Jiang, B. et al. (Eds.) (2025). Proceedings of the 33rd International Conference on Computers in Education. Asia-Pacific Society for Computers in Education

Towards Pedagogical Design Thinking: Exploring the Role of Scaffolding in Pre-Service Teacher's Development as Learning Designer

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Abstract: In today's educational context, teachers are expected to design meaningful learning experiences that respond to diverse learning needs. Yet, pre-service teacher education programs often emphasize prescribed knowledge and lesson planning, preparing teachers more as implementers than as reflective designers of learning. Design Thinking (DT) offers potential to foster creativity, empathy, and problem-solving. However, existing DT models are either overly procedural or too open-ended, creating challenges for novice teachers without structured support. This research proposes a scaffolding framework that conceptualizes and integrates two novel supports for PSTs: ***Noticing-with-Video-based-Student-Personas*** to strengthen **empathy and problem framing** skills, and ***Expert Modelling*** to guide **ideation and prototyping**. Using a Design-Based Research approach, the research aims at conceptualizing and designing scaffolds and understanding how scaffolds influence DT processes and pedagogical reasoning of PSTs. The expected outcome is a validated scaffolding framework for Pedagogical Design Thinking that advances teachers as designers of learning, which can also inform design guidelines for teacher education programs.

Keywords: Design Thinking, Pre-service Teachers, Personas, Expert Modelling

1. Introduction and Background

In today's classrooms, teachers are expected not only to deliver lessons but also to design meaningful learning experiences that address student needs, diverse contexts, and classroom challenges. Yet, pre-service teacher education often emphasizes lesson planning and content delivery, with limited focus on developing creative problem-solving skills (Jordan, 2016). This gap is most visible in STEM education, where complex concepts, varied learner backgrounds, and limited resources demand innovative solutions. Design Thinking (DT) offers a human-centered approach that fosters creativity, empathy, and problem-solving (Koh et al., 2015; Jordan, 2016), which has been shown to help PSTs design engaging lessons and reflect on their teaching (e.g., Liu et al., 2023). Despite recognition, teachers struggle to practice DT due to limited training and methodological understanding (Henriksen et al., 2018), making early integration in pre-service teacher education crucial. However, the existing DT models are either overly procedural (i.e., providing detailed step-by-step procedures with tools and resources) (Calavia et al., 2023) or excessively open-ended (i.e., principle-based approach providing only guiding principles with open space for exploration, creativity, and reflection) (e.g., Henriksen et al., 2017). This research addresses the need for a contextualised approach that combines DT processes in a pedagogical context with novel scaffolds, such as *Noticing-with-Video-based-Student-Personas* and *Expert Modelling*, enabling PSTs to design low-resource physical models for authentic teaching-learning problems.

2. Scaffolding DT Work of PSTs: An Underexplored Territory

Despite the growing recognition of Design Thinking (DT) in education, teachers remain uncertain about its classroom application due to limited understanding and lack of training (Henriksen et al., 2018). This necessitates a shift in teacher education paradigms that can

cultivate these competencies from the very beginning of a teacher's professional journey (Koh et al., 2015). Yet DT's fluid structure often confuses PSTs, who struggle to see themselves as *"designers"* (Baran & AlZoubi, 2023). Knowledge-building approaches offer some value but lack consistent scaffolding across DT phases such as empathy, ideation, prototyping, and testing (Koh et al., 2015). Without support, PSTs often fail to apply DT in authentic classroom contexts. Scaffolding helps learners navigate complex processes (Puntambekar & Kolodner, 2005). Since design is cognitively demanding, novice teachers need modeling, structured support, and repeated practice, while even experienced teachers improve when guided by expert input (Puntambekar & Kolodner, 2005). Without scaffolding, PSTs often fail to apply DT principles in authentic classroom contexts. Although DT has clear pedagogical potential, PSTs often face cognitive overload when tackling open-ended design tasks in unfamiliar contexts. Existing DT models are abstract and insufficiently tailored to teacher education, reinforcing the need for scaffolding to build PSTs' pedagogical repertoire (Koh et al., 2015). The proposed research aims to explore, design, and test scaffolding mechanisms to support PSTs in engaging productively with DT.

3. Pedagogical Design Thinking: Scaffolding Framework for PSTs

In the proposed research, we have conceptualized a model that integrates Video-based Student Personas (VSPs) as a pedagogical scaffold in the empathy and define phases of DT and Expert Modelling as a design scaffold in the ideation and prototype phases of DT (see Figure 1). The conceptual framework guiding this research builds on the Double Diamond model of DT. The key conceptualization of this research is the Authentic Pedagogical Design Challenge (APDC), a broader framework within which the proposed work is situated. PSTs will be presented with an authentic teaching-learning problem — a case designed based on real or plausible classroom scenarios depicting difficulties and challenges faced by students with a particular concept in science, along with their misconceptions, needs, and experiences. Based on this, the PSTs will be posed a design challenge - *design a physical model using low-resource materials*, which addresses the students' misconceptions, challenges, and needs.

