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Mapping Pre-service Teachers' Experiences in Integrating Design Thinking and ChatGPT: An Analysis of 21st-Century Learning Tools Development

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ABSTRACT

Despite growing interest in Design Thinking and artificial intelligence (AI) in education, empirical research examining how pre-service teachers integrate these approaches into instructional design remains limited. Teacher training programs often lack structured guidance for such integration, creating a gap in preparing educators for 21st-century classrooms. Addressing this gap, this study explores the experiences of Pre-service Teacher Professional Education (PPG Prajabatan) students in Indonesia as they integrate the Design Thinking method with the AI tool ChatGPT to develop 21st-century learning tools. Employing a qualitative exploratory approach, the study utilised the Gioia method, selected for its systematic rigour in developing grounded theoretical insights through progressive abstraction from raw data to theoretical concepts. Data were collected through semi-structured interviews with 20 participants. The findings reveal three key conceptual contributions: (1) the pedagogical roles of ChatGPT as a cognitive support tool facilitating ideation, content generation, and iterative feedback; (2) a process model for Design Thinking-AI integration encompassing the empathise, define, ideate, prototype, and test phases; and (3) the emergence of reflective digital literacy as a critical competency for pre-service teachers. While Design Thinking enabled prospective teachers to gain a deep understanding of students' needs through diagnostic assessments, ChatGPT supported the formulation of learning objectives and the design of teaching materials. The study acknowledges limitations inherent to qualitative research, including the contextual specificity of findings to the Indonesian PPG program and the interpretive nature of thematic analysis.

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Ultimately, it contributes to the design of innovative and adaptive teacher training strategies for the digital age.

Keywords: Design Thinking, ChatGPT, teacher education, pre-service teacher, instructional design, Gioia method, digital literacy, Indonesia

INTRODUCTION

The rapid development of technology has driven the transformation of education, especially in preparing students to face the challenges of the 21st Century. Teachers, as key actors in education, need to master strategies that support technology-based learning and innovation. One approach that has gained significant attention is the integration of Design Thinking with artificial intelligence (AI), such as ChatGPT, which can support the development of learning tools that are relevant to the needs of today's learners. However, the implementation of this strategy is not without challenges, particularly for pre-service teachers undergoing training (Anderson, 2020; Baidoo-Anu & Ansah, 2023; Brown & Green, 2019; Kasneci et al., 2023; Zhai et al., 2021).

Specifically, pre-service teachers professional education face several key challenges when integrating Design Thinking with AI tools: (1) technical proficiency barriers, including limited experience with AI tools and their pedagogical applications; (2) critical evaluation skills, particularly difficulty in assessing AI-generated content for accuracy, bias, and contextual appropriateness; (3) pedagogical integration challenges in meaningfully connecting AI capabilities with Design Thinking stages; (4) ethical awareness concerns regarding academic integrity, data privacy, and responsible AI use; and (5) contextual adaptation difficulties in adapting AI outputs to local curriculum standards and diverse learner needs (Celik et al., 2022; Ng et al., 2021; Yan et al., 2024).

Design Thinking has long been recognised as an effective method for solving complex problems through five main stages: empathise, define, ideate, prototype, and test (Liedtka, 2015; Scheer et al., 2012). In educational contexts, this approach enables pre-service teachers to gain a deep understanding of students' needs, define instructional problems, and develop creative solutions based on data and classroom realities (Cross, 2023; Razzouk & Shute, 2012). The empathise stage helps prospective teachers recognise diverse learning styles, while the prototype stage allows for iterative testing of learning tools prior to full implementation.

Meanwhile, ChatGPT, as one of the innovations in generative artificial intelligence, offers various features that support the learning process, such as providing instant feedback, helping to design teaching materials, and analysing student data to inform pedagogical decisions (Holstein et al., 2020; E. Mollick & L. Mollick, 2023). Research indicates that

such tools can enhance teacher efficiency, personalise learning, and enrich student engagement (Lo, 2023; Luckin et al., 2016; Yan et al., 2024; Zhai et al., 2021). However, effective implementation requires high digital literacy, critical evaluation of AI outputs, and strong ethical awareness (Holstein et al., 2020; Ng et al., 2021).

