus and Empirical Grounding, please use the following prompts to guide your overall response and evaluation.

- Is this a topic that needs addressing?
- Is the area investigated by the article: significant? timely? important? in need of addressing because it has been neglected? intrinsically interesting? filling a gap in current knowledge?
- Are data collection processes, textual analyses, or exegeses of practice sufficient and adequate to answer the research questions?
- Does the article adequately document, acknowledge, and reference the existing findings, research, practices, and literature in its field?
- Does the article relate in a coherent and cogent way with issues of real-world significance?

RESPONSE:

- The article lacks a well-defined thematic focus, making it difficult to identify the main topics covered in the article. In addition, the article also lacks a strong empirical basis. There is no empirical research conducted by the authors of this article to support the claims made. The article is more descriptive and theoretical, with no empirical data that can provide concrete evidence on the topics discussed. In scientific research, it is important to have a clear thematic focus and a strong empirical basis to ensure the reliability and validity of the findings. Therefore, this article needs to be improved by providing a clearer thematic focus and supporting its claims with relevant empirical research.

SCORE:

- (2 of 5)

2. Conceptual Model

When considering the Conceptual Model, please use the following prompts to guide your overall response and evaluation.

- Are the main concepts or categories appropriate to the investigation?
- Should other concepts or categories have been considered?
- Are key concepts adequately defined? Are they used consistently?
- Does the article make necessary or appropriate connections with existing theory?
- Does the article develop, apply, and test a coherent and cogent theoretical position or conceptual model?

RESPONSE:

- The article does not provide a clear explanation of how CT and DT are interrelated and how they can be applied in an educational context. It also does not provide a strong conceptual framework for understanding the relationship between CT and DT. There is no explanation of the theories or concepts underlying the use of these two approaches in education. In scientific research, it is important to have a clear and well-defined conceptual model to guide the research and understand the relationship between the variables involved. Therefore, this article needs to be improved by providing a better development of the conceptual model used to understand the relationship between CT and DT in the educational context.

SCORE:

- (1 of 5)

3. Explanatory Logic

When considering the Explanatory Logic, please use the following prompts to guide your overall response and evaluation.

- How effectively does the article reason from its empirical reference points?
- Are the conclusions drawn from the data, texts, sources, or represented objects clear and insightful? Do they effectively advance the themes that the article sets out to address?
- Does the article demonstrate a critical awareness of alternative or competing perspectives, approaches, and paradigms?
- Is the author conscious of his or her own premises and perhaps the limitations of his or her perspectives and knowledge-making processes?

RESPONSE:

- The article does not provide an adequate explanation of the causal relationship or mechanisms underlying the relationship between computational thinking (CT) and design thinking (DT). The article is more descriptive and does not provide an in-depth explanation of why CT and DT are considered important in education or how they complement each other in solving problems. In scientific research, it is important to have a strong explanatory logic to understand the relationship between the variables involved and why a phenomenon occurs. Without an adequate explanation of the explanatory logic, it is difficult to understand the implications and significance of the research findings. Therefore, this article needs to be improved by providing a more in-depth explanation of the explanatory logic underlying the relationship between CT and DT in the educational context.

SCORE:

- (2 of 5)

4. Implications and Applications

When considering the Implications and Applications, please use the following prompts to guide your overall response and evaluation.

- Does the article demonstrate the direct or indirect applicability, relevance, or effectiveness of the practice or object it analyzes?
- Are its implications practicable?
- Are its recommendations realistic?
- Does the article make an original contribution to knowledge?
- To what extent does it break new intellectual ground?
- Does it suggest innovative applications?
- What are its prospects for broader applicability or appreciation?
- How might its vision for the world be realized more widely?

RESPONSE:

- The article does not provide concrete recommendations on how CT and DT can be applied in educational contexts or how teaching and learning can be changed to integrate these two approaches. In addition, the article does not provide an adequate explanation of the implications of the research findings. There is no discussion of the possible impacts of applying CT and DT in education, both for students and for teachers and educational institutions. In scientific research, it is important to provide clear implications and practical applications of the research findings. This helps the reader to understand how the findings can be used in a real context and make a meaningful contribution in the relevant field. Therefore, this article needs to be improved by providing a more in-depth explanation of the implications and applications of CT and DT research findings in the educational context.

SCORE:

- (2 of 5)

5. Quality of Communication

When considering the Quality of Communication, please use the following prompts to guide your overall response and evaluation.

- Is the focus of the article clearly stated (for instance, the problem, issue, or object under investigation; the research question; or the theoretical problem)?
- Does the article clearly express its case, measured against the standards of the technical language of its field and the reading capacities of audiences academic, tertiary student, and professional?
- What is the standard of the writing, including spelling and grammar?
- If necessary, please make specific suggestions or annotate errors in the text.

RESPONSE:

- This article does not provide a clear and structured explanation of the concepts of CT and DT, and the relationship between the two. The presentation of information in this article feels incoherent and it is difficult to follow the author's train of thought. In addition, the article lacks clear and operational definitions of CT and DT. There is no detailed breakdown of the key elements of these two approaches, making it difficult for the reader to understand in depth what CT and DT mean. In scientific research, it is important to have quality communication to ensure good understanding and effective knowledge transfer. This article needs to be improved by providing a clearer, structured and coherent explanation of the concepts of CT and DT, as well as providing operationalized definitions for both approaches.

