

PEDAGOGICAL INNOVATION: A LABORATORY FOR COLABORATIVE AND INCLUSIVE DESIGN

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ABSTRACT

This study describes the design and implementation of a Pedagogical Innovation Space (PIS) in a higher education institution. Designed to be dynamic and inclusive, the PIS fosters experimentation, collaboration and cultural diversity across disciplines such as engineering and design. It operates as an educational laboratory in which teachers, students and researchers collaborate to create and test solutions using user-centred and challenge-based methodologies. Inspired by Design Thinking and grounded in experiential and project-based learning principles, the PIS integrates multiple functional areas — creative, collaborative, research, interactive, development and presentation — to support transitions between ideation, experimentation, reflection and knowledge sharing. By linking physical and digital environments, the PIS fosters active, autonomous and collaborative learning, thereby enhancing technical, creative, social and empathetic skills. Design Thinking guides the transformation of traditional teaching models through its human-centred stages of empathy, definition, ideation, prototyping, testing and continuous evaluation, enabling innovative responses to complex and diverse educational contexts. The project adopts inclusive and participatory design practices that are in line with contemporary collaborative design education trends, making equality, diversity, and inclusion (EDI) core principles. Ultimately, the PIS aims to serve as a reference model integrating education, design, and diversity to prepare future professionals to develop more human-centred, collaborative, and inclusive solutions.

Keywords: Pedagogical innovation, design thinking, learning spaces, active learning, inclusion

1 INTRODUCTION

The rapid evolution of digital technologies has redefined technical education. The integration of these tools in the PIS is specifically designed to support the iterative prototyping and technical visualisation required in engineering and product design curricula. Unlike traditional classrooms, this space allows for a seamless transition between conceptual sketching and digital modelling, which is essential for modern design education [1]. The PIS operates as a dynamic laboratory where students and researchers collaborate to test solutions using user-centred methodologies. In this context, 'diversity' is addressed through two complementary dimensions to ensure a truly inclusive environment. First, it encompasses 'interdisciplinary diversity,' promoting active collaboration between students from distinct fields like engineering and design to solve complex problems. Second, it integrates 'functional and inclusive diversity' (EDI – equity, diversity, and inclusion), ensuring that physical layouts and digital tools are adaptable to different learning needs and physical abilities [2]. By defining diversity in this dual manner, the PIS moves from a generic concept to a structural principle that informs both spatial design and pedagogical practice. design thinking guides this transformation through its human-centred stages—empathy, definition, ideation, prototyping, and testing—enabling continuous evaluation of pedagogical effectiveness [3]. By linking physical and digital environments, the PIS fosters active learning and enhances the technical and empathetic skills necessary for future professionals. This study argues that the PIS serves as a critical pedagogical enabler by transitioning from lecture-based models to student-centred learning landscapes. The paper is organised as follows: Section 2 details the design thinking phases; Section 3 analyses the spatial diagnostics and conceptual design; and Section 4 presents the

expected outcomes and conclusions.

2 DESIGN THINKING METHODOLOGY FOR THE PIS

The development of the PIS is grounded in a hermeneutical application of Design Thinking (DT), serving as an interpretive bridge between educational needs and spatial solutions. DT is a highly effective active methodology for enhancing student engagement and developing the social and technical skills required in 21st-century education [4]. Rather than a linear sequence, this study adopts DT as a dynamic framework that informs decisions regarding interior design, technological integration, and collaborative practices [5]. Following the human-centred principles established by Brown [6], the project was organised into iterative phases:

- **Empathy and Definition:** Qualitative data from focus groups and spatial diagnostics were interpreted to identify gaps in traditional lecture-based models, ensuring a deep understanding of diverse users—students, teachers, and researchers [7]
- **Ideation and Prototyping:** Drawing on Sawyer's (2012) [3], principles of creative innovation, insights were translated into tangible modular zones. This phase focused on the pedagogical benefit of seamless transitions between conceptual sketching and digital modelling.
- **Testing and Validation:** This stage ensured that the proposed solutions aligned with the institution's Equity, Diversity, and Inclusion (EDI) goals, promoting the continuous adaptation of spaces to a rapidly evolving global context [8].