Despite the growing interest in both Design Thinking and AI in education, empirical studies examining how pre-service teachers practically integrate these two approaches in instructional design remain limited (Celik et al., 2022; Chiu et al., 2023; Yan et al., 2024). This creates a gap in teacher education literature, particularly regarding the preparation of 21st-century learning tools. While institutional frameworks increasingly encourage innovation, structured guidance for such integration is often lacking in teacher training programs (Kasneci et al., 2023; Mishra & Koehler, 2006; Ng et al., 2021).

The urgency of addressing this issue is further supported by global calls to transform teacher competencies. Mishra and Koehler (2006) emphasised that meaningful technology integration requires a balance of technological, pedagogical, and content knowledge (TPACK). Vygotsky (1978) argued that learning is mediated by tools and social interaction tools, which today include AI technologies. Without clear scaffolding and practical engagement, prospective teachers risk remaining passive consumers rather than critical, reflective practitioners.

Understanding how pre-service teachers make instructional decisions when integrating Design Thinking and AI is crucial for effective teacher preparation. The decision-making process involves multiple cognitive and practical considerations: selecting appropriate AI tools for specific pedagogical purposes, evaluating AI-generated content for accuracy and contextual relevance, adapting materials to meet diverse learner needs, and reflecting on the effectiveness of technology-enhanced instruction. This study maps these decision-making processes by examining how participants navigate each stage of Design Thinking while leveraging ChatGPT capabilities. Such process-oriented qualitative insights contribute to a more nuanced understanding of AI integration in teacher education, moving beyond simple adoption studies to explore the complex interplay between pedagogical reasoning and technological affordances (Celik et al., 2022; Chiu et al., 2023).

In the Indonesian context, this issue becomes particularly pressing within the Teacher Professional Education (PPG) program, which expects pre-service teachers to design instructional materials that are inclusive, contextual, and innovative. However, the actual practice of integrating AI within a design thinking framework remains underexplored. Zhao and Frank (2003) highlight that technology adoption is influenced not only by teacher readiness but also by environmental and institutional support. Investigating how pre-service teachers navigate this integration is thus essential to strengthening teacher preparation policy and practice.

To address this gap, the present study aims to explore how pre-service teachers,

specifically those in the PPG Prajabatan program, experience the integration of Design Thinking and ChatGPT in the development of 21st-century learning tools. The research seeks to document the opportunities, challenges, and decision-making processes that shape their instructional design, to contribute practical insights to future teacher training models.

The study addresses the following research question: How do pre-service teachers experience and perceive the integration of Design Thinking and ChatGPT in developing learning tools that meet 21st-century educational needs? Details regarding the methodology, including the Gioia method, participant selection, and data analysis procedures, are presented in the Methodology section.

LITERATURE REVIEW

The present study is grounded in the intersection of two central domains in education: the Design Thinking framework and the application of generative Artificial Intelligence (AI), particularly ChatGPT, in instructional development. A synthesis of existing literature is used to establish the key constructs that underpin this research and guide the analysis of pre-service teachers' experiences.

The Design Thinking model, widely used in educational innovation and user-centred design, comprises five iterative stages: empathise, define, ideate, prototype, and test (Liedtka, 2015; Razzouk & Shute, 2012; Scheer et al., 2012). In educational contexts, this approach fosters reflective practice, learner-centred planning, and iterative refinement of learning tools (Cross, 2023; Scheer et al., 2012). For example, the empathise stage involves identifying student needs through diagnostic assessments, while the prototype and test stages facilitate experimental development and evaluation of instructional materials.

Simultaneously, generative AI tools, especially large language models like ChatGPT, have shown increasing relevance in supporting teacher planning, differentiation, content generation, and formative assessment (Holstein et al., 2020; E. Mollick & L. Mollick, 2023; Zhai et al., 2021). Recent studies suggest that these tools may enhance teacher creativity, reduce cognitive load, and enable adaptive instruction when used within reflective frameworks (Alqahtani et al., 2023; Chan & Hu, 2023; Dwivedi et al., 2023). However, effective pedagogical integration of ChatGPT requires more than technological proficiency; it demands ethical awareness and critical evaluation skills.

