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RESEARCH ARTICLE

Reflective Practice Mediated by Digital Tools: Analyzing the Learning Process through Padlet in a Design Thinking Course

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ABSTRACT

Reflective practice is essential for supporting learners in addressing complex, ill-defined problems, yet its developmental processes in digitally mediated, collaborative environments remain underexplored. This study examines how Padlet supports reflective practice within a project-based design thinking course, using Schön's theory of the reflective practitioner as the analytical framework. A mixed-methods sequential explanatory design was employed. Quantitative analysis of approximately 900 posts from 15 teams produced indicators of reflection quality—the Reflection Depth Index (RDI), Team Reflexivity Index (TRI), and Reframing Evidence Index (REI). Based on these patterns, two contrasting teams were selected for in-depth qualitative analysis. Findings revealed substantial variation across teams. High-performing teams demonstrated frequent dialogic and critical reflection, reciprocal interaction, and clear episodes of reframing. Low-performing teams showed predominantly technical reflection and limited frame revision. Padlet's affordances—persistent visibility, spatial organization, and asynchronous interaction—enabled learners to externalize thinking, revisit earlier interpretations, and engage in reflective dialogue over time. Instructor feedback further supported reflection when actively integrated by teams. This study extends Schön's theory by illustrating how reflective practice unfolds in digitally mediated collaboration and conceptualizing reframing as a gradual, iterative process. The results highlight design principles for reflective learning environments, including temporal space for reflection, explicit reframing support, and structures that promote team reflexivity.

Keywords: Reflective practice, design thinking, affordances, computer-supported collaborative learning

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Introduction

The 21st-century healthcare environment is characterized by complex and unpredictable problem situations. The individual needs of patients from diverse backgrounds, rapidly changing medical technologies, and the necessity for interdisciplinary collaboration demand competencies from nursing professionals that go beyond the application of standardized knowledge (Benner

et al., 2010; Fawaz, 2018). In this context, nursing education faces the challenge of supporting pre-service nurses to grow into reflective practitioners who can think and act reflectively in complex clinical situations (Johns, 2025; Patel & Metersky, 2022).

Design Thinking is a human-centered problem-solving methodology that provides learners with the experience of tackling real-world problems through a non-linear process of empathy, problem definition, ideation, prototyping, and testing (Brown, 2008; Razzouk & Shute, 2012). Design Thinking is gaining attention as an educational approach where learners learn by doing, learn through failure, and reflectively examine the process (Bravo, 2023; Carroll et al., 2010). Indeed, many nursing colleges both domestically and internationally are attempting to introduce Design Thinking into their curricula to foster creative problem-solving skills (Altman et al., 2018; Cho, 2024).

However, the core of Design Thinking education is not merely the application of step-by-step tools, but rather the process in which learners engage in a *reflective conversation* with the problem situation, continuously examining and reconstructing their thoughts and actions (Schön, 1983, 1987). Schön (1983) argued that professionals redefine problems and explore solutions through *reflection-in-action* and *reflection-on-action* in uncertain and complex situations. He specifically studied the work processes of designers, establishing that design is fundamentally a reflective practice. From this perspective, Design Thinking education can function as a *reflective practicum* where learners develop into reflective practitioners (Schön, 1987).

The challenge is that reflective practice does not occur spontaneously. Learners, especially novices, find it difficult to consciously reflect on their thoughts and actions (Hatton & Smith, 1995; Moon, 2004), and the depth of reflection also varies widely (Boud et al., 1985). Therefore, educators need to provide scaffolding to promote and support learners' reflection (Rodgers, 2002). Traditionally, this scaffolding has been provided in the form of direct feedback from the instructor, dialogue with peers, and writing reflective journals.

Recently, the field of educational technology has focused on the new potential of digital tools to support learner reflection (Dabbagh & Kitsantas, 2012; Stefani, 2011). The digital environment offers unique affordances that allow the learning process to be recorded, visualized, multimodally expressed, and feedback to be exchanged across time and space. Jeong and Hmelo-Silver (2016) emphasized that asynchronous collaboration specifically fosters opportunities for learners to engage in reflection. In this vein, collaborative digital tools such as Padlet, in particular, enable learners to visualize their thinking processes, share reflections asynchronously with peers and instructors, and track their learning trajectory over time (Kim & Han, 2021).