SCORE:

- (1 of 5)

RECOMMENDATION:

How is the quality of communication as it relates to English language proficiency?

[ ] Publishable as is (Language problems are few to none)

[ ] Minor Proofing Required (Content should be proofread by a colleague or critical friend of the author)

[Y] Professional Editing Required (English language errors are significant and detract from the overall quality of the article)

Our publishing model is intended to ensure that authors speaking English as a second language are given the equal opportunity to receive feedback from a peer-review process to critique and improve the conceptual material of their article. Some articles can be well researched and formulated but may require assistance with certain nuances of the English language.

REVISITING COMPUTATIONAL THINKING: MAKING THE UNIVERSAL METAPHOR CONCRETE

Abstract: Computational Thinking (CT) is critical for 21st-century life; and, especially in occupations where one confronts unstructured problems. Informal CT reasoning can be described as the analytical mental activity in formulating a problem, which leads to a computational solution through a set of universally applicable settings, algorithmic reasons, and repeatedly learned patterns. These functional skills combine human and machine applications to drive determination to tackle puzzles and provide solutions. CT is considered an essential skill for the 21st-century workforce. As a skill, using ideas of computing integrated into existing disciplines, CT should be seen as a valuable part of the school curriculum. In this paper, CT is primarily a way of thinking and behaving that can be demonstrated using a particular skill and is the basis for the performance-based assessment of CT skills. Based on the literature, this paper expands CT traditional components to include the thinking practices in Design Thinking (DT) as a cross-disciplinary mental skill beyond those previously identified. These standard components include decomposition, abstraction, pattern recognition, and algorithmic. Also, this paper looks broadly at CT from the informatics perspective while extending recent discussions of the concept of CT in an attempt to revisit educational efforts in the development and enhancement of students' CT; discuss opportunities and challenges in pursuing similar cognitive exercises from other disciplines beyond computer science; while highlighting the research and scholarship needed to support mental cognitive growths. Thus, this paper's overarching purpose stimulates extended discussions on Computational Thinking in the broader conversation of curricula reforms.

Keywords: design thinking, computation thinking, thinking skills, concept formation, problem-solving processes, decomposition, abstraction, informatics.

No matter how the effects of the global pandemic crisis and its aftermath unfolded, there is no doubt that digital technologies will continue to transform education and the work environment. COVID-19 effects will likely become even more acute as educational organizations weigh the costs and benefits of curriculum reforms, especially in preparing students to enter the workforce with appropriate skills to excel. Individual researchers, national professional bodies, government agencies, and other stakeholders are reassessing existing curriculum components and policies considering the COVID-19 crisis and are seeking concerted collaboration and dialogue. The last two decades have brought about significant changes in technology and its impact on education systems. More recently, the global pandemic has presented a challenge to educational institutions to improve their modes of course delivery and to transfer the workforce is facing complex and interrelated problems that require problem-solving employees. In addition, several other voices currently call for reform in areas beyond the science and math curriculum. In a world where technology is deeply embedded in everyday life and learning, computing is essential to education. Educational systems at all levels must equip students with numeracy skills to fully participate in the changing nature of the workforce and their communities and social change more broadly (Angevine et al., 2017). Because of the various benefits, a skilled problem solver would experience in daily life and business, problem-solving is also regarded as one of the most crucial talents a student should possess in the twenty-first century.

A more recent demand is the introduction of Computational Thinking (CT, from now on) as competency. This problem-solving process involves identifying patterns, logically organizing, and analyzing data, creating abstractions, developing algorithms, and formulating problems so that computers can solve them (Fadhillah, 2023, Araya, 2021, Grover, 2013). In an era of artificial intelligence (AI) and big data toward the fourth industrial revolution, a movement for curriculum reform (UNESCO 2019). CT is becoming a key component of curricula for establishing the digital economy. CT is increasingly recognized as an important cognitive trend. It is imperative to solve the challenges of a digital society. However, CT requires basic knowledge of how computers process information, connect to the Internet of Things (IoT) and smartphones, and integrate Artificial Intelligence (AI) and big data. CT is closely related to computer and mathematical sciences; however, it is essentially a systematic thinking skill that draws its structure on concepts from computer science; but is a fundamental skill used by and valuable for all disciplines (Wing, 2006). Furthermore, Finally, this paper is purposed to contribute to the discussion on curriculum reform while adding to the literature on CT into the K-12 generative dimension of design thinking in areas beyond STEM.

An impressive number of nations globally, more so in European nations, have policies on curriculum that modify their compulsory education and, in strategic manners, modify their national curricula to adapt CT skills. CT thinking is a universal metaphor of reasoning used by humankind and machines. CT is at the core of the computing curriculum and supports learning and thinking in other curricula. According to Paul (2007)**, ". . .** much of our thinking, left to itself, is biased, distorted, partial, uninformed or downright prejudiced. However, the quality of our life and that of which we produce, make, or build depends precisely on the quality of our thought" (p. 4). CT is a relatively innovative approach to education centered on problem-solving, system design, and analysis based on the paradigms mostly found in computer science.