This technological development aligns with the TPACK framework (Mishra & Koehler, 2006), emphasising the blend of technological, pedagogical, and content knowledge in effective digital teaching. It also connects with Vygotsky's (1978) sociocultural learning theory, which positions tools, including AI, as mediators of meaningful learning. Without deliberate scaffolding, teachers risk surface use of AI, rather than reflective and context-sensitive application.

These theoretical perspectives—Design Thinking, AI in education, TPACK, and Vygotsky's sociocultural theory—form an integrated conceptual framework for understanding pre-service teachers' experiences. TPACK provides the knowledge framework, identifying the three types of knowledge (technological, pedagogical, and content) that teachers must integrate for effective technology use. Design Thinking provides the process methodology, offering a structured approach through which this integration can occur in practice. Vygotsky's concept of tools as cognitive mediators positions AI as a modern pedagogical tool that can extend teachers' capabilities when used within their Zone of Proximal Development. Together, these frameworks suggest that effective AI integration requires: (a) balanced knowledge across TPACK domains, (b) a systematic design process for creating contextually appropriate materials, and (c) scaffolded engagement with AI tools that support teachers' progression from novice to reflective practitioners. This integrated framework guides both the design of this study and the interpretation of findings.

Building upon this theoretical foundation, the study delineates five core constructs that guide the analysis of pre-service teachers' experiences. The first construct, understanding student needs (empathise), relates to how pre-service teachers recognise and interpret learners' challenges and expectations in the classroom. The second construct, identifying learning goals and problems (define), focuses on their ability to articulate clear instructional objectives while diagnosing key issues in the learning process. The third construct, generating instructional ideas and content (ideate), highlights the creative process through which teachers develop innovative learning strategies and materials. The fourth construct, developing and iterating materials (prototype), concerns the design, testing, and refinement of instructional tools or media. Lastly, the fifth construct, evaluating and refining learning tools (test), emphasises the process of assessing effectiveness, collecting feedback, and making continuous improvements to ensure that the developed materials meet learners' needs and learning objectives effectively.

These constructs, drawn from the Design Thinking framework, inform the design of the semi-structured interview guide and the Gioia coding structure. This conceptual model bridges literature, instrumentation, and data analysis, ensuring alignment with the study's aims: to explore how pre-service teachers integrate Design Thinking and ChatGPT in developing 21st-century learning tools.

METHODOLOGY

This study employed a qualitative exploratory design to investigate how pre-service teachers experience the integration of Design Thinking and ChatGPT in developing 21st-century learning tools. Given the complex and contextual nature of the phenomenon, an interpretive paradigm was adopted, with the Gioia method serving as the primary analytic strategy (Corley & Gioia, 2011;

Gioia et al., 2013). This approach facilitates inductive theory development grounded in participants' lived experiences.

The Gioia method is a systematic qualitative approach designed to bring rigour to inductive research while preserving the richness of participant perspectives (Gioia et al., 2013). This method was selected for the present study because it offers a structured process for moving from raw qualitative data to theoretical insights through three progressive levels of abstraction. First, first-order concepts capture participants' own language and perspectives (in vivo codes), preserving their authentic voices. Second, second-order themes represent the researcher's theoretical interpretations of patterns across first-order concepts, involving analytical abstraction. Third, aggregate dimensions synthesise second-order themes into broader theoretical constructs that can inform theory development. This three-tier structure ensures transparency in how theoretical insights emerge from empirical data, making it particularly suitable for exploring complex, understudied phenomena such as AI integration in teacher education. In this study, we applied the Gioia method by: (1) conducting verbatim transcription of all 20 interviews within 48 hours of recording, (2) identifying first-order concepts using participants' exact words through line-by-line coding, (3) grouping these into theoretically meaningful second-order themes through constant comparison, and (4) synthesising themes into aggregate dimensions aligned with Design Thinking stages.