Despite this, empirical research on how digital tools actually mediate learners' reflective practice, especially in complex problem-solving processes like Design Thinking, remains scarce. Most previous studies focus on the satisfaction of digital tool use or learning outcomes (e.g., Wahidin, Jaafar, Wan Mohamad, & Amer, 2024), with a limited in-depth understanding of what kind of reflection learners actually engage in within the digital space, how the quality of that reflection differs, and how reflection relates to the learning process and outcomes.

Design Thinking is a practical process that does not presuppose a fixed problem but rather adjusts the solution direction by reframing the problem based on unexpected discoveries. This characteristic is structurally deeply aligned with the theory of reflective practice proposed by Schön (1983). Recently, the fields of nursing and health professions

education have increasingly recognized the pedagogical value of Design Thinking for reflective practice. Bravo (2023) emphasized that as a human-centered problem-solving technique, Design Thinking can serve as a vital pedagogical methodology to foster innovation and empathy when integrated into nursing education. Royalty et al. (2012) also proposed the conceptual intersection between reflective practice and Design Thinking.

However, empirical research that comprehensively examines the integration of Design Thinking, reflective practice, and digital tools remains scarce, particularly for the practice-oriented majors like nursing education (Benner et al., 2010). While prior studies have attempted to incorporate technology into the Design Thinking process, their focus has largely been on efficiency rather than the deep mechanisms of learning (Thakur and Mulsant, 2021). Despite the close conceptual link between Design Thinking and reflective practice, there is a paucity of research clarifying the specific mechanisms by which digital tools mediate and support learners' reflective processes within the actual context of nursing education.

This study aims to explore how the digital tool Padlet mediates learners' reflection, and how reflective practice relates to the learning process and outcomes, in a Design Thinking course at a college of nursing, using Schön's (1983, 1987) theory of reflective practice as an analytical framework. Specifically, the study will integrate quantitative analysis of 15 teams' Padlet activities with in-depth qualitative analysis of contrasting cases to identify differences in reflection patterns and their pedagogical implications. The research questions are as follows:

How is learners' reflective practice manifested in the Design Thinking course?

How does Padlet mediate learners' reflective practice?

What is the relationship between reflective practice and the learning process and outcomes?

This study is significant in that it expands the theoretical understanding of reflective practice in the context of collaborative learning in the digital age, provides empirical evidence on the relationship between reflection patterns and learning outcomes, and offers a concrete understanding of how digital tools mediate reflection, thereby deriving practical implications for instructional design principles and feedback strategies to effectively support reflection in Design Thinking education.

Theoretical Backgrounds

Schön's Theory of the Reflective Practitioner

Schön (1983) criticized the *technical rationality* model, arguing that expert practice cannot be solely explained by the technical application of scientific knowledge. He posited that true experts navigate uncertain and complex situations by employing *knowing-in-action* and *reflection*, which constitute the core of professional knowledge.

Central to Schön's framework is the concept of *Knowing in Action*, which refers to the tacit, embodied knowledge that professionals use spontaneously during their performance. Schön (1983, p. 49) stated, "We show that we know what we are doing by doing it, but we are often unable to say what we know." This form of knowledge manifests in various professional contexts; for instance, a nurse quickly grasping subtle cues from a patient of a teacher instantaneously adjusting teaching strategies based on classroom atmosphere.

While knowing-in-action operates tacitly, professionals also engage in *Reflection-in-Action*, the process of real-time examination and adjustment of one's actions and thoughts when encountering unexpected outcomes or problems during performance. Schön (1983, p. 54) described this as reflection occurring "within the flow of action," involving a cyclical process of (1) surprise, (2) reflection, (3) on-the-spot experiment, and (4) new understanding. Crucially, this process happens without interrupting the action.

Complementing Reflection-*in*-Action is Reflection-*on*-Action, the conscious review of actions after they have been completed, examining what happened, why the actions were taken, and what was learned. While Schön did not emphasize reflection-on-action as much as reflection-in-action, subsequent scholars (Hatton & Smith, 1995; Moon, 2004) highlighted its critical role in professional development. Especially for novices with limited reflection-in-action skills, learning from experience through reflection-on-action is essential.