The term CT, coined by Papert (1980), has been popularized by Wing (2019) as the thought forms included in defining an issue and communicating its solution(s) in a similar way that a computer- human or machine - can viably carry out. CT refers to defining and solving a problem so that the solution can be skillfully and successfully executed. Adding that knowledge to students' analytical skills is critical to learning science, technology, engineering, and math (STEM). Wing argued. CT refers to defining and solving a problem so that the solution can be skillfully and successfully executed. Adding that knowledge to every student's analytical skills is critical to learning science, technology, engineering, and math (STEM), Wing argued. The elements of CT are reasonably well known, given that they include the computational concepts, principles, methods, language, models, and tools that are often found in the study of computer science. With much precision Papert (1980), in his seminal book dating over 40 years, was emphatic about the place of CT as not a behavior, a deliberate imitation of ". . . mechanical thinking, the learner becomes able to articulate what mechanical thinking is and what it is not. The exercise can lead to greater confidence ability to chose a cognitive style that suits the problem" (p. 27). Papert (1980) further claimed against the notion of- the ". . . computer being used to program the child. He states that in "my vision," the child programs the computer. In doing so, both acquire a sense of mastery over a piece of the most modern and powerful technology and establish an intimate contact with the deepest ideas from science, mathematics, and the art of intellectual model building" (p. 29).

Thus, CT relatively includes the reformulation of complex concepts by reduction and transformation; approximate solutions, parallel processing, type checking, and model checking as a generalization of dimensional analysis; problem abstraction and decomposition, problem representation; modulization, reasoning planning, testing the formal correctness of solutions (Curzon, 2014; Rich 2015). Adding this knowledge to students' analytical skills is critical to learning in the disciplines that include science, technology, engineering, and mathematics (STEM). As efforts to integrate CT into formal education increased over the last decade, the yield should not be considered a modification of human cognitive facilities to "thinking like a computer." Instead, it is a fundamental skill that can solve problems using computing behaviors and power. This includes formulating problems in a computer-solvable way, analyzing raw and processed data, using models, creating simulations, and applying step-by-step sequential approaches to solving problems effectively and efficiently. The use of "the core concepts of computer science to solve problems, develop systems, and comprehend human behavior" is how Wing (2006), in her seminal paper, defined computational Thinking (CT). Wing pointed out that CT involves several elements. Among them are familiar concepts such as problem decomposition, data representation, modeling, and vague ideas like binary search, recursion, and parallelization are covered. Wing (2017) argued. This belief is reflected in its inclusion of computational Thinking in Next Generation Science Standards (NGSS) as a scientific and engineering practice. The theory of computation is still one of the main branches of computation, studying computer models' fundamental capabilities and limitations. A computer model can be defined as a mathematical abstraction over a computer system. Historically, calculus was associated with loose thinking as a tool until math educators emphasized the importance of students understanding what they were doing in calculus. CT is now a core competency in the STEM field. ISTE defines Computational Thinking Competency as skills that guide educators to integrate CT across disciplines with all students and supports students` development of skills to become computational thinkers "who can use the power of computing to innovate and solve problems." (SIT).

Computer science concepts are important in other subjects, and thinking computationally is an essential skill for everyone. This leads to the increasing interest in developing CT as early as at the early childhood education level. Today's society uses computational thinking practices for solving problems and solving problems (Resnick 2016; Caeli 2020;). As with reading, writing, and arithmetic, CT is a key skill every child needs to support their analytical skills. Just as the printing press helps spread the three R's, that vision is appropriately incestuous because computing and computers help the spread of CT. CT involves solving problems, understanding human behavior, and designing systems using fundamental computer concepts.

CT includes a set of mental tools that reflects a broad area of computer science. Furthermore, published studies have demonstrated that CT and complex numerical skills (Román-González 2017), verbal reasoning skills (Fadhillah 2023; Tsarava 2022; Tsarava 2019), and nonverbal visuospatial skills (Città 2019; Moschella 2020). showed a positive association with (Tsarava 2022; Shute, 2017). The instinct for computational CT can bridge the gap between a student's "real life" and the science classroom. CT is increasingly being recognized as a critical cognitive trend. One of the new requirements is the introduction of computational Thinking (CT) in primary school. CT is a problem-solving process that involves recognizing patterns, logically organizing, and analyzing data, drawing inferences, developing algorithms, and formulating problems so that computers can solve them (CSTA, 2021).

Further, CT incorporates different capacities of the 21st century, such as issue tackling, expository considering, and imaginative considering creating competencies of; improvement and helping individuals' problem-solving abilities with the assistance of innovation and setting the creating innovation into work. Problem-solving aptitudes and innovation utilization, which are of colossal significance in arranging that people reach the education level in the scholarly zone, ought to get to proficient forms in instructive situations.

