

INNOVATIVE PEDAGOGY IN K-12 EDUCATION: A COMPREHENSIVE STUDY OF COMPUTATIONAL AND DESIGN THINKING WITH EMERGING TECHNOLOGIES THROUGH THE EXTEN(DT)² PROJECT.

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Abstract

Introduction: In the dynamic landscape of education, innovation plays a crucial role in driving progress. Supported by Horizon Europe and Innovate UK, the Exten (DT)² project emerges as a transformative initiative aiming to propel Design Thinking into the digital age (Extendt2, n.d.). This integration enhances pedagogy, promotes sustainable digitization, and encourages broader adoption of Design Thinking (DT). It also seeks to reshape interdisciplinary learning and foster essential 21st-century skills (Milrad et al., 2023). Computational Thinking (CT) equips learners with adaptability and innovative thinking abilities (Yadav et al., 2011; Oh et al., 2018). Design and Computational Thinking are increasingly acknowledged as effective pedagogical approaches (Bocconi et al., 2016), valuable for skill development and problem-solving (National Research Council, 2010; Panke, 2019). Incorporating these adaptable activities into classroom projects aligns with the objectives of twenty-first-century education, bridging student learning with digital fabrication (Iwata et al., 2020). The project also leverages emerging technologies (ET) to enhance these methodologies (Veletsianos, 2016), as DT and CT are recognized for developing 21st-century skills (Li and Zhan, 2022).

Study gap and Motivation: The integration of DT, CT, and ET holds promise in enhancing the feasibility, accessibility, and inclusivity of K-12 education for students, teachers, and administrators. However, gaps persist in understanding the specific challenges, opportunities, and potential impacts of this integration (Samberg, 2018).

While each approach—DT, CT, and ET—is increasingly recognized for its individual merits, comprehensive studies on their combined application in K-12 education remain limited. There is a critical need to explore the feasibility, accessibility, and inclusivity of these pedagogical methods, as well as how data-driven insights can inform educational practices. This study aims to address these gaps by investigating

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effective strategies for integrating DT, CT, and ET to create a more accessible and inclusive educational experience. Such efforts are crucial for advancing sustainable methodologies in K-12 settings. Through the lens of the Exten (D.T)² project—leveraging technologies like ChoiCO, SoBert, MalT2, and GearsBox—this study embarks on a multifaceted exploration. Its goal is to inspire transformative pedagogical practices that cater to diverse learner needs across the educational spectrum. The study's motivation is to foster robust skill development, promote innovation, and motivate students, teachers, and administrators to unlock new opportunities for educational advancement.

Research Questions: The following research questions were identified for assessing the overall investigating aim of this study:

RQ 1a: How can the combined use of CT and DT, with ET, enhance the educational experience of teachers and students in K-12 settings as reflected in existing literature?

RQ 1b: What is the current state of CT and DT with ET in K-12 education, as reflected in social media opinion with a focus on identified gaps, trends, and areas for further exploration?

RQ 2: How can the data obtained from questionnaires with text analytical approach be utilized to understand factors that impact the feasibility, accessibility, and inclusivity of these pedagogical approaches in Exten (D.T)²?

RQ 3: How can the findings obtained from the study serve as a catalyst to inform useful decisions when implementing CT, DT with ET in K-12 education?

Methods: Data related to DT, CT, and ET in K-12 education was collected from Facebook, Web of Science, Google Scholar, Research Rabbit, and other reliable scholarly repositories. Additionally, the study analyzed data collected through questionnaires, which gathered experts' opinions on the integration of the Exten (D.T)² project in educational settings. The study utilized both programming and non-programming techniques to achieve its objectives. Formal scholarly datasets were prioritized to publications from the past 12 years and studies worldwide published in English. These datasets were analyzed using VOSviewer, along with machine learning (ML) and deep learning (DL) techniques, to explore trends and gaps in academic literature. Facebook posts, specifically focused on opinions and reviews related to the intersection of DT, CT, and ET in K-12 education, were scraped with Bardeen, a web extension tool and analyzed using Orange BioLab, ML, and DL. In ML, topic modeling and sentiment analysis are employed, and network graphs used for visualization. While in the DL techniques, on the other hand, utilized the BERT model and Naive Bayes for performance evaluation. Orange BioLab facilitates sentiment analysis, presenting results through intuitive bar plots. Additionally, topic modeling techniques such as MDS and LDAVis are utilized to provide comprehensive insights and visual representations of the data. Expert opinions collected through questionnaires were examined with NVivo and MS Excel to gather insights on feasibility, accessibility, and inclusivity. Together, the insights from these analyses aim to provide a comprehensive understanding of the combined use of CT, DT, and ET in K-12 education and inform future implementations.

Outcomes: The study from formal scholarly dataset underscored the importance of interdisciplinary approaches, innovative teaching methodologies, and the necessity for further research to effectively integrate these concepts. It also highlighted the significance of CT skills, coding practices, AI and DT for enhancing problem-solving abilities and improving creativity among students. However, it also revealed challenges such as the scarcity of studies focused on design thinking and the need for more exploration with computational thinking and emerging technologies.

The study from social media data highlighted the importance of skill development, innovation, and enhancing learning outcomes. However, challenges such as privacy concerns, disparities in access to technology, and ethical considerations emerge, underscoring the importance of addressing these issues to ensure ethical implementation of CT, DT and ET in K-12 education. Additionally, the analysis suggests a pressing need for teacher training and support programs to equip educators with the necessary skills and knowledge to integrate these tools into their teaching practices. Furthermore, the social media analysis highlighted the issues and challenges that need attention in translating theoretical concepts into real-world applications and the development of practical solutions that bridge the gap between theory and practice within educational settings.

The study from the questionnaire revealed the importance of continuous professional development opportunities, adequate resource allocation, seamless technological integration, supportive educational policies, inclusive teaching practices, comprehensive support systems, and accommodations for diverse student and educator needs to enhance feasibility, accessibility, and inclusivity.

Conclusion: In conclusion, the findings of this study reveal the critical importance of a multifaceted approach to integrating CT, DT and ET within K-12 education. The analysis has identified significant gaps in understanding the specific challenges, opportunities, and potential impacts of this integration, emphasizing the urgent need for research to bridge these divides. A comprehensive curriculum design framework that incorporates these elements can significantly enhance students' critical thinking, problem-solving, creativity, and collaboration skills.

The study faced several limitations. Due to time constraints, data scraping was performed only on the Facebook platform, excluding others like LinkedIn and Twitter. The questionnaire-based data collection method may have missed in-depth insights that could be obtained from direct interviews or voice mining. Additionally, the analysis focused solely on textual posts, overlooking the emotional value of images and emojis in comments. Moreover, advanced DL techniques for data analysis were not utilized, which could have enhanced the accuracy and depth of insights. Considering these limitations, future research should adopt a more comprehensive approach by incorporating multiple platforms and diverse data collection methods to gain a deeper understanding.

Keywords: Computational Thinking, Design Thinking, Emerging Technologies, K-12 education, 21st century skills, Exten (D.T) ²

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