

Unleashing Creativity: Summer Camps Insights into Empowering Education with Computational Thinking

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Abstract: In our rapidly evolving society, technology has profoundly reshaped various aspects of our lives, influencing the way we work, communicate, and interact. This raises a fundamental question: Is the current K-12 education system adequately preparing students for success in this technology-driven era, where innovation and problem-solving skills are essential? This study aimed to integrate Computational Thinking (CT) into the domains of Creative Writing and Creative Media and assess its impact. This document outlines the development and refinement of summer camp experiences in which predominantly Hispanic female students participated in hands-on CT-based learning for creative storytelling and film production. Educational outcomes were evident through increased student engagement, enhanced collaboration, and improved problem-solving skills, underscoring the intervention's advantages. Furthermore, the researchers gained transformative insights, recognizing the versatility of CT across domains. Camp participants experienced a shift in perspective, exhibiting heightened enthusiasm for careers and domains closely linked to computing. We share successes and challenges from these summer camps to inform researchers and practitioners interested in designing similar experiences. In summary, the study outlines a trajectory where students and educators skillfully navigate the complexities of contemporary paradigms.

Keywords: Computational Thinking, CS Education, Creative Writing, Creative Media, Summer camps interventions

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1. Introduction

In our fast-evolving digital landscape, the concept of Computational Thinking (CT) plays a pivotal role in equipping individuals with versatile problem-solving capabilities, whether for human or computer execution (Wing, 2006). It encourages the systematic approach to addressing challenges and articulating solutions in clear and understandable terms. As the world becomes increasingly dependent on technology, CT has emerged as a fundamental skill set. DEPICT, an acronym for 'Discover Computational Thinking through Creative Writing,' is part of a series of innovative interventions aimed at introducing students to CT through non-computing techniques. This unique program builds on the foundations laid by previous initiatives (Lamb, 2018; Mohaghegh, 2016; Tengler, 2021). What sets DEPICT apart are two distinctive aspects. Firstly, it explores the convergence of creative writing (CW) with the production of movies and plays, a fusion that holds appeal for students, especially women and

Hispanics, who have demonstrated self-efficacy in related courses. Secondly, DEPICT employs CT as a methodology to teach within the creative domain, unearthing CT concepts that inherently exist within this domain, waiting to be extrapolated.

The initial DEPICT implementation involved three distinct phases:

- *The Curricular Phase:* This phase integrated Computational Thinking (CT) into Creative Writing (CW) curricula for different courses.
- *The Reinforcement Phase:* Focusing on extracurricular project-oriented activities, it transitioned from CT infusion to explicit CT understanding, with an emphasis on collaborative and teamwork skills.
- *The Extrapolation Phase:* A summer intervention designed to complete the transition from infused CT to full STEM pathway preparation, which is the main focus of this paper.

This paper delves into the conceptualization and execution of two DEPICT summer camps, immersing high school students in hands-on CT-based learning experiences. It brings several valuable contributions to light. Firstly, it advances our understanding of effective strategies for facilitating CT-focused learning and introduces an innovative approach to integrating CT into a non-STEM curriculum. Secondly, it outlines the development and implementation of this approach, drawing insights from predominantly Hispanic high school students, their educators, and computer science peers. Lastly, it shares important lessons and insights derived from the experiences of teachers and peers, the effectiveness of the newly designed curriculum, and the potential of CT to engage learners with minimal prior exposure to computing while fostering collaborative problem-solving skills.

2. Conceptual Framework and Literature Review

In the realm of Computational Thinking (CT), we adhere to the perspective presented by Cuny and colleagues (2010), which defines CT as "the thought processes involved in formulating problems and their solutions so that the solutions can be effectively executed by an information processing agent." The exploration of CT as a general problem-solving skill and the identification of core CT concepts that underlie computing have been subjects of interest among various researchers (Barr, 2011; Lee et al., 2011; Orton 2016; Perlis, 1963, Pollock et al., 2019; Yadav, 2017). The infusion of CT into non-STEM curricula has emerged as an effective way to introduce students to computing. This approach simplifies the illustration of CT by contextualizing it through domain-inspired problems and linking computing to topics relevant to students.

The infusion of CT into targeted disciplines provides benefits beyond the development of CT skills. It assists students in constructing mental representations of the issues under study, thereby facilitating inquiry-based learning and exploratory analysis (Gunstone and Mitchell, 1998; Ryokai et al., 2003). Effective pedagogy requires structured educational materials, mechanisms to develop a high level of automaticity, and well-supported instructional environments. CT and its modeling strategies (Dalton et al., 2002; Plass et al., 1998) prove to be excellent tools in achieving these goals (Jonassen, 2003; Gilbert, 1998). CT enables reasoning at different levels of abstraction and emphasizes the transition from using information to creating knowledge.