THINKING PRACTICES

Numerous models underlying problem-solving have been developed. Using various phases of the problem-solving process, they all attempt to aid students in developing or improving their problem-solving abilities. Educators have the responsibility to instill in their students a general curiosity in all areas of study. Educators must have the confidence to tackle ambiguous problems, the tenacity to overcome challenges that require repetition and experimentation, strong communication skills to facilitate collaboration and presentation, and the ability to ask and answer big questions. Nevertheless, problem-solving skills are more than just a mere model application. It is accompanied by associated thinking strategies fostered during the investigation of the problem space following the problem-solving steps. Teaching thinking strategies (such as divergent thinking, convergent thinking, metacognition, etc.) is of prime importance in developing problem-solving skills (Berardi-Coletta et al., Declos 1991; Lai, Griffin, Mak, Wu, & Dulhunty, 2001). However, what thinking strategies should a foster teacher to increase students' problem-solving skills?

In this manner, it is anticipated that students' efforts will be focused on locating the appropriate or ideal solution to a problem. In today's high-tech and ever-changing world, is an urgent need for new pedagogical, instructional, and assessment paradigms, given the rapidly growing interest in CT in K–12 education (Ventura et al., 2017). Problem-solving is part of life, and no one can avoid it. CT is used to solve complex problems, so the more you adopt it, the better prepared you will be when serious challenges arise. Problem-solving as a computer thinker also requires a particular problem-solving attitude. Learners gain the confidence to tackle ambiguous problems, the tenacity to overcome challenges that require repetition and experimentation, strong communication skills to facilitate collaboration and presentation, and the ability to ask and answer big questions. CT requires learners to be aware and purposeful throughout the problem-solving process and builds essential habits like embracing ambiguity with confidence, persisting through replication and experimentation, teamwork, leading learning that incorporates inquiry, and engaging oneself as a lifelong learner. Further, learners gain confidence in asking bold questions and persist through head block toward the yet-to-be-imagined results. In addition, learners collect and dissect data lists as they develop a mindset through learning to grasp nebulosity and reframe challenges as opportunities, whether with or without technology.

CT Thinking is a prerequisite for understanding future technologies, and it is more of a thought process than a specific body of knowledge about devices or languages. CT is often associated with computers and coding, but it is valuable to note that it can be taught without devices. CT is a valuable skill procedural tool in solving any problem. It is a process that teaches students how to think like a computer by guiding them through a series of steps to solve problems. This skill is especially beneficial for solving open-ended challenges. Essential functions of CT are related to finding well-defined, step-by-step solutions to complex problems. However, the approach to computational thinking suitable for any level across the P-16 level and beyond is incredibly challenging because there has not been a widely agreed-upon definition of CT.

P-16 Educators must instill in their students a general curiosity in all areas of study to gain proficiency in problem-solving strategies. CT helps develop the following skills:

Algorithmic Thinking, Abstraction, Decomposition, Pattern Recognition, and Design Thinking.

FIGURE 1: COMPUTATIONAL THINKING COMPONENT

<table>
<tr><th>Decomposition</th><th>Pattern Recognition</th></tr>
<tr><td>Breaking down problems into smaller sections.
Breaking down problems into smaller parts can make complicated challenges more manageable. This enables other computational thinking elements to be applied more effectively to complex challenges. The solutions to the smaller problems are then combined to solve the original, larger problem.
Real-world Examples: For instance, when you clean your room, you may put together a to-do list. Identifying the individual tasks (making your bed, hanging up your clothes, etc.) allows you to see the smaller steps before you start cleaning.</td><td>Recognizing if there is a pattern and determining the sequence.
Examining the problem for patterns, or similarities to previously solved problems, can simplify the solution. Pattern recognition can lead to grouping, organizing, or streamlining problems for more efficient outcomes. Conversely, a lack of patterns is also useful because it means there is no more simplification to be done.
Real-world Examples: You have likely used pattern recognition in games like UNO, checkers, mancala and SET. Sports like football and basketball also use pattern recognition to identify the opponent's strategy.</td></tr>
<tr><th>Abstraction</th><th>Algorithm</th></tr>
<tr><td>Generalization of a problem - focus on the big picture and what's important.
Taking a step back from the specific details of a given problem allows you to create a more generic solution. This requires analyzing the problem to remove extra detail and highlight the basic parts. Once completed, begin brainstorming a solution to the problem.
Real-world Examples: Public transportation maps are examples of abstraction that you may encounter often. The maps show only the important information (the stops, the general direction that you are heading) and leave out the finer details.</td><td>Step by step instructions to solve a problem.
When solving a problem, it is important to create a plan for your solution. Algorithms are a strategy that can be used to determine the step-by-step instructions on how to solve the problem. Algorithms can be written in plain language, with flowcharts, or pseudocode.
Real-world Examples: We use algorithms daily, normally in the form of step-by-step instructions. Recipes, instructions for making furniture or building blocks sets, plays in sports, and online map directions are all examples of algorithms.</td></tr>
</table>

Source: The Bower Institute. (n.d.). *Tech Tip: Computational thinking - the tech interactive*. TECH TIP: Computational Thinking. https://www.thetech.org/sites/default/files/techtip_computationalthinking_v3.pdf