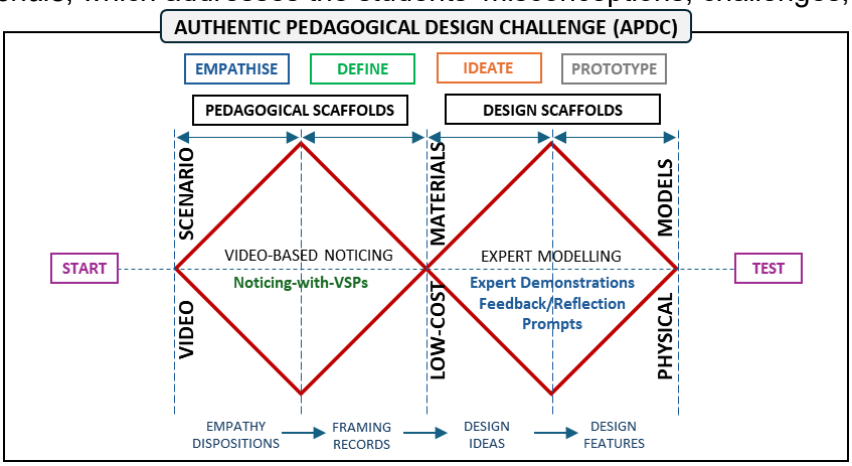

Figure 1. PSTs Pedagogical Design Thinking: Scaffolding Framework

3.1 Noticing-with-Video-based Student Personas (VSPs): A Novel Pedagogical Scaffold

Personas emerged as an "*efficient mental tool*" valuable for teachers when designing for learners (Kerr & Kelly, 2024). We conceptualize a novel pedagogical scaffold, called Video-based Student Personas (VSPs). PSTs will be provided curated video vignettes of students explaining, reflecting on, or discussing their understanding related to a concept or a phenomenon (i.e., Video-based student personas - VSPs) (see Figure 2). These will be accompanied by noticing prompts encouraging PSTs to: attend to student responses, interpret underlying misconceptions, and frame a precise instructional problem (van Es & Sherin, 2021) (see Figure 2). Teacher noticing refers to how teachers observe and make sense of important moments in the classroom, especially related to students' thinking and learning and/or events that influence student learning in a positive or negative way and to use knowledge of one's specific teaching context to reason about a given situation. It involves three main actions:

noticing specific events or student actions (*attending*), making meaning of what those actions reveal about student understanding (*interpreting*), and deciding how to respond in ways that support learning (*responding*). This process helps teachers become more aware of students' needs, adapt their teaching strategies, and improve classroom interactions (van Es & Sherin, 2021).

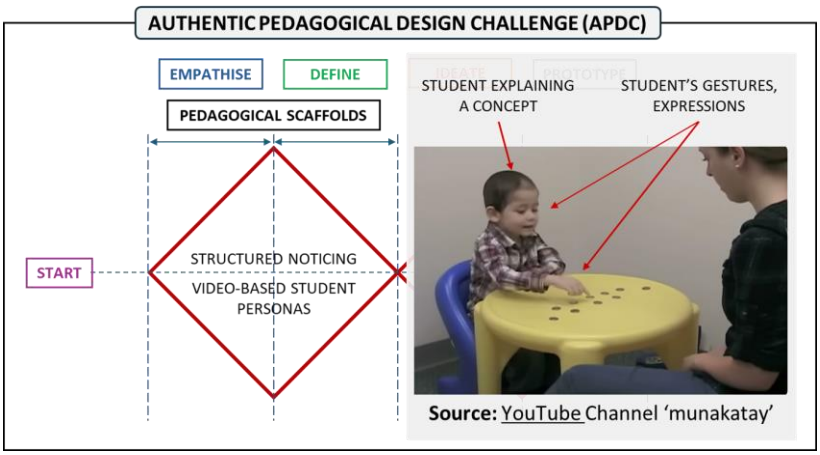

Figure 2. The snapshot of a VSP showcasing student explaining a concept

3.2 Expert Modelling (EM)

This research also examines how expert modeling, combined with VSPs, can scaffold PSTs in the ideate and prototype phases of DT. Unlike novices, who rely on narrow, trial-and-error approaches, experts map broader problem spaces, mentally simulate options, and ground decisions in prior experience (Koh et al., 2015). For PSTs, physical modeling requires pedagogical as well as design knowledge, and without guidance they risk reinforcing misconceptions (Puntambekar & Kolodner, 2005). Expert modeling could make tacit expert processes of framing, reasoning, and iteration of physical models visible to PSTs. Based on the experts' processes of designing physical models, we aim to develop reflection and feedback prompts to support PSTs physical model prototyping, enabling them to design low-resource instructional models that balance conceptual depth with clarity.