The research model is based on the five stages of Design Thinking (empathise, define, ideate, prototype, and test), which serve as analytical constructs derived from the literature (Liedtka, 2015; Razzouk & Shute, 2012; Scheer et al., 2012). These constructs guided both the development of the semi-structured interview guide and the structure of the data analysis. The alignment of these constructs with the instrumentation ensures theoretical coherence and conceptual rigour throughout the study.

Participants

The study involved 20 pre-service teachers enrolled in the Teacher Professional Education (PPG Prajabatan) program at a state university in Indonesia. From approximately 150 active program participants across multiple cohorts, a purposive sampling strategy was applied, guided by predefined inclusion criteria: (1) participants had demonstrated experience using ChatGPT in lesson design; (2) participants had applied the Design Thinking process during instructional development; and (3) participants were willing to engage in a 45–60 minute semi-structured interview. This sampling approach ensured that only participants with both theoretical exposure and practical application of AI and Design Thinking were included. While the sample size of 20 is consistent with qualitative standards aiming for depth over breadth (Creswell & Poth, 2018), diversity in background (gender, subject matter, cohort, and school placement) was deliberately sought to increase information-rich variation (Patton, 2015).

Ethical Considerations

This study adhered to ethical research standards and received approval from the institutional Research Ethics Committee (Approval Reference: [IRB: 5.2.4/UN32.14/PB/2026]). Before data collection, all participants were provided with detailed information about the study's purpose, procedures, potential risks and benefits, and their rights as research subjects. Written informed consent was obtained from each participant, emphasising the voluntary nature of participation and their right to withdraw at any time without consequence. To ensure anonymity, all identifying information was removed from transcripts, and pseudonyms (P1–P20) were used throughout the analysis and reporting. Interview recordings and transcripts were stored securely with access limited to the research team. Participants were assured that their responses would not affect their academic standing. Data will be retained for five years after publication and then securely destroyed.

Instrumentation and Data Collection

The primary research instrument was a semi-structured interview guide consisting of 15 core questions organised around the five Design Thinking stages. For the empathise stage, questions included: "How did you identify your students' learning needs?" and "What methods did you use to understand student characteristics?" For the define stage: "How did you formulate learning objectives based on student data?" and "What instructional problems did you identify?" For the ideate stage: "How did you use ChatGPT to generate learning ideas?" and "How did you evaluate AI-generated content?" For the prototype stage: "How did you develop and refine your learning materials?" and "What feedback did you receive during testing?" For the test stage: "How did you implement and evaluate your learning tools?" and "What adjustments did you make based on student responses?" Additional probing questions were used to explore responses in depth. The interview protocol also included an observation checklist to note participant demeanour and contextual factors, and a document review guide for examining participants' learning materials and ChatGPT interaction logs when available.

Data were collected through semi-structured interviews conducted both online (via video conferencing) and face-to-face. The interview process was guided by a structured framework derived from the five stages of Design Thinking. During the empathise stage, questions focused on identifying student needs and the ways assessments were utilised. In the define stage, interviews explored how participants formulated learning objectives and identified instructional problems. The ideate stage emphasised the generation of creative ideas, particularly examining ChatGPT's role. In the prototype stage, participants described developing and testing materials. Finally, the test stage addressed practical application, evaluation, and revision of developed tools.

Each interview lasted 45–60 minutes and was audio-recorded with participant consent. All recordings were transcribed

verbatim within 48 hours. Participants were invited to review transcript summaries for member-checking and accuracy (Merriam & Tisdell, 2016).