Algorithmic Thinking

They are designing a sequence of steps to conduct a specific task. One of the key ideas in algorithmic reasoning is recursive reasoning (Kilpatrick, 1985; Knuth (1985). Algorithmic Thinking relies on recognizing repetition patterns in problems. We then describe these patterns as a set of rules for dealing with such situations (without having to ponder this every time a problem arises). In effect, create (formally or informally) an algorithm or analytical procedure. This type of thinking skill is commonly used in problem-solving and computer programming. Many mathematical methods can be recognized as algorithms if the program represents algorithmic Thinking (Knuth 1997). [48–50]. Algorithmic Thinking is seen when creating or using well-defined and sequential steps to achieve a desired result. Although humans can be more creative than computers when following an algorithm, students must be able to both communicate and interpret clear instructions to produce predictable and reliable output. Most of the problems that students meet in their studies and daily life are minor problems that we can solve more quickly. Unraveling problems allows analysis of various aspects, grounding thinking and directing to an adequately defined endpoint. Thus, algorithmic thinking involves breaking the problem into smaller parts, identifying patterns, and removing redundant details to define and iterate a step-by-step solution. Many disciplines, therefore, require or lend themselves to algorithmic thinking as they, in varied ways, promote and teach problem-solving skills, logical thinking, or algorithmic thinking.

Decomposition

The power of CT begins with decomposition, which breaks down complex problems into smaller, more manageable parts. Decomposition is defined as the process of breaking down a problem into its sub-components (that are smaller and manageable. On the decomposition dimension, problems that seem overwhelming at first become much more manageable; thus, decomposition is a process of breaking down a problem into its sub-components (that are smaller and manageable. CT uses decomposition when facing an enormously complex task or designing an extensive system. Breaking problems down by functionality is identified by Wing (2006, 2018) as part of computational Thinking. Decomposition is required when dealing with significant problems, complex systems, or complex tasks. To explain the problem, one must choose an appropriate representation or model the relevant aspects. With the help of invariants, it is possible to describe the system's behavior briefly and descriptively.

CT uses abstraction and decomposition when facing an enormously complex task or designing an extensive system. Breaking problems down by functionality is identified by Wing (2018) as part of CT. Decomposition is required when dealing with extensive problems, complex systems, or complex tasks. This can be used to change and influence an extensive complex system without fully understanding all aspects of it. Edelson points out that creating a solution requires dividing the problem into blocks with specific functionality and ordering the blocks. Analyze puzzles piece by piece, picture by color, and article by paragraph. These are attributes or parts of the object or idea being decomposed. In decomposing the problem, we identify meaningful axes for classifying the parts of the problem and divide and group those parts into the identified categories along the specified axes.

Abstraction

Abstraction, as an essential part of the computational thinking process, is the most critical and demanding computational Thinking. In layman's language, an abstraction is a simple act of the filtration process of data not needed and that which is not needed. Wing (2006) defines abstraction as the cornerstone of computational Thinking. An abstraction defines a generalized pattern and is parameterized by a specific case and setting parameters. Its utility is in allowing multiple objects to stand on one object. This means stripping away from unnecessary details to develop a general solution or represent a complex system with a simple model or visualization.

Making problems or systems more abstract makes them easier to think about. It simply entails reducing superfluous complexity by obscuring detail. The trick lies in selecting the appropriate detail to conceal so the problem can be solved more efficiently without compromising crucial information. It is used to facilitate the development of intricate algorithms and whole systems. Selecting an effective system representation is a crucial aspect of it. Various representations facilitate different actions. An object represents multiple objects and captures important parcels common to a set of objects while hiding inapplicable differences between objects. For illustration, an algorithm is an abstraction of a process that takes an input, performs a series of ways, and produces an affair to achieve an asked thing. An abstract data type identifies an abstract set of values and operations for manipulating those values while hiding the actual representation of the values from users of the abstract data type. Essentially, designing efficient algorithms involves designing abstract data types. The concept of abstraction is explored by L'Heureux et al., (2012), where it is one of six aspects of their information technology approach to computational Thinking.

Pattern Recognition

Recent studies (Kellman 2010) have shown a strong association between K-12 pupils' ability to perform patterning assignments and their effectiveness on word problems utilizing mathematical ideas like equality and variable identification. Finding trends in a particular pattern is known as pattern detection. A pattern can be defined as anything that follows a trend and has some regularity. The human brain has the unique capacity to recognize patterns and use inductive reasoning to deduce what those patterns could imply about what will happen next. Every scientific investigation is based on pattern identification and inductive reasoning.

As learners develop, they are exposed to various patterns. Early pattern recognition is crucial to resolving many other, more complicated issues and thinking about the addition and multiplication timetable patterns used in early mathematics. For a learner to predict future actions or occurrences and to use basic logic in everyday situations, they must be able to spot patterns and reason inductively. Students who struggle with pattern recognition may find it difficult to transition between activities and follow lessons because they may find it challenging to get into the "flow" of the lesson.