3. Overview of DEPICT Summer Camps

During the summers of 2022 and 2023, we hosted two two-week camps, engaging 20 local high school students (14 females, 5 males, and one non-binary) in a unique experience centered around Performance and Creative Writing (PCW), with a strong emphasis on project-based learning. These camps offered deep dives into Computer Science (CS), Computational Thinking (CT), Creative Writing (CW), Creative Media (CM), and animation content. Tools such as Merge Cubes, Specdrums, Rocketbooks, and Finch Robots were utilized, alongside the introduction of new software like PhotoPea and Capcut. Additionally, web browser applications such as CoSpaces, Studio Binder, and Teachable Machine from Google were incorporated into the learning process.

Throughout these summer intensives, students learned to integrate CS, CT, CM, and PCW, acquiring the skills needed to create remarkable projects. In the 2023 DEPICT summer camp, a "Mystery" concept was applied to each exercise, fostering collaboration between CS, CM, and PCW students (see Figure 1). The projects students worked on combined various visual and auditory elements, including movie posters with voiceover narration and mystery stories presented using Co-Spaces and Merge Cubes. At the conclusion of the camps, students showcased their projects to their families through PhotoPea poster designs for their Story-Movies, alongside videos or scripts from Studio Binder.

Furthermore, during the 2023 summer camp, students gained insights into how Computational Thinking concepts, such as *Decomposition*, align with professional methodologies in creative media disciplines such as animation and filmmaking. These concepts involve systematically breaking down overarching ideas into finer elements, mirroring the gradual refinement of narratives into intricate details in visual storytelling practices.

Concepts like shape language allowed students to leverage *Pattern Recognition*, using simple shapes to associate characters based on visual similarities or differences. *Abstraction* became a crucial tool when editing projects, emphasizing the importance of distilling information. For instance, in a radio drama, the audio selections, whether included or excluded, are essential for captivating the audience and setting the atmosphere. The use of *Algorithms* was evident in the production pipeline, where filmmakers progressed through step-by-step phases from Pre-Production to Production through Post-Production.

3.1 Camp Design

The camp activities were thoughtfully designed by teams of experts, organized in triads, each consisting of high school teachers, undergraduate CS students, and instructors from the Creative Media program. These triads were intentionally formed to harness a diverse range of perspectives in shaping the CT curriculum and teaching techniques. Both teachers and instructors actively participated in the development process, while undergraduate students played a pivotal role in devising activities aimed at seamlessly integrating CT into the curricula. The triad teams dedicated two months of collaborative effort prior to the camps, brainstorming and refining a set of activities to be included in the camp's curriculum.

3.2 Camp Collection of Data

To assess the impact and extent of exposure to CT concepts during the summer camps, DEPICT employed retrospective online surveys. Participants were asked a set of questions focusing on how they felt "before the program" and another set emphasizing how they felt "after the program." Additionally, pre and post-performative interviews were conducted on the first and last days of the camps. These interviews were audio-recorded, and students were asked to describe their awareness of CT terms, define the terms, and complete tasks related to loops, decomposition, and abstraction (Lamb, 2018). Each camper worked on individual projects, with the first week dedicated to introducing technology and CT concepts and the second week focused on final project creation. Campers were encouraged to brainstorm personally and socially relevant projects for their final presentations and uploaded their deliverables to a Google Classroom platform for storage.

3.3 Camp Outcomes

DEPICT summer camp participants experienced modest, positive gains in their sense of belonging and identity in STEM fields, as well as their future plans involving computing and technology. Their retrospective survey scores showed less change in their perceived value of computing and CT. However, these students saw modest, positive gains in their conceptual understanding of CT, as indicated by assessment scores from performative interviews. The youth-focused approaches used in DEPICT were effective in supporting interest and engagement in the program. Practice and play were essential for student computing identity development and alleviating uncertainty about their ability to participate in computing.

Lesson 03 - Story

Lesson Plan

Overview

This lesson should take about 4 hours to cor
This lesson explores visual storytelling throu

Figure 1.
plan and student



Storyboarding lesson
examples

4. Successes of Summer Infusions of Computational Thinking in Creative Arts

The DEPICT summer camps have demonstrated several key successes in their design and execution. Notably, these successes highlight the alignment between CT and the creative process. This alignment allows for the integration of CT principles into the curriculum while appealing to a diverse range of learning styles. Every activity used in DEPICT's summer camps provided an opportunity for students to discover how CT is embedded in the creative content.

Successes for Camp Design

The collaboration of interdisciplinary experts in designing camp activities has proven beneficial. High school teachers and Creative Media instructors brought content knowledge, while undergraduate CS students mentored the activities, and the implementation team oversaw the process. This diverse input enriched the lesson plans and curriculum, providing students with a comprehensive learning experience.

Applying a common theme, such as the "Mystery" concept during the summer camp, encouraged collaboration between different disciplines. This thematic approach effectively connected CT with Creative Media content, reinforcing the practical application of CT concepts.

The willingness to adapt and experiment was evident in the introduction of CT concepts to individuals outside the realm of CS. For example, when Algorithmic Thinking was initially introduced for character design, it was later adjusted in favor of Pattern Recognition, better suited to the creative context (see Figure 2).

Successes for Camp Data Collection

The data collection methods used by DEPICT have been effective in assessing the impact of the summer camps. The use of an online survey platform allowed for real-time data compilation, achieving a 100% return rate on participants' surveys. The utilization of Google Classroom as a platform for uploading participants' deliverables streamlined data management.

