

# From Empathy to Engineering: A Pedagogical Framework and its Authentic mHealth Implementation

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## ABSTRACT

Accessible design is crucial for ensuring equitable access to digital services, yet it remains relegated to elective modules or late-stage compliance in many computing curricula. We propose a human-centered pedagogical framework that embeds inclusive thinking across key phases of the software development process. We introduce two reusable educational tools: a cross-phase persona engine for guiding requirement prioritization and evaluation, and a guideline-reflection instrument that couples accessibility heuristics with structured prompts. The framework is instantiated in an undergraduate course through the redesign of a national mobile health (mHealth) application—a domain where poor accessibility directly exacerbates systemic health inequities. Preliminary pre-course surveys ( $N = 45$ ) reveal moderate conceptual knowledge of inclusive design but low confidence in its application, underscoring the need for structured longitudinal scaffolding. We discuss the course design, assignments, toolkit and argue that this approach helps students move from abstract empathy to actionable accessibility, offering a framework that can be adapted to other domains.

## KEYWORDS

Software Engineering Education, Project-based Learning, Inclusive Design, Human-centered Design, Accessibility, mHealth

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## 1 INTRODUCTION

With software permeating nearly every aspect of daily life, accessible design is essential for ensuring equitable access to digital services and is increasingly recognized as a core competency for modern software engineers. For example, in mobile health (mHealth) applications, poor accessibility can directly exclude users from vital services and worsen health inequities [7]. Despite its importance, students often conflate accessible design with superficial aesthetics or late-stage compliance checklists, lacking the rigorous practice

needed to translate inclusive values into tangible design decisions and functional requirements [3].

Software engineering (SE) education has attempted to address this gap through various approaches, ranging from stand-alone accessibility courses to integrated programming modules [5, 6]. While these efforts successfully raise awareness and cultivate empathy, they often suffer from fragmentation. Accessibility is frequently taught as an optional module or a one-off exercise at the end of the development cycle rather than being embedded as a fundamental constraint throughout the software lifecycle [1]. Furthermore, instructors often face a scarcity of teaching resources and a lack of reusable curricular frameworks that can structure this complex sociotechnical learning [4]. Consequently, students may graduate with a conceptual appreciation for accessibility but report low confidence in their ability to apply it to real-world engineering problems [2].

To bridge the gap between abstract empathy and concrete engineering practice, we present a human-centered pedagogical framework that embeds inclusive thinking across the requirements, design, and prototyping phases of the software lifecycle. The contributions of this study are as follows.

- We propose a pedagogical framework that organizes the curriculum around living personas, artifacts that evolve through discovery, design, prototyping, and evaluation, serving as the connective tissue that links user research to final validation.
- We develop a reusable instructor toolkit, comprising a *cross-phase persona engine* and a *guideline-reflection instrument*, designed to scaffold student decision-making and enable educators to adapt the pedagogical framework to various application domains.
- We instantiate this framework within an authentic mHealth course context (the redesign of a national health insurance app), demonstrating how real-world domains can be leveraged to engage students with the specific barriers faced by their own communities and families.

## 2 FRAMEWORK AND TOOLKIT

The core of our pedagogical framework is the use of personas as living artifacts that interconnect the key phases of the software development process, where students iteratively refine and apply these personas to drive design decisions through four sequential assignments (ASS).

- **ASS1: Discover** – Students collect user requirements via surveys/interviews, focusing on inclusive access. They must explicitly identify barriers faced by diverse users (e.g., older adults, low-literacy users) and begin drafting personas.
- **ASS2: Design** – Using the refined personas, teams develop scenarios and build low-fidelity wireframes. They employ a Value



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Proposition Canvas to connect user pains, goals, and gains to interface features. Alternative wireframes are compared to demonstrate trade-off reasoning.

- **ASS3: Prototype** – Students transform selected wireframes into interactive prototypes, emphasizing accessible interaction elements. Annotated prototypes explicitly map features back to persona goals.
- **ASS4: Evaluate** – Teams perform a persona-based cognitive walkthrough. They report usability and accessibility issues, prioritize fixes, and iterate accordingly. External stakeholder feedback is encouraged but not graded.