Both learners and teachers look at problem-solving techniques frequently as patterns; once they are identified, we use specific procedures or formulas that culminate in a solution. The process of determining the trend in a given pattern is known as pattern recognition. Anything that follows a trend and demonstrates some regularity is a pattern. Pattern recognition can be accomplished physically, mathematically, or through algorithms. By applying real-world situations to the classroom, students can find their learning skills relevant and vital beyond the classroom. Lu et al. (2019) argue that CT skills in the primary and secondary school curriculum should begin by teaching vocabulary and symbols to provide a solid foundation for further skill development. They equate programming with building proofs from mathematics.

Design Thinking

Although there is general agreement that computational thinking is a cognitive activity, some advocate including particular forms of thinking. Logical thinking, algorithmic thinking, engineering thinking, and mathematical thinking are examples of these particular thinking styles. The research community has attempted to provide an integrated view of design thinking at various levels, assigning it as an approach to problem-solving processes. Simonse et al. (2014), for example, proposed a concept of strategic design thinking from the perspective of business model innovation:

> [Strategic design thinking is] a series of cognitive activities (such as reasoning, creative problem solving, decision-making), which are directed to the understanding of the business problems, its network structure, and value exchange possibilities to co-create a design process and outcome which are meant to provide a strategic direction and communication of a shared vision and commitment.

As a result of non-linear Design Thinking (DT), methods based on scenarios and feedback mechanisms are synthesized to assist in developing the concept, program, and others while offering the highest level of flexibility. The fundamental element of the approach is the natural feedback loop based on several scenarios to optimize settings and anticipate potential changes to the design process. The diversity of approaches and viewpoints needs to be correlated with collective intelligence. When a learner, who is perhaps a valued member of the team, employs design thinking - a non-linear, iterative approach - known factors of a problem and uncovering more alternative ways that contribute to the correct solution, come to the forefront and offer opportunities to the learner to question presumptions, reframe challenges, and develop original ideas for prototyping and testing. Since they may reframe these issues in human-centric ways and concentrate on what is most essential for users, design teams utilize design thinking to address poorly defined or unidentified challenges. Individuals can come up with novel ideas while using DT. DT refers to a set of ways of thinking that can be used across all levels of education; however, as previously discussed, it is particularly well-suited to the needs and characteristics that new media educators have identified. The idea of design Thinking as a process is nothing new. This has been a belief for decades. The first attempt to convert this into a process was made by Simon in 1969. Contemporary variations of this process exist today, the most popular being the 5-step process in Figure 2, introduced by the Stanford Design School in 2005. For instance, the use of 'constructive' thinking by Nigel Cross is based on what Charles Pierce refers to as 'abductive' reasoning, which involves working from 'unallocated information and evidence' and involves 'creative and intuitive guesswork' (p. 20). In other words, abductive reasoning may be the thinking that many people use daily when dealing with a world that often does not provide all the necessary information. Buchanan (2001), who provides a slightly different perspective, offers claims that ". . . design has become the new learning of our time, opening a pathway to the neoteric disciplines that we need to connect and integrate knowledge from many specializations into productive results for individual and social life" (2001: p 7).

Initially, design thinking aimed to instruct engineers in designers' creative problem-solving methods. DT positively impacts 21st-century education across disciplines even though it has become essential to business, design, and engineering, and its importance is associated with developing creative problem-solving activities. Students must read critically, reason rationally, and solve complicated issues in academic settings

(Rotherham & Willingham, 2009). Therefore, educators should support students in developing and honing 21st-century skills (such as design systems thinking, design thinking, and teamwork skills) that enhance their problem-solving abilities and prepare them for college and career in order to help them succeed in the interconnected, digital world we live in (Rotherham et al., 2009; Shute et al., 2012).

While DT is still a work in progress, even in the business discipline, when considering employing a problem-solving process based on user experience when making products assists teams in identifying issues, restructuring them, and developing innovative solutions. As an approach, it could be identified as a participatory design (Kensing, 1998), in which learners work in teams on open-ended problems and decide entirely autonomously how to move their projects forward (Royalty, 2021, von Thienen, 2017, Goldman et al., 2012). Horgarty et al. (2021) define DT from a business perspective as "a procedure for resolving issues that put the customer's requirements first. It is based on watching with empathy how people interact with their surroundings and uses an iterative, practical process to develop novel solutions." (n.p.). DT, like the broader focus of CT, focuses on problem-solving. DT, like engineering, focuses on product specification and the requirements imposed by humans and the environment (i.e., practical problems). At a high level, the steps in the design thinking process are simple: First, fully understand the problem; Check out a wide range of possible solutions; third, iterative revision of modeling and testing; and finally, implement through standard delivery mechanisms. When developing design thinking capability in an organization, the focus is on design competencies and tools rather than mindset. This bias towards design processes, methods, and tools is also reflected in design thinking literature and design research. What is mindset? Mindset is the way a person perceives and interacts with the world. Design thinking is typically described as a creative and analytical process offering opportunities for experimentation, model creation and prototyping, feedback gathering, and redesign.