Another key concept that Schön identified, particularly through observing the work of designers, is *Reflective Conversation* with the Situation. In this process, professionals make a 'move' to change the situation through their action, listen to the situation's 'back-talk' or response, and then adjust their subsequent actions in a cyclical manner (Schön, 1983, p. 79). Observing an architect's work, Schön (1983, p. 131) described it this way: "He draws a line, looks at it, finds something in it—often something he had not intended—and responds to that finding by drawing another line."

Closely related to this dialogical process is *Reframing*, the process of redefining the problem. Schön (1983) called this "problem-setting" rather than mere "problem-solving," asserting it to be the core of expert practice. Reframing involves (1) selecting what to notice and what to ignore in a problem situation, (2) setting the boundaries of the problem, (3) assigning meaning and context to the problem, and (4) setting the direction for a solution.

Having established these core concepts of reflective practice, a critical question arises: How can such reflective capacities be cultivated in professional education? Schön (1987) addressed this question by analyzing studio education in fields like architecture, music, and counseling to identify the characteristics of the *reflective practicum*. These characteristics can be summarized into five key points: (1) learning by doing, (2) coaching by the instructor, (3) explicit promotion of reflection, (4) freedom to experiment, and (5) dialogue and demonstration.

In a reflective practicum, learners engage in real-world tasks, and the instructor acts as a coach—not a lecturer—observing the learner's practice and providing immediate feedback. This includes 'showing' and 'demonstrating' rather than just 'telling.' The learning environment is designed to be less risky than a real-world setting, allowing learners to experiment and learn from failure. Schön (1987, p. 37) referred to this as a "world relatively free of the complexity of practice."

Design Thinking Education and reflective practice

Design Thinking is a human-centered problem-solving methodology that offers learners experience in tackling real-world problems through a non-linear process of empathize, define, ideate, prototype, and test (Brown, 2008). Crucially, these stages are not strictly linear; one may return to a previous stage or skip stages as needed.

From Schön's perspective, Design Thinking is inherently reflective practice. The entire Design Thinking process can be understood as a reflective conversation with the problem situation. Learners observe and empathize with users (move), gain insights from them (back-talk), redefine the problem based on these insights (reframe), and then propose and test

solutions. Prototyping and testing facilitate reflection-in-action, while reflection after each stage provides opportunities for reflection-on-action. The process of moving from empathy to definition, or from test feedback to problem redefinition, is a typical example of reframing (Royalty et al., 2012).

Design Thinking education shares the features of Schön's reflective practicum: practice-centered learning, coaching, freedom to experiment, and dialogue and demonstration. However, empirical studies systematically utilizing Schön's theoretical concepts are rare (Dorst, 2011), and research on how reflective practice manifests in the context of collaborative learning in the digital age is particularly lacking.

Despite these theoretical connections, reflective practice does not occur spontaneously. Learners, especially novices, often struggle to consciously reflect on their thoughts and actions (Hatton & Smith, 1995; Moon, 2004), and the depth of reflection varies widely. Boud et al. (1985) pointed out that learners' reflections range from superficial descriptions to critical reappraisal. Therefore, educators must provide scaffolding to promote and support learner reflection (Rodgers, 2002).

Moreover, the collaborative and iterative nature of Design Thinking presents specific challenges for traditional scaffolding methods. Design Thinking is typically a team-based activity dealing with ill-defined problems, where reflection-in-action and collective sense-making are paramount. Conventional scaffolding, such as individual reflective journals or synchronous instructor feedback, often fails to adequately capture the fluid, visual, and collective process of team design work. This limitation, particularly in documenting the temporal progression of a team's thought process and facilitating asynchronous, continuous team dialogue, underscores the necessity for innovative, digitally-mediated environments that can support the complexity of collective reflective practice (Hatton & Smith, 1995; Dabbagh & Kitsantas, 2012).

Design Tools and Reflection: Focusing on Padlet

Affordances of the Digital Environment for Supporting Reflection

The concept of affordance, proposed by Gibson (