4. Research Goals

This research seeks to develop a contextualized approach to Design Thinking (DT) in pre-service teacher education by conceptualizing and integrating novel scaffolds to support and connect DT processes with pedagogical goals and classroom realities. Further, broadly, this study aims to answer the following research and design questions: *How can we design a noticing with video-based student personas scaffold that provides pedagogical richness and foster pre-service teachers' empathy competencies and problem-framing skills?* ***(DQ1)****; How does Noticing with VSPs support pre-service teachers' development of empathy competencies and problem-framing skills?* ***(RQ1)****; What design processes and pedagogical considerations do experts employ while designing physical models and learning activities?* ***(RQ2)****; How can expert design processes be modelled into a scaffold that supports PSTs design ideas, rationales, and prototypes of physical models?* ***(DQ2)****; How does Expert Modeling Scaffold influence PSTs design ideas and decisions, design rationales, and prototypes of physical models for science instruction?* ***(RQ3).***

5. Research Methodology

This study adopts a Design-Based Research (DBR) methodology (see Figure 3), which supports iterative cycles of analysis, design, implementation, and refinement in real-world settings. Participants include pre-service teachers (PSTs), who are the primary users of the scaffolding framework, and expert designers with experience in STEM model development, who contribute to development of design scaffold and refinement. The preliminary findings of our research has demonstrated that PSTs find it difficult to design and conduct user interviews

in the empathy phase, showing the need to scaffold empathy processes. Approximately 90–100 PSTs will be engaged in APDC tasks for RQ1 and RQ3; DQ1 and DQ2 will involve 3–4 experts and 6 PSTs for usability testing; and RQ2 will involve 3–4 experts to document modeling processes. Data collection will include classroom observations, design artefacts, reflective journals, and semi-structured interviews, while analysis will combine thematic coding of qualitative data with artefact-based evaluation of design quality.

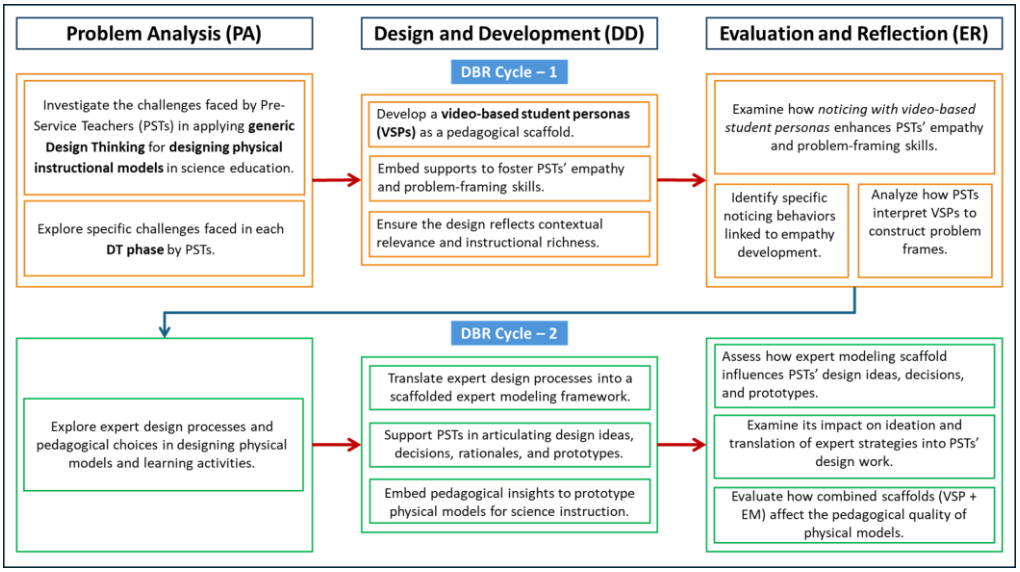

Figure 3. The potential trajectory of the DBR phases and cycles of this research

6. Potential Outcomes

The expected outcomes are: *(i) An empirically validated* ***Noticing-with-Video-based Student Personas as a pedagogical scaffold*** *for supporting empathy and problem-framing skills; (ii) An* ***Expert Modelling scaffold*** *that translates expert design reasoning into accessible strategies for novice teachers; and (iii) Contributions to theory and practice in pedagogical design thinking, supporting the preparation of teachers as adaptive designers of learning.*

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