With the switch to an experience-and-service-based economy (Pine and Gilmore, 1999), aspects of designing have transformed into giving people meaningful experiences. Nonetheless, despite what would seem to be its widespread use, DT continues to resist a precise definition. However, since it presents itself as an approach that alters how individuals learn and solve issues, design thinking has gained much attention in engineering, architecture, and design majors in colleges during the past 20 years. Most of today's published variants of DT range from three to seven stages; nevertheless, the five-step version is exhaustive enough to provide a sufficient structure and coverage to support a transfer, as necessary, to another team. All versions are consistent, employ identical design concepts, and produce comparable results. It addresses undiscovered or undiscovered issues.

FIGURE 2: STAGES OF DESIGN THINKING	
Empathize	With user research, normally, one should get an empathic grasp of the problems one is attempting to solve often through research. Empathy is essential to a human-centered design approach such as design thinking as it enables one to put aside their worldview and understand individuals and what they want.

Define	This stage entails objectively observing a situation. It draws on the user-centric aspect of design thinking and calls for listening to individuals touched by an issue, getting to know their problems, and asking them questions about it. The issue statement or question that guides the rest of the design thinking process may then be created using the knowledge you have gained. The Define stage will assist the design team in gathering excellent ideas to create features, functions, and other components to address the issue at hand or, at the very least, make it possible for actual users to tackle the challenges on their own with little effort.
Ideate	Start brainstorming solutions for yourself. Consider solutions to your problem or question based on trends or findings gathered during the clarifying stage. In this stage, try to come up with radical design alternatives. In terms of thoughts and results, it mentally symbolizes a process of "going broad"; it is more of a "flaring" mode than a "focus" mode. Go beyond simple fixes and attempt to assemble diverse viewpoints. Find unexpected places worth exploring. Create fluency (volume) and flexibility (variety) in your innovation possibilities. Go creative and stop thinking about the simple fixes. Here, you can experiment with outlandish concepts while attempting to stay on topic.
Prototype	Testing your greatest concepts or solutions may be done by developing a prototype. Prototypes are typically quick and affordable ways to test a concept that is simple to make. A prototype might be as basic as a pencil and paper drawing or as complicated as a fully developed visual wireframe created with a program like Sketch. While each has advantages and disadvantages, spending more time on your prototype may cause the design thinker to become less willing to modify it. Early in the prototyping process, simpler, more basic prototypes often make sense. However, more sophisticated prototypes make sense as your idea is perfected.
Test	Implement the solution you've developed. Again, you'll probably have to go back a few steps and redo the final solution, but that's the bulk of the step. After many attempts and modifications, you will find a solution that can give you positive results.

As a result, design thinking has been reduced, which has limited the potential of designing and the objective it aspires to achieve creative results. Thus, drawing from the design's disciple, DT is yet another component for inclusion in the repertoire of approaches available to students to develop students' CT thinking properties rather than a limiting problem-solving skill that is a property of engineers and business professionals. A successful design thinker should have skills and qualities, including creativity, vision, and the ability to see the whole and the separate components in problem-solving. Integrating DT into a teaching and learning environment that currently includes decomposition, abstraction, pattern recognition, and algorithms, educators must define what students need to know and drive their development as successful computational thinkers. As educators engage learners in projects, the ". . . students become design thinkers, they emerge with significant changes in their approaches to problem-solving and new challenges. They develop a sense of resiliency that enables them to think "outside the box." (Goldman et al., 2012). Although a relatively new methodology is still included in pedagogical approaches, some success has been attributed to using DT in classrooms. The focus on brainstorming, group work, and respect for peer ideas has resulted in such positive academic performance that more and more educators rely on technology in their instructional spaces, especially to complement other contemporary methods.

DT necessitates problem-solving by thinking like a designer (Massari, 2022; Chasanidou et al., 2015). Recent debate attempts to provide an integrated view of design as a problem-solving process involving players from various disciplines. The problem-solving model brings together students from different disciplines to solve real challenges using design thinking. While not new, much of this approach is applied in P-12 or higher education institutions; some organizations are building similar educational models (Royalty et al., 2014). As organizations strive to find innovative ways to address critical challenges and drive value for their users in a rapidly changing market and landscape, the enthusiasm around DT thinking in management is evident. Companies that include Jetblue, PandG, Intuit, and SAP have embraced DT and incorporated it into corporate culture (Korn and Silverman 2012). Thinking has become essential in executive-level training and many independent trainers, executive training programs, and companies. A key value of design thinking is to provide a defined innovation process. Although trial and error is an excellent approach to testing and experimenting with what works and what does not, it is frequently time-consuming, expensive, and ultimately unsuccessful. On the other hand, applying specific design thinking processes is an effective strategy for creating original and creative solutions. Although design thinking is an ideology based on the workflow of designers to determine the design stages, its purpose is to provide students with a standardized innovation process to pursue solutions that lead to a decision.