By linking physical and digital environments through this methodology, the PIS fosters a culture of active and interdisciplinary learning, allowing stakeholders to collaboratively engage with real-world challenges (Costa & Barreto, 2024).

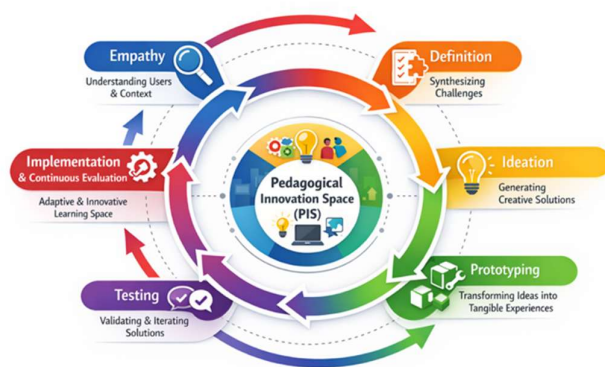


Figure 1. Design Thinking methodology applied to the Pedagogical Innovation Space

Figure 1 illustrates the structured and iterative Design Thinking process applied to the development of the PIS. Organised into six interconnected phases—Empathy, Definition, Ideation, Prototyping, Testing, and Implementation/Evaluation—the circular layout emphasises the non-linear nature of this methodology and its capacity for continuous refinement. In the Empathy and Definition stages, qualitative tools such as focus groups and spatial diagnostic panels were used to frame the pedagogical challenges of existing traditional layouts. The Ideation and Prototyping phases focused on generating spatial configurations that support active learning principles, such as 'Flipped Classroom' and 'Project-Based Learning' (PBL), ensuring the physical environment acts as a catalyst for creative problem-solving. Finally, the Testing and Validation stages involved stakeholder feedback to refine the modular zones, ensuring alignment with Equity, Diversity, and Inclusion (EDI) standards. This hermeneutical approach reinforces Design Thinking as a reflective framework for creating innovative, technology-enhanced learning environments.

3 DESIGNING SPACES FOR ACTIVE LEARNING

The data collection methods and techniques are primarily applied to the case study classroom at the School of Education of the Polytechnic Institute of Viana do Castelo (IPVC), which is one of the six schools that constitute the Polytechnic Institute of Viana do Castelo. The remaining five schools are the School of Agriculture, the School of Technology and Management, the School of Health, the School of

Business Sciences, and the School of Sport and Leisure. This provides the empirical basis for defining parameters that can be transferred to the other spaces analysed. The classroom is predominantly used by undergraduate and master's students, faculty members who employ both lecture-based and collaborative teaching practices, and informal groups that occupy the space during free periods. Its use is intensive, characterised by frequent transitions between classes, prolonged group activities, and a recurring need to reorganise the furniture, which is rigid and poorly adaptable. Although the room dimensions (12.05 m × 6.54 m, with a total area of 78.81 m²) are suitable for medium-sized classes, they are insufficient for certain active learning dynamics without spatial reconfiguration. Photographic record of the analysed classroom, highlighting fixed furniture and limited flexibility (Figure 2).



Figure 2. Existing classroom conditions (Education School of IPVC)

