Paper ID #51788

Interactive Digital Panels as Catalysts for Hybrid Learning in Pre-Engineering Programs

Dr. Diego Hernandez Arjoni, Instituto Mauá de Tecnologia

Diego Hernandez Arjoni is a Professor at Instituto Mauá de Tecnologia (IMT), Brazil, where he teaches courses in Control and Automation Engineering and coordinates initiatives related to robotics, artificial intelligence, and engineering education. He holds a Ph.D. in Aeronautical and Mechanical Engineering from the Instituto Tecnológico de Aeronáutica (ITA), with research focused on augmented and virtual reality applications for flight training and human factors. His current interests include hybrid learning environments, digital twins, industrial automation, and the use of emerging technologies to enhance engineering education and student engagement.

Miss Andressa Corrente Martins, Instituto Mauá de Tecnologia

Andressa Martins is holds a master's degree in Aerospace Systems and Mechatronics with a focus on Robotics from the Aeronautics Institute of Technology and a degree in Control and Automation Engineering from the Universidade Paulista. Currently, she is a professor at the Mauá Institute of Technology. She has experience in the field of Control and Automation Engineering (Mechatronics), working mainly on the following topics: Intelligent Systems, Digital Twin, Industrial Automation, Instrumentation, Robotics, Mechanism Design, and Engineering Fundamentals.

Fernando Silveira Madani Ph.D., Instituto Mauá de Tecnologia

Fernando Silveira Madani holds a Bachelor's degree in Control and Automation Engineering (Mechatronics) and a Ph.D. in the same field, with extensive experience in engineering education, including over 20 years of teaching and more than 18 years in academic leadership as a Program Director. He obtained his M.Sc. (2001) and Ph.D. (2009) in Aeronautical and Mechanical Engineering from the Aeronautics Institute of Technology (ITA), with research emphasis on Aerospace Systems Dynamics and Mechatronics. He completed his undergraduate studies at Universidade Paulista in 1997.

He is currently Vice-Provost at the Centro Universitário do Instituto Mauá de Tecnologia, where he is also a researcher affiliated with the Intelligent Mechatronic Systems and Robotics (S.M.I.R.) research group. In addition, he serves as a member of evaluation committees of the Brazilian Ministry of Education (INEP/MEC), contributing to the assessment of undergraduate programs in Control and Automation Engineering and Mechatronics.

Interactive digital panels as catalysts for hybrid learning in pre-engineering programs (Work in Progress)

Abstract

This Work in Progress paper describes the design and initial implementation of a hybrid learning activity developed for high school students enrolled in a pre-technology program offered by a higher education institution focused on undergraduate degrees in technology-related fields, with emphasis on Artificial Intelligence. The activity takes plane in a program named Mauá Experience at the Institute Mauá of Technology, and aims to introduce engineering-related practices, such as problem identification, ideation, and solution conceptualization, through a Design Thinking approach supported by a collaborative digital whiteboard environment. The activity was structured around a single shared digital panel that guided students through the stages of empathy, problem definition, ideation, and the formulation of a preliminary project proposal. Students initially collaborated to identify everyday problems in a collective space and subsequently progressed through individual stages, using the panel as a continuous visual representation of the design process. The digital environment enabled the simultaneous visualization of individual and collective work, supporting student autonomy while maintaining awareness of peer contributions. Rather than emphasizing technical implementation or advanced programming skills, the activity focused on conceptual design practices relevant to engineering and computational thinking. As a Work in Progress, this paper does not present formal assessment data or causal claims regarding learning outcomes. Instead, it documents the instructional design of the activity, the structure and use of the collaborative digital environment, and preliminary observations based on the artifacts produced by the students, with the goal of supporting replication and future refinement of similar hybrid, design-oriented learning experiences in pre-college engineering education.