Discussion

To successfully engage students in learning how to solve problems, lead teams, communicate, and innovate, they will need to take advantage of the unique capabilities of computers. They will use computers not only to view information or perform routine tasks such as reading, writing, and presenting. CT is described as using structured thinking; it is about the thinking process as much as it is about solving the problem. A limited number of preparatory programs in the United States provide opportunities to develop CT skills; however, interventions and experimentation of this type of learning are emerging with limited emphasis on developing knowledge of educational content. This study responds to the literature gap by providing training that includes modeling and the opportunity to practice, teach, and reflect on activities in authentic contexts (Mason et al., 2019; Rodriguez et al., 2019; Yadav et al., 2017).

In addition to the four contributing strategies to CT, this paper has proposed Design Thinking (DT) as a fifth contributing tactic to CT. It may positively impact 21st-century education across disciplines even though it has become essential to business, design, and engineering. DT has a defined procedural approach and promotes creative problem-solving properties. For example, students must read critically, reason rationally, and solve complicated issues in academic settings (Rotherham et al., 2009). Therefore, educators should support students in developing and honing 21st-century skills (such as design thinking, systems theory, and teamwork skills) that strengthen their problem-solving abilities and prepare them for college and career and enable them to thrive in the current interconnected digital world (Rotherham et al., 2009; Shute & Torres, 2012). Learning, particularly in STEM subjects, often does not align with student interests and is often different from students' everyday experiences. The teaching and learning community agrees that deep and practical learning is best facilitated by embedding and embedding learning in meaningful and engaging activities (e.g., Burnett et al., 2021a; Burnett et al. al., 2021b; Paolucci et al., 2021); knowledge is presented in authentic settings and relevant contexts so that it can be appropriately understood (Wang, 2022, Johnson et al., 2019, Edelson, 1998) and, social interaction (Lave, 1990), and collaboration are essential components of contextual learning (Bustami et al., 2018, Suryawati et al., 2017, Karweit,1998). CT thus becomes valuable in helping students derive accurate and efficient solutions to real-world problems. As work is rapidly digitizing in the workplace, even after a university career, graduates must have the necessary fluency to find and solve problems and develop their ideas in the digital society and the ability to observe and deal with various phenomena. Needs in the real world as information and combine them appropriately and efficiently. CT is easy to bring into the classroom and helps students achieve the learning goals they have already set. Consider these skills and attitudes as you plan your lessons and use the language throughout the year. Bring ambiguity to class projects, connect lessons learned with real-world examples and evidence, and dream big. Over time, students may be surprised at the connections they make and the new challenges they take on.

CONCLUSION

This article was about extending the teaching and modeling of CT across disciplines outside of computer science. In recent years, a strong interest abounds in CT Education at K- 12 level and its part in children's accession to thinking chops and digital capabilities. In agreement with this need, CT and coding have recently become integral to academic classes in numerous countries. Estonia, Israel, Finland, and the United Kingdom exemplify governments' growing interest in integrating rendering as new knowledge and supporting scholars in creative problem-working tasks (Hubwieser, 2015).

Given the multiplicity of definitions and concepts of CT, it is not surprising that accurate assessment of CT remains a significant weakness in the field. CT is broader than systems Thinking, which focuses on identifying and understanding how systems work. Beyond modeling and understanding, CT aims to solve problems efficiently and effectively by integrating algorithmic design, automation, and generalization to other systems/problems. CT should thus be considered a valuable literacy skill for all students, and P-12 classrooms could increase the historically underrepresented number of students pursuing computer-related careers. Integrating CT into K-12 for discipline outside the traditional STEM (science, technology, engineering, and math) discipline may enhance student learning and increase student engagement in learning that incorporates scientifically based (Li et al., 2023; De Santo, 2022). While (CT) has often been considered consistent with core STEM areas, teaching methods' effectiveness is essential in supporting students' learning outside of the STEM areas. Others (Wing, 2011; Ezeamuzie et al., 2022) have argued that CT needs to be on par with reading, writing, and arithmetic.

Precision in integrating CT into the curriculum for all disciplines, beginning from early K-12 levels, prepares learners for now complex, technologically rich future that requires creativity and problem-solving skills (Sjödahl et al., 2023). Empirical studies of K-12 students' broad mathematical and scientific reasoning (Bicer et al., 2015) noted that no STEM students received far less attention (Lye et al., 2014). However, CT practice in K-12 STEM learning is rarely investigated (Sengupta et al., 2018), and CT is far less included in STEM education for K-12s (NRC, 2011). Perhaps a significant challenge in implementing CT at any level is relative to the minimal existence of assessment tools. Thus, it is difficult to measure the effectiveness of interventions reliably and effectively (Barr et al., 2011; Grover and Pea, 2013; Kim et al., 2013; Settle et al., 2012). The lack of standardized CT assessments also makes it difficult to compare the results of different CT studies. Researchers try to develop and implement their own CT assessment measures depending on the specific activity of CT (Kim et al., 2013). CT is a prerequisite for understanding future technologies, and it is more of a thought process than specific knowledge of a device or language.

This paper concludes that computational thinking can support active learning scenarios and developing 21st-century skills for both STEM and non-STEM college graduates. Finally, this article emphasizes the importance of continuing to explore methods to engage people with little interest in CT through active learning.

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