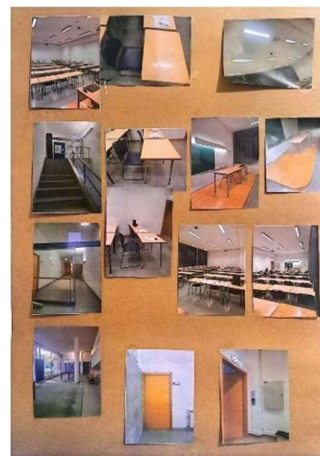


Figure 3. Spatial diagnostic panel

Natural lighting is provided by two large windows with opaque curtains for light control, while the artificial lighting, though uniform, lacks the comfort required for intensive reading and writing. The existing furniture is fixed, consisting of individual desks and rigid chairs without casters, which significantly limits mobility. This layout reinforces a traditional lecture-based model, contrasting with the needs for flexibility and ergonomics discussed previously. Photographic documentation was conducted systematically to record circulation flows and spatial conflicts, providing empirical data that complement the research (Figure 3). Based on these records, a spatial diagnostic panel was developed to synthesise identified problems and opportunities. This panel serves as an intermediate tool between empirical observation and the design phase, organising functional and behavioural information to inform the new layout. The PIS is conceived as a contemporary educational ecosystem designed to address challenges such as digital transformation and diverse learner profiles. Recent research highlights that both physical and digital environments significantly influence engagement and learning outcomes [8],[9]. The PIS is specifically architected to facilitate active learning strategies that, although established in theory, require specialised spatial affordances to be effective. By integrating modular layouts and high-tech infrastructures, the space provides the flexibility for Project-Based Learning (PBL) and Flipped Classroom models, which are frequently constrained by rigid, traditional settings. Current literature emphasises that flexible spaces are critical enablers of pedagogical innovation [10],[2]. Collaborative learning areas (Figure 4) feature modular furniture and interactive technologies that foster teamwork and knowledge co-construction [11]. These zones support both individual expression and co-creation through activities like brainstorming and prototyping, encouraging divergent thinking and innovation [3]. Equipped with tools such as 3D printers and interactive panels, students can translate theoretical knowledge into practical outputs, iterating and refining ideas in a low-risk, experiential setting.



Figure 4. Collaborative learning areas

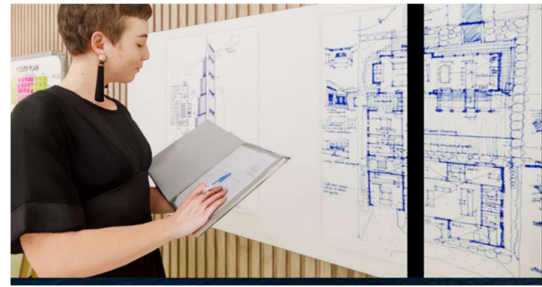


Figure 5. individual work and concentration

In parallel, the PIS incorporates zones dedicated to individual work and concentration (Figure 5), acknowledging the importance of self-regulated learning, critical reflection, and autonomous study in achieving deep and sustained learning. These spaces support individual research and inquiry-based activities, particularly within hybrid learning contexts that combine online and face-to-face components [11]. Designed for autonomous study, investigation, and reflection, this area provides a quieter and more controlled environment. It offers conditions conducive to focused activities such as reading, academic writing, and individual project development. Students are encouraged to explore independently, acting as active researchers who learn through practice rather than passive listening. Teachers can facilitate inquiry- and project-based learning, aiming to enhance students' analytical skills and critical thinking.



Figure 6. Pedagogical experimentation and prototyping areas



Figure 7. Technological and multimedia support areas

A distinctive feature of the PIS is the inclusion of pedagogical experimentation and prototyping areas (Figure 6), conceived as living laboratories for educational innovation. These spaces enable teachers and researchers to test new pedagogical approaches, digital resources, and emerging educational technologies—including artificial intelligence-enhanced tools and immersive learning environments—within a framework of action research and continuous improvement [12], [1]. Additionally, these areas can serve as flexible meeting spaces, supporting collaborative discussions, workshops, and planning sessions among educators and research teams. The PIS integrates technological and multimedia support areas (Figure 7) not merely as infrastructure for equipment, but as a dedicated environment for 'learning by design' and active knowledge construction. These areas enable students to transition from passive consumers to active creators of educational content, such as videos and podcasts. Also, the pedagogical value of multimedia production lies in the externalisation of thought; by restructuring complex information to communicate it through different media, students engage in deeper cognitive processing and synthesis [13]. Furthermore, this production-oriented approach fosters 'digital agency'—a critical competency in modern engineering and design education—ensuring that students develop the technical and reflective skills to solve real-world challenges through diverse representational formats.