1. Introduction and Context

Pre-university engineering education initiatives increasingly seek to introduce high school students to authentic engineering practices prior to undergraduate study, emphasizing competencies such as problem formulation, creativity, collaboration, and real-world application [1]. Within this context, design-centered and active learning approaches have gained prominence in STEM preparation programs, as they provide structured yet accessible pathways for engaging students in engineering thinking without requiring advanced prior knowledge [2], [3], [4].

Design Thinking offers a pedagogical framework that emphasizes empathy, problem definition, ideation, and iterative solution development, aligning closely with core engineering practices [3], [2]. In pre-college settings, this approach enables students to engage meaningfully with complex problems while focusing on conceptual design processes rather than technical sophistication, thereby serving as an entry point to engineering and computational thinking [5], [2].

Concurrently, hybrid instructional models that integrate face-to-face interactions with collaborative digital environments have expanded opportunities for participation and collective knowledge construction [6], [7]. Research in engineering education suggests that visually mediated collaborative tools can enhance engagement, support reflection, and promote shared awareness of design processes, particularly when structured around clearly defined tasks [6], [8], [9], [10].

This Work in Progress documents the design and initial implementation of a hybrid, Design Thinking–based activity developed for high school students enrolled in a pre-technology program focused on Artificial Intelligence named Mauá Experience within Instituto Mauá of Technology in São Caetano do Sul, São Paulo, Brazil. Structured around a shared interactive digital board, the activity guided students through collaborative problem identification, individual analysis, and the formulation of preliminary project proposals, emphasizing problem delimitation, requirement identification, and solution communication rather than advanced technical implementation [11], [12], [2], [5]. Although no formal quantitative assessment results are presented, the study contributes to the PCEE community by describing a replicable and scalable hybrid model that supports early engineering identity formation and offers practical guidance for implementing design-oriented AI experiences in pre-college contexts.

2. Activity Design and Implementation

This Work in Progress describes a hybrid Design Thinking activity implemented with high school students enrolled in a pre-technology program linked to a higher education institution focused on technology and Artificial Intelligence. The program aims to provide early exposure to engineering-related academic and professional practices, even for students with no prior technical background.

The activity centered on the conceptual design of an AI-based application. Its primary objective was to engage students in foundational engineering and computational thinking practices, including problem framing, requirement clarification, ideation, and solution communication. Emphasis was placed on structured reasoning and design processes rather than advanced programming or formal mathematics [3], [2].

Before the hybrid session, students attended three preparatory face-to-face meetings. These sessions introduced core AI concepts, a visual machine learning tool for training and classification, and a block-based programming environment focused on logic and interaction design. This preparation ensured that students could scope their ideas realistically during ideation, consistent with experiential and design-based learning principles [3], [11], [2].

The main activity took place in a structured online digital whiteboard organized around four Design Thinking stages: Empathy, Problem Definition, Ideation, and Solution Proposal (Figure 1). The instructor provided a partially completed example board as scaffolding without limiting student autonomy, supporting task clarity and problem structuring (Figure 2) [3], [6], [8].

All stages were developed within a single, continuous workspace. This configuration enabled students to visualize the entire design trajectory simultaneously and reinforced the iterative nature of the process. The browser-based platform required no installation and offered a free version sufficient for implementation, supporting feasibility across varied institutional contexts. The board remained accessible after the session for continued reference and artifact analysis.

