Literature Review By Israel Itua

1. Title and Authors

Title: *A Problem-Based Learning Approach to Teaching Design in CS1*
Authors: Christopher William Schankula, Habib Ghaffari Hadigheh, Spencer Smith, & Christopher Kumar Anand

2. Attributes (Keywords)

Design Thinking, Problem-Based Learning, Human-Centred Design, Collaborative Learning, Programming Pedagogy, TEASync Framework.

3. Was the abstract clear enough to get a glimpse of the work?

Yes. The abstract clearly outlines the motivation, the proposed teaching approach, and the study context which is introducing a Problem-Based Learning and Design Thinking framework in a first-year CS course. It briefly explains the methods, such as structured worksheets and the Parkinson's Disease game project.

4. Were the introduction and background sufficient and apt enough to describe the problem topic?

The introduction effectively places the paper within challenges of teaching design to novice programmers. It highlights the gap between open-ended software design and beginner cognitive load, providing a rationale for combining Design Thinking (DT) and Problem-Based Learning (PBL). The background references existing literature on design education and by identifying key student "failure modes," the authors justify their framework's focus on empathy and problem exploration. Overall, the section is comprehensive and directly supports the need for structured design education in introductory computing courses.

5. Was the related work comprehensive?

Yes. The related work section is broad and historically grounded. It reviews literature on Problem-Based Learning, Design Thinking, and Human-Centered Design (HCD), tracing their educational applications from design disciplines to computing education. The authors reference recent CS education studies, including those addressing creativity, teamwork, and empathy in software design. While some earlier studies are

cited to establish theoretical roots, most works referenced are from the last decade, ensuring contemporary relevance. The review effectively positions the authors' contribution as an evolution of prior frameworks that struggled to balance structure and creativity in early programming courses.

6. Purpose of the Paper

The paper aims to design and evaluate a framework that integrates Problem-Based Learning with Design Thinking to teach software design in CS1. Its scope involves addressing common student pitfalls in design projects such as substituting users with themselves, overreliance on technology-first approaches, and premature idea fixation. The study introduces a structured system of worksheets, collaborative templates, and the TEASync programming framework to support mixed-experience teams. This paper is relevant as it illustrates how empirical research methods and design-based interventions can be applied to study and improve learning processes in computer science education.

7. Design/Methodology/Approach

The methodology combines educational design research and empirical classroom evaluation. The course enrolled over 200 first-year students working in teams of four to seven. Using the British Design Council's Double Diamond model, students progressed through Discover, Define, Develop, and Deliver phases while designing a game to aid Parkinson's Disease diagnosis. Structured PowerPoint worksheets guided each stage, ensuring consistent documentation and collaboration. The TEASync framework enabled distributed, event-driven programming for teams of varied skill levels. Data were collected through surveys, focus groups, and code analysis. The methodology advanced CS education by operationalizing design thinking through concrete, scalable classroom tools.

8. Research Limitations/Implications

The primary limitation lies in context specificity: findings are derived from a single institution and course offering. Furthermore, the qualitative feedback, while rich, limits generalizability. However, the study contributes a replicable model for integrating human-centred and problem-based learning in early computing education. The use of the Game Matrix and TEASync framework introduces innovative teaching tools adaptable to other domains. By documenting and analyzing failure modes, the authors provide a framework that informs curriculum design and future research on collaborative and empathetic learning.

9. Findings

Structured scaffolding and empathy-driven projects improve creativity, teamwork, and design understanding among novice programmers while mitigating common learning failure modes.

10. Practical Implications

The paper offers a practical framework for instructors seeking to incorporate real-world design challenges into early programming courses. Its use of scaffolded worksheets and the Game Matrix provides clear templates for managing complex, open-ended projects. The TEASync framework simplifies distributed event-driven programming, reducing technical barriers for beginners. Collectively, these tools demonstrate how Design Thinking and PBL can be systematically implemented in large classes. Educators can adopt these strategies to improve engagement, foster empathy, and support collaborative reasoning in software design. The approach also provides a scalable structure for continuous assessment and reflection in computing education.

11. Social Implications

Promotes empathy-driven design thinking among students, fostering awareness of social and accessibility issues through projects like Parkinson’s Disease game design.

12. Originality/Values (100 words)

This paper is original in combining structured Design Thinking with PBL in a first-year CS setting and grounding it in empirical classroom practice. Unlike prior theoretical proposals, it introduces specific pedagogical tools—the Game Matrix and TEASync framework—that operationalize human-centred principles. The originality also lies in identifying and addressing four key design failure modes through practical interventions. Its educational value is evident in improving inclusivity, creativity, and metacognitive awareness among novice learners. By merging cognitive science with design education, the study extends traditional approaches to CS1 beyond programming syntax toward holistic software design thinking.

13. Explanation of Results

The authors explain their results thoroughly using both qualitative and quantitative data. Survey responses and focus group discussions revealed significant improvements in

teamwork, communication, and design iteration. Students demonstrated greater empathy for users and appreciation for structured design processes. Code analysis confirmed that teams successfully applied the MVU and LG-MVU patterns in TEASync. The results show that structured scaffolding enhances design reasoning without suppressing creativity. The discussion effectively connects findings to the initial failure modes, illustrating how each was mitigated through targeted interventions. Overall, the results are coherent and well-supported by the presented evidence.

15. Achievement of Goals

Yes. The authors achieved their goals by successfully integrating Design Thinking and Problem-Based Learing into CS1. They demonstrated measurable improvements in student engagement, empathy, and design quality. The structured worksheets, Game Matrix, and TEASync framework directly addressed the identified failure modes, fulfilling the study's aim of improving design learning outcomes.

16. Conclusions Related to Goals

The conclusions align closely with the study's objectives. The authors assert that structured scaffolding can effectively teach open-ended design to beginners while accommodating diverse experience levels. They conclude that combining PBL, empathy-based problem contexts, and collaborative tools leads to more inclusive, reflective, and creative learning experiences in computer science education.

17. Personal Thoughts / What You Learned

This paper demonstrates that introducing human-centred, problem-based frameworks into introductory programming can meaningfully transform how students learn to design. I learned that structured scaffolding does not constrain creativity but rather enhances it by providing cognitive support. The Parkinson's Disease game project exemplifies how empathy and real-world relevance can increase engagement and inclusivity. I also found the Game Matrix and TEASync frameworks to be practical innovations for managing complexity and teamwork. Overall, the study reinforces the importance of design education that emphasizes empathy, iteration, and collaboration as foundational skills in computer science.