Figure 8. Examples of informal meeting and socialisation spaces

Informal meeting and socialisation areas (Figure 8) are essential for promoting well-being and the development of 'communities of practice.' These environments facilitate spontaneous knowledge exchange and interdisciplinary collaboration, fostering a sense of belonging that is critical for sustainable pedagogical innovation and student success [14], [2]. In conclusion, the PIS represents a dynamic and flexible learning ecosystem aligned with international trends in educational transformation. By strategically integrating space, pedagogy, and technology, the PIS moves beyond traditional instruction toward active, learner-centred approaches. This model not only supports the immediate needs of Engineering and Design curricula but also contributes to the long-term quality, relevance, and sustainability of teaching and learning processes in higher education.

4 CONCLUSIONS AND FUTURE WORK

The development of the PIS marks a strategic shift from traditional, rigid educational settings to a dynamic, flexible and inclusive learning ecosystem. This research shows that shifting from conventional lecture-based models to active, collaborative learning environments requires a robust methodological framework based on Design Thinking principles. This approach ensures that spatial, pedagogical, and technological solutions remain genuinely user-centred and responsive to users' needs. An empirical analysis conducted in a classroom at the School of Education of the Polytechnic Institute of Viana do Castelo, used as a case study, highlighted that fixed furniture and limited spatial adaptability can restrict collaboration, experimentation, and the iterative processes, which are all essential in design and engineering education. In response, the PIS incorporates designated areas for collaboration, independent study, pedagogical experimentation and multimedia production. This configuration fosters co-creation, rapid prototyping and reflective learning, supporting the construction of both individual and collective knowledge. Equality, diversity and inclusion (EDI) are positioned as core principles of the project. The PIS was designed to ensure accessibility, participation and adaptability in response to the increasing diversity and complexity of contemporary higher education contexts, promoting inclusive learning experiences for all users. Although this study focused primarily on the conceptual design and initial implementation of the PIS, future work should place greater emphasis on the testing and validation phases of the design thinking methodology. Systematic testing of spatial layouts, pedagogical scenarios, and technological tools in real educational settings is essential for assessing usability, learning effectiveness, inclusivity, and user satisfaction. Longitudinal evaluation will enable strengths, limitations and necessary adjustments to be identified, supporting continuous improvement and long-term sustainability. Regarding the current stage of the project, it is important to acknowledge that as a conceptual and procedural proposal, this study does not yet include post-implementation empirical data. The primary focus remains on the methodological framework and the design of the PIS ecosystem. However, the transition from theory to practice involves inherent challenges that must be addressed to ensure long-term sustainability.

Implementation costs, particularly concerning modular furniture and high-end technological integration, represent a significant factor for institutional scalability. Furthermore, the effectiveness of these flexible spaces is deeply dependent on faculty training; without pedagogical support to transition away from traditional lecture-based models, the physical affordances of the PIS may remain underutilised. Finally, maintenance protocols for mobile equipment and specialised digital tools are essential to prevent technical obsolescence and physical wear. Future longitudinal studies will be fundamental to provide quantitative metrics on student engagement and usability, validating the scalability of this model to other

units within the institution. Several directions for future research are therefore proposed. Firstly, the scalability of the design will involve adapting the spatial and pedagogical guidelines developed in this study for an additional four classrooms in other PUVC schools, while respecting the specific disciplinary and material conditions of each context. Secondly, the spatial impact of flexible and modular learning environments on student engagement, collaboration and the development of transversal skills compared to traditional classroom settings will be assessed through longitudinal studies. Thirdly, the integration of emerging technologies will involve incorporating artificial intelligence-enhanced tools and immersive learning environments (VR/AR) into prototyping and experimentation areas, thereby extending the boundaries of physical and digital educational practices. These developments are intended to enable the Pedagogical Innovation Space to evolve as a living laboratory for pedagogical innovation, thereby reinforcing its role as a reference model for inclusive, collaborative, and future-oriented design and engineering education.

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