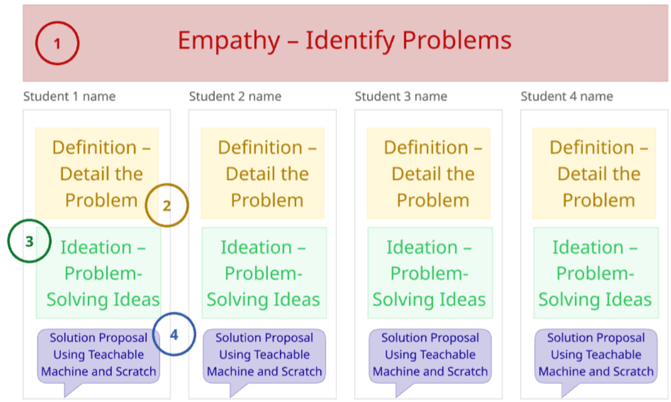

Figure 1 - Example Board

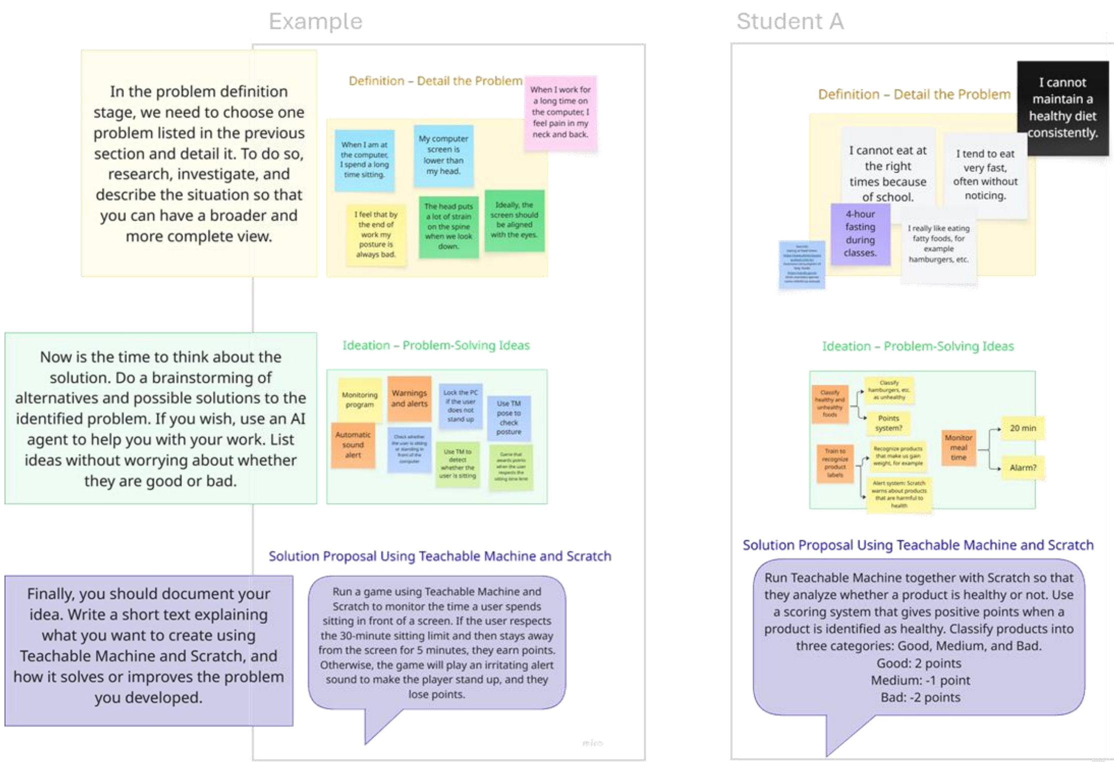

Figure 2 - Provided example and a student's board example

During the empathy stage, students collaboratively and anonymously listed everyday problems from personal or community contexts. They then individually selected one problem for deeper analysis, examining causes, constraints, and impacts before generating multiple solution alternatives. Immediate feasibility evaluation was intentionally deferred to encourage divergent thinking.

In the final stage, each student produced a preliminary project proposal outlining system objectives, the intended role of AI or block-based programming, and user interaction. Although technical implementation was not required, proposals were expected to demonstrate conceptual coherence and alignment with previously introduced tools. The completed boards served as guides for subsequent development and reflected the iterative character of the design process.