Data Analysis

Data from semi-structured interviews were analysed using the Gioia methodology following systematic procedures (Gioia et al., 2013). The analysis unfolded through four iterative stages. In Stage 1 (First-Order Coding), we identified concepts by coding participants' statements using their own words. For example, when P8 stated, 'I began by interviewing my students about their learning habits,' this was coded as 'student interview on learning habits.' In Stage 2 (Second-Order Theming), we grouped first-order codes into broader conceptual categories. For instance, codes like 'student interview,' 'questionnaire administration,' and 'classroom observation' were grouped under the theme 'Understanding student needs.' In Stage 3 (Aggregate Dimensioning), we synthesised themes into aggregate dimensions aligned with Design Thinking stages—codes related to understanding students mapped to 'Empathise,' problem identification to 'Define,' and so forth. In Stage 4 (Cross-Case Comparison), we examined variations among participants based on subject area and teaching context through within-case and across-case matrices (Miles et al., 2014).

The classification in Tables 1-3 reflects both commonalities and divergences across the sample. For example, although multiple participants reported using diagnostic assessments, their methods varied—from Google Forms surveys to informal conversations—based on school context. This variation was preserved to maintain representational accuracy.

The analytic process was supported by NVivo 12 software and followed established qualitative coding protocols. This included researcher triangulation (two coders independently coded 30% of the transcripts, achieving an inter-rater reliability of 0.87), memoing, and member checking. Reflexivity journals were maintained throughout to monitor potential researcher bias (Guba & Lincoln, 1989; Merriam & Tisdell, 2016).

RESULTS

The research findings are organised according to the five stages of the Design Thinking framework: Empathise, Define, Ideate, Prototype, and Test. The Gioia coding structure is summarised in Table 1, research data with all 20 participants is presented in Table 2, and structural analysis is shown in Table 3.

Table 1 presents the first-order concepts identified from participant interviews, mapped to their corresponding Design Thinking stages and aggregate dimensions. The coding process followed Gioia's methodology guidelines for systematic inductive analysis.

Table 1
Thematic coding summary from interview transcript analysis

First-order Concepts	Design Thinking Stage	Aggregate Dimensions
Analysing student needs through interviews	Empathise	Understanding students
Using questionnaires for learning styles	Empathise	Differentiated Learning
Identifying student characteristics	Empathise	Understanding Student Context
Determining learning objectives	Define	Learning Design
Using diagnostic assessments	Define	Understanding students
Creating steps for learning activities	Ideate	Learning Plan Development
Using technology for assessments	Ideate	Innovation in Learning
Developing creative ideas from assessments	Ideate	Creativity in Design
Collaboration with mentor teachers	Prototype	Collaboration in Education
Evaluating teaching materials	Test	Improving Quality of Learning
Trial and revision of teaching materials	Test	Improving Quality of Learning

Table 2 provides a comprehensive overview of all 20 participants' data, showing first-order concepts derived from their interview responses, the Design Thinking stages these concepts relate to, aggregate dimensions, the specific methods and instruments each participant used for student assessment, and the stages of device testing they underwent. The 'Participant' column uses pseudonyms (P1-P20) to maintain anonymity. The variation in methods reflects participants' adaptation to their specific teaching contexts.

Table 3 presents the structural relationships in the Gioia analysis, showing how first-order concepts (participant language) were abstracted into second-order themes (researcher interpretations) and then synthesised into aggregate dimensions (theoretical constructs). This progression from data to theory demonstrates the analytical rigour of the Gioia methodology and illustrates the theoretical framework emerging from participants' experiences.