Successes for Camp Outcomes

The infusion of CT concepts into the context of Creative Arts and performance has demonstrated several noteworthy successes. It has enhanced previously applied pedagogical approaches in creative classrooms by providing structure and a methodological approach. This strategic approach offers the potential for in-service teachers to apply the strategies employed during the summer camps in their future lessons, further enhancing the integration of CT into the broader curriculum.

Participants in the DEPICT summer camps have not only been introduced to various technologies but have also gained a profound understanding of how technology seamlessly integrates with creative arts and performance. This integration has been enthusiastically embraced by the students, and they have successfully applied computational innovations in conjunction with their preexisting creative concepts.



Figure 2. Character Design process developed into final movie poster

5. Challenges of Summer Infusions of Computational Thinking in Creative Arts

While the DEPICT program has achieved notable successes, it has also encountered several challenges in its efforts to infuse Computational Thinking (CT) into the realm of creative arts. These challenges, although significant, provide valuable insights for future implementation and refinement of the program.

Challenges for Camp Design

One of the notable challenges during the camp design phase was the variation in the time required for activities. Despite the initial allocation of specific time slots for activities, the actual time spent on these activities

often deviated from the schedule. This necessitated adjustments to the weekly calendar to accommodate evolving time requirements for daily activities. This challenge highlights the need for flexibility and adaptability in program design to ensure that all aspects are adequately covered.

Additionally, while the DEPICT summer camps have gained proficiency in applying CT concepts through practical experimentation in the summer sessions, it's important to note that the upcoming apprenticeship in the summer of 2023 has not been implemented yet. The effects of the proposed modifications will need to be observed to determine their effectiveness, emphasizing the need for ongoing evaluation and adjustment.

Challenges for Camp Data Collection

Challenges also arose in data collection during the summer camps. Participants, who were focused on preparing final presentations of their projects, did not consistently take the time to provide detailed information about their summer camp experiences in retrospective surveys. This challenge underscores the importance of incentivizing and prioritizing data collection for more accurate assessments.

In some instances, camp participants faced difficulties in uploading their deliverable tasks because they were unfamiliar with the Google Classroom platform. This technical challenge highlights the importance of ensuring that participants are well-versed in the tools and platforms used for data collection, reducing potential barriers to participation.

Challenges for Camp Outcomes

The infusion of CT concepts into Creative Arts and performance necessitated a shift in teaching methods, presenting a learning curve for both educators and camp participants. This transition may result in resistance or difficulties in smoothly shifting from traditional teaching methods to a more structured and methodological approach. Overcoming these challenges requires ongoing training, support, and adaptation to ease the transition for all stakeholders.

6. Results and Warrants for Arguments

The DEPICT program, aimed at infusing Computational Thinking (CT) into high school arts and humanities courses, has successfully achieved its intended outcomes during the implementation of two summer camps in its extrapolation phase. These outcomes encompass a substantial increase in CT exposure for high school teachers and a more diverse group of students who may not have previously considered computing as an option. The program has equipped teachers with the necessary tools and curricula to impart CT problem-solving skills to their students, resulting in enhanced competency and performance not only in CT but also in their respective disciplines, such as creative writing. Moreover, the empirical evidence derived from the summer camps strongly supports the argument for CT integration in non-STEM subjects, highlighting its potential to broaden participation in computing and foster crucial skills.

7. Scholarly Significance and Conclusion

The accomplishments of DEPICT underscore its scholarly significance and the potential for further research and development in the field of CT education. This pioneering program strategically targets language and arts-dominant courses for the infusion of CT principles, with the overarching goal of broadening the appeal of computing to students who may not traditionally identify with technical fields.

DEPICT's unique approach of introducing creative and artistic design elements into the curriculum seeks to redefine the perception of who belongs in the computing field. By offering complementary STEM pathways that resonate with students skilled in arts, language, and theater, DEPICT fosters a network of educational collaborations between the research team and local high schools. This collaboration results in Arts and Humanities educators becoming competent in CT, further promoting the integration of CT concepts into the broader curriculum.

The infusion of CT into Creative Writing (CW) and film production has bridged disciplinary boundaries, leading to enhanced problem-solving skills, increased engagement, and improved collaboration among participants. DEPICT's outcomes not only highlight the potential for CT to transcend its conventional boundaries but also demonstrate its potential as a powerful tool for addressing modern challenges and offering an innovative pathway to engage underrepresented groups.

Future endeavors in this domain should focus on the scalability of DEPICT's approach across diverse educational settings and disciplines. This can involve refining and expanding the curriculum to encompass a broader spectrum of creative domains and computational concepts. Long-term research may explore the sustained impact of CT exposure on students' academic trajectories, career choices, and problem-solving abilities.

The success of DEPICT's extrapolation phase serves as a compelling argument for the continued exploration of CT integration in non-STEM subjects, ultimately contributing to broader initiatives aimed at

promoting inclusivity and closing gaps in computing education.

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