3. Preliminary Observations

The primary artifacts consisted of individual digital boards structured around problem definition, ideation, and solution proposal. These boards included concise descriptions, identified causes and constraints, alternative solutions, and a final synthesis. Even without requiring technical implementation, students produced coherent problem–solution narratives that articulated user needs, system objectives, and feasible operational strategies, consistent with introductory engineering design practices [3], [2].

Figure 3 illustrates the structure of a complete board. While the depth of content varied, most students adhered closely to the proposed framework and adapted the organization to their individual working styles. The selected problems spanned everyday contexts, including health, personal organization, safety, well-being, and physical activity support. The activity involved 16 students, all of whom remained engaged throughout the two-hour session.

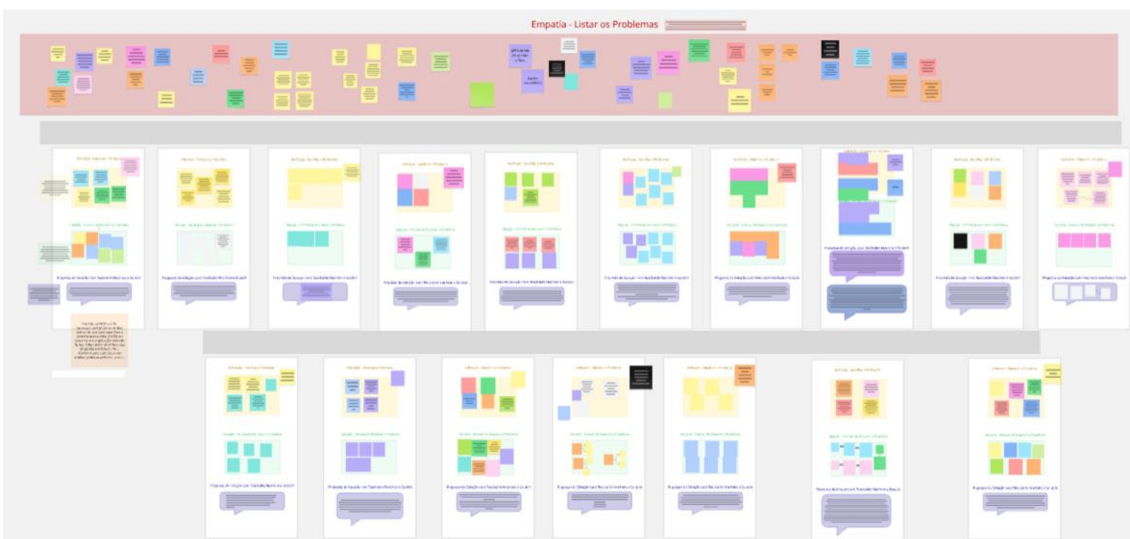

Figure 3 - Completed Board

Strong alignment was observed between the conceptual proposals documented on the boards and the applications subsequently developed. Because the boards remained editable, students iteratively refined their ideas during later development phases. The shared visual workspace appeared to facilitate informal comparison across proposals and to stimulate spontaneous revisions, including clarification of descriptions, expansion of ideas, and reorganization after observing peers' work. This behavior aligns with research highlighting the role of collaborative visual environments in supporting reflection and collective cognition [9], [10].

Informal feedback collected during a closing discussion indicated that students perceived the shared board as helpful for visualizing idea evolution and organizing thinking prior to technical implementation. Several reported that observing peers' work prompted refinements in their own proposals. From the instructor's perspective, the unified visual structure reduced repetitive procedural clarification and supported more efficient time management during the hybrid session.

Overall, the activity generated conceptually structured artifacts within a limited time frame. While no causal claims about learning outcomes are made, the boards and student reflections suggest engagement in core engineering thinking practices, including problem structuring, constraint consideration, and solution communication. Future iterations will incorporate a more systematic evaluation plan, including a pre–post survey examining changes in perceptions of engineering and AI, a rubric-based artifact analysis, and a comparative implementation in a face-to-face-only format to explore the added value of the hybrid collaborative environment.