Table 2
Research data - Participant coding summary

Participant	First-order Concepts	Second-order Themes	Aggregate Dimensions	Methods and Instruments	Device Testing Stages
P1	Diagnostic assessment, culture, and learning styles	Empathise	Understanding students	Questionnaire	Consultation, implementation, reflection, evaluation
P2	Assessment of student characteristics	Define	Understanding students	Questionnaire, interview	Revision of device, implementation, and evaluation
P3	Assessment of gender, hobbies	Define	Understanding students	Questionnaire, observation, discussion	Consultation, reflection, improvement
P4	Activities according to student needs	Define	Learning Design	AI, questionnaire, interview	Implementation, reflection, evaluation
P5	Students with low cognitive ability	Define	Understanding students	Questionnaire, discussion, social media	Consultation, implementation, reflection
P6	Less active students	Define	Understanding students	Questionnaire, observation, interview	Revision, implementation, reflection
P7	Dominant visual learning style	Define	Understanding students	Questionnaire	Revision, implementation, evaluation
P8	Students unfamiliar with scouting	Define	Understanding students	Questionnaire, observation, interview	Implementation, reflection, evaluation
P9	Student readiness to learn	Define	Understanding students	Questionnaire, observation, interview	Consultation, revision, implementation, reflection
P10	Students with low cognitive ability	Define	Understanding students	Questionnaire	Implementation, evaluation, reflection
P11	The majority with a visual learning style	Define	Understanding students	Questionnaire, observation, interview	Implementation, reflection, discussion
P12	Kinesthetic learners dominant	Define	Understanding students	Questionnaire, interview	Implementation, reflection, revision
P13	Diverse learning styles, kinesthetic dominant	Define	Understanding students	Questionnaire, observation, interview	Implementation, reflection, evaluation

Table 2 (*continued*)

Participant	First-order Concepts	Second-order Themes	Aggregate Dimensions	Methods and Instruments	Device Testing Stages
P14	Male students are predominantly kinesthetic	Define	Understanding students	Questionnaire, observation	Implementation, evaluation, revision
P15	Diverse learning styles	Define	Understanding students	Questionnaire, observation, interview	Implementation, reflection, evaluation
P16	Diverse learning styles and cognitive abilities	Define	Understanding students	Questionnaire, observation, interview	Implementation, reflection, discussion
P17	Diverse learning motivation	Define	Understanding students	Questionnaire, observation	Implementation, evaluation, reflection
P18	Diverse students in learning	Define	Understanding students	Questionnaire	Implementation, evaluation, reflection
P19	Interests, talents, and learning styles diverse	Define	Understanding students	Questionnaire, interview	Implementation, evaluation, reflection
P20	Social-emotional and economic diversity	Define	Understanding students	Questionnaire, interview	Implementation, evaluation, reflection

Table 3
Structural data from gioia analysis

First-order Concepts	Second-order Themes	Aggregate Dimensions
Observing student learning styles	Understanding student needs	Understanding student needs
Using questionnaires for assessments	Defining problems based on assessment results	Identifying learning problems
Using ChatGPT to design objectives	Collaboration between technology and humans	Developing learning ideas
Discussing ideas with mentors and peers	Testing prototypes in small groups	Testing learning devices
Testing prototypes in small groups	Evaluating prototype effectiveness	Iterating devices based on data
Revising devices based on student feedback	Evaluating devices	Improving teaching materials

Empathise (Understanding Students' Contexts and Learning Needs)

In the empathise phase, participants emphasised engaging with students' realities to understand their backgrounds, preferences, and learning challenges. This was achieved through informal assessments, interviews, and observations.

> I began by interviewing my students about their learning habits and hobbies; it helped me design more engaging materials. (P8)

Additional examples demonstrate the diversity of approaches: P1 administered a Google Forms questionnaire covering learning styles, cultural background, and interests, which revealed that 70% of students preferred visual learning materials. P3 conducted informal discussions during break times to understand students' hobbies and found that many students were interested in gaming, which informed the design of game-based learning activities. P14 used observation checklists to identify kinesthetic learners who struggled with lecture-based instruction, leading to the incorporation of hands-on activities. P20 discovered through interviews that socio-emotional factors, particularly family economic challenges, affected student engagement more than academic readiness.

Key second-order themes included 'contextual understanding,' 'learner profiling,' and 'diagnostic insight.' Participants in rural contexts reported different challenges compared to urban schools, especially regarding digital tool access.

Define (Identifying Instructional Problems and Objectives)

Participants used empathetic insights to articulate instructional challenges, translating student data into pedagogical problems and specifying learning objectives.

> I realised the main problem wasn't the material, but how it was delivered—too theoretical and hard to visualise. (P3)

Further examples: P5 identified that students with lower cognitive abilities needed more scaffolded instruction with concrete examples before abstract concepts. P7 recognised that visual learners dominated the classroom and required more image-based and video materials. P9 determined that student readiness varied significantly, requiring differentiated pacing. P11 found that while most students had visual learning preferences, a significant minority were kinesthetic learners, being underserved by existing materials.