For assessment, we employ a dual-faceted strategy that evaluates both the quality of the software artifacts and the rigor of the inclusive design process. This approach balances technical execution with critical reflection, requiring students to not only produce accessible prototypes but also explicitly justify their design trade-offs and document their evolving understanding of user barriers.

To support the transferability of this pedagogical framework, we developed the following two reusable scaffolding toolkits, designed not only to scaffold student learning, but also as reusable curricular templates for educators.

- **Cross-Phase Persona Engine.** This is a comprehensive set of instructions and toolkit for embedding personas across multiple assignments. Students learn to derive and refine personas from empirical data in ASS1, use these personas to prioritize requirements and inform wireframe and prototype decisions in ASS2–ASS3, and then anchor persona-based cognitive walkthroughs in ASS4. The engine includes a simple prioritization matrix to help teams rank requirements based on persona goals, feasibility, and accessibility needs, thus teaching students how to justify design trade-offs.
- **Guideline–Reflection Instrument.** This is a comprehensive set of accessibility-focused prompts and heuristics that span the course. At the start of the course, the instructor presents relevant accessibility standards and domain-specific guidelines to orient students to common challenges. During ASS1, the instrument helps students refine research questions and design interview or survey prompts to explore potential accessibility barriers. In ASS2, it guides the construction of personas by prompting students to consider motivations, frustrations, and needs from an accessibility perspective. In ASS2–ASS3, it serves as a design checklist, reminding students to incorporate accessible interactions and layouts when prototyping. By ASS4, it acts as a scaffold for persona-based cognitive walkthroughs, helping teams structure evaluation tasks, anticipate user actions, and reflect on how their design choices align with accessibility principles. Throughout, it encourages students to recognize and address their own biases, blending critical reflection with practical application.

### 3 MHEALTH COURSE IMPLEMENTATION

To implement our pedagogical framework, we designed and conducted a course centered on *mobile JKN*, the Indonesian national health insurance app. We selected this domain because accessible design in mHealth is essential for equitable healthcare access and gives students an authentic context to empathize with real-world barriers faced by their own family or community.

To ensure the authenticity of the learning context, the instructors developed the assignment materials through a three-stage empirical preparation. We first analyzed app reviews to identify prevalent accessibility barriers, then interviewed general practitioners (GPs) to refine the domain scope, and finally synthesized these findings into the design briefs. This process ensured that the initial personas and scenario prompts were grounded in real-world data rather than hypothetical assumptions.

As the course is still ongoing, we report preliminary data from 45 second-year informatics students. The study was conducted under an IRB exemption with informed consent. Pre-course surveys using a 5-point Likert scale reveal a gap between concept and practice: students reported moderate familiarity with accessible design (Mean=3.75, SD=0.66) but lower confidence in applying these concepts to real projects (Mean=3.36, SD=0.78). In contrast, student motivation is high (Mean=4.56, SD=0.65,  $\alpha=0.75-0.92$ ), with approximately 70% of respondents strongly expressing a desire to integrate human-centered and accessibility principles into their future practice.

### 4 CONCLUSION AND FUTURE WORK

To bridge the gap between abstract empathy and concrete engineering practice, we presented a human-centered pedagogical framework that embeds accessible design within key phases of the software development process. We implemented this framework within an undergraduate course centered on the mHealth domain, where a pre-course survey ( $N = 45$ ) revealed a significant gap between high student motivation and low practical confidence.

Future work will focus on the comprehensive evaluation of the framework following the course conclusion. We plan to analyze post-course surveys and final student artifacts to measure actual skill acquisition and changes in confidence levels. Additionally, we aim to refine the toolkits based on student feedback. Finally, we intend to adapt this pedagogical model to other application domains beyond mHealth to validate its transferability and robustness across the broader software engineering curriculum.

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