The model also demonstrates adaptability. The board structure can be applied to themes beyond AI, compressed into a short workshop, or expanded into a multi-week design project. Because the platform is browser-based and free, it supports implementation in resource-constrained contexts. Although this implementation emphasized individual boards within a shared workspace, small-group configurations may be explored in future applications. This flexibility enhances transferability across secondary schools, outreach initiatives, and early undergraduate settings.

4. Conclusions

This Work in Progress described the design and initial implementation of a hybrid, Design Thinking–based activity for high school students in a pre-technology program focused on Artificial Intelligence. Findings were derived from qualitative analysis of student artifacts and instructor observations, without formal assessment instruments; therefore, no causal claims regarding learning outcomes can be made.

Results must be interpreted within the specific context of a small cohort and limited duration. Although the produced artifacts demonstrated conceptual organization and alignment with introductory engineering design practices, no longitudinal data were collected to examine persistence of learning or influence on future academic pathways.

Future implementations will incorporate more systematic evaluation methods, including structured artifact analysis and comparative conditions (e.g., with and without Design Thinking or hybrid tools). The model will also be refined for replication across varied pre-college contexts, supporting broader transferability and scalability.

Acknowledgments

The authors gratefully acknowledge the support provided by Instituto Mauá de Tecnologia through the Mauá Experience program, whose resources, infrastructure, and institutional commitment were essential for the development and execution of this work.

References

[1] J. Wu e M. Dalal, “High School Students’ Perspectives on Pre-college Engineering Education,” em *2024 ASEE Annual Conference & Exposition*, Portland, 2024.

[2] Y. Li, A. H. Schoenfeld, A. A. diSessa, A. C. Graesser, L. C. Benson, L. D. English e R. A. Duschl, “Design and Design Thinking in STEM Education,” *Journal for STEM Education Research,* pp. 93-104, 30 Outubro 2019.

[3] T. Brown e B. Katz, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, 1ª ed., Harper Business, 2009.

[4] Q. Yu, K. Yu e R. Lin, “A meta-analysis of the effects of design thinking on student learning,” *Humanities and Social Sciences Communications,* Junho 2024.

[5] L. Katehi, G. Pearson e M. Feder, Engineering in K-12 Education: Understanding the Status and Improving the Prospects, Washington: The National Academies Press, 2009.

[6] A. Jamison, A. Kolmos e J. E. Holgaard, “Hybrid Learning: An Integrative Approach to Engineering Education,” *Journal of Engineering Education,* pp. 253-273, Abril 2014.

[7] Q. Li, R. Xie e M. Li, “Factors influencing positive perceptions of hybrid teaching in higher education: a case study of an engineering university,” *International Journal of Educational Technology in Higher Education,* Maio 2025.

[8] X. Wang, T. Ratanaolarn e J. Sitthiworachart, “Integrating project-based blended learning and design thinking to enhance creativity and openness to experience,” *Cogent Education,* Maio 2025.

[9] Y.-L. E. Liu, “Enhancing Team Creative Efficacy Through Online Whiteboard-Based Collaborative Environment in Design Thinking: A Team Cognition Perspective,” *International Journal of Human–Computer Interaction,* pp. 2884-2897, 2025.

[10] X.-L. Zheng, J. Huang, X.-H. Xia, G.-J. Hwang, Y.-F. Tu, Y.-P. Huang e F. Wang, “Effects of online whiteboard-based collaborative argumentation scaffolds on group-level cognitive regulations, written argument skills and regulation patterns,” *Computers & Education,* Setembro 2023.

[11] D. A. Kolb, Experiential Learning: Experience As The Source Of Learning And Development, Prentice-Hall, 1984.

[12] L. S. Vigotski, Mind in Society: Development of Higher Psychological Processes, Harvard University Press, 1978.