This stage demonstrated participants' ability to shift from surface-level complaints to structured problem statements. Themes such as 'problem framing' and 'instructional alignment' emerged.

Ideate (Generating Creative Solutions Using ChatGPT)

In ideation, participants utilised ChatGPT as a co-creative partner, employing it to generate lesson ideas, quizzes, narratives, and alternative instructional formats.

> I asked ChatGPT to create a story problem involving environmental

> issues, and it gave me three versions—I modified one to fit my students. (P11)

Participants described various ChatGPT uses: P4 requested differentiated activity suggestions based on learning styles identified in the empathise stage. P6 used ChatGPT to generate game-based quiz formats that addressed the engagement issues identified in the definition. P9 noted:

> Sometimes ChatGPT gives information that doesn't match Indonesian curriculum standards, so I always verify and adapt.

P16 asked ChatGPT to suggest worksheet improvements, adding questions the participant hadn't considered.

Second-order themes included 'AI-supported brainstorming,' 'content generation,' and 'creative stimulation.' Concerns about content accuracy indicated varying levels of critical AI literacy.

Prototype (Designing and Refining Instructional Materials)

During prototyping, participants transformed ideas into tangible learning materials, including worksheets, interactive media, and project-based activities.

> I created the initial worksheet draft, then asked ChatGPT to suggest improvements—it added questions I hadn't considered. (P16)

Participants demonstrated iterative thinking by testing materials on peers or mentors and revising based on feedback. Themes included 'design iteration,' 'peer validation,' and 'digital enhancement.'

Test (Implementation and Reflective Adjustment)

The test phase involved piloting learning tools in real or simulated classrooms. Participants observed student responses, collected feedback, and reflected on effectiveness.

> I noticed students were more focused during the game-based quiz I created using ChatGPT. It was fun for them. (P6)

Themes like 'learner engagement monitoring,' 'reflective practice,' and 'design responsiveness' emerged. Table 3 highlights how participant characteristics influenced this process.

Evidence of Transition from Passive Consumers to Reflective Designers: The findings reveal clear evidence of participants' transformation from passive content consumers to reflective, responsive designers across the five stages. In the empathise stage, rather than assuming student needs, participants like P1, P8, and P14 actively sought student input through questionnaires, interviews, and observations—demonstrating a shift from teacher-centred assumptions to learner-centred inquiry. In the ideate stage, participants critically evaluated and adapted AI-generated content rather than accepting it uncritically; P9's practice of verifying ChatGPT outputs against curriculum standards exemplifies this critical stance.

In the test stage, participants iteratively refined their materials based on evidence rather than implementing designs without reflection. P16's experience is particularly illustrative: after receiving negative feedback on an initial worksheet, the participant completely redesigned it, stating,

> I realised I was creating what I thought was good, not what students needed.

This shift from teacher-centred to learner-centred design thinking was consistently observed across the sample, representing a fundamental transformation in pedagogical orientation.

DISCUSSION

This section interprets the findings in relation to research objectives and broader theoretical contexts. The integration of Design Thinking and ChatGPT reveals a paradigm shift in pedagogical thinking.

The Role of Empathy in Instructional Design

The empathetic stage demonstrated that participants contextualised learning by understanding students' backgrounds, preferences, and challenges. Our data showed that participants who invested more time in empathising (e.g., P1, P8, P14) produced more contextually appropriate materials. Specifically, P1's detailed questionnaire data informed differentiated activities, P8's interviews revealed hobby-based engagement opportunities, and P14's observations led to incorporating kinesthetic activities for struggling learners. This supports prior studies highlighting empathy as the foundation of learner-centred design (Almog & Shechtman, 2007; Cross, 2023; Razzouk & Shute, 2012). The varied methods used—from formal questionnaires to informal conversations demonstrate Design Thinking's flexibility across teaching contexts.

Framing Pedagogical Problems through Design Thinking

Defining pedagogical problems through learner data marks a cognitive transition from general to targeted instruction. Participants like P3 and P7 demonstrated reframing vague challenges ('students are bored') into specific, solvable questions ('visual learners need image-based content'). This alignment occurred through the systematic connection between empathetic data and defining outcomes: P3's observation that students struggled with theoretical content led to the specific objective of creating visualisation tools; P7's questionnaire findings about visual learner dominance directly informed the goal of developing image-rich materials. This aligns with TPACK (Mishra & Koehler, 2006) and backward design principles (Wiggins & McTighe, 2005).

ChatGPT as a Cognitive Support Tool in Ideation

ChatGPT supported ideation by providing access to ideas, draft texts, and examples. Our findings suggest AI can scaffold creativity when used thoughtfully—P4's differentiated activities, P6's game-based quizzes, and P11's story problems all

originated from ChatGPT prompts but were significantly adapted based on empathy and defined insights. The 'how' of this integration involved participants: (1) formulating specific prompts based on identified student needs, (2) critically evaluating AI outputs against curriculum standards (as P9 described), (3) adapting content for local context, and (4) iterating based on peer feedback. This corresponds with literature regarding AI as cognitive support (Luckin et al., 2016; E. Mollick & L. Mollick, 2023), while highlighting the essential role of critical digital literacy (Holmes et al., 2019; Ng et al., 2021).

Iterative Prototyping and Peer Validation

Prototyping enabled participants to test designs through peer review, microteaching, and classroom application. The iterative alignment between stages occurred as follows: empathise with data-informed prototype features, define objectives guided by prototype scope, and ideate outputs provided prototype content. For example, P16's worksheet prototype incorporated ChatGPT-generated questions (ideate) targeted at visual learners (empathise/define), then underwent peer review, revealing gaps, leading to revision. This mirrors design-based research and experiential learning principles (Kolb, 1984) and Schön's (1983) 'reflection-in-action.'

Reflective Testing and Adaptive Practice

In testing, participants implemented and evaluated tools in authentic environments. The connection to results is evident in how test outcomes informed further iteration: P6's observation that students were 'more focused during the game-based quiz' validated the ideate decision to use gamification; negative feedback in P16's case led to a complete redesign. This evidence-based reflection demonstrates adaptive expertise (Hatano & Inagaki, 1986) and metacognitive maturity associated with teacher effectiveness (Marzano & Brown, 2007). The shift in teacher role—from sole content creator to learning designer who curates and contextualises AI resources—represents a fundamental pedagogical transformation.

CONCLUSIONS AND IMPLICATIONS

This study explored how pre-service teachers in the Indonesian PPG Prajabatan program experience integrating Design Thinking and ChatGPT in developing 21st-century learning tools. Through the Gioia method analysis, findings reveal that this integration offers a structured yet flexible framework for instructional innovation, enabling participants to transition from passive content consumers to reflective, responsive designers. Three key conceptual contributions emerged: First, ChatGPT serves multiple pedagogical roles as ideation partner, content generator, and feedback mechanism—that complement rather than replace human creativity. Second, integration follows a coherent process aligned with Design Thinking stages. Third, successful integration requires developing reflective digital literacy.

Practical Implications

For teacher education programs, Design Thinking provides an effective framework for integrating AI tools. Institutions should embed structured opportunities for AI-assisted instructional design within authentic teaching contexts. Explicit instruction in critical AI literacy—including evaluating output accuracy and adapting content for local contexts—should be incorporated into curricula.

Research Implications

Future research should examine long-term impacts on teaching effectiveness and student outcomes. Comparative studies across cultural and institutional contexts would establish generalizability. Research exploring ethical considerations in AI-assisted education represents an important future direction.

Limitations

This study acknowledges limitations inherent to qualitative research. Findings are contextually specific to the Indonesian PPG program and may not be directly generalizable. The interpretive nature of thematic analysis introduces researcher subjectivity, mitigated through triangulation and member checking. The study captures experiences at a specific point in time; longitudinal research would provide insights into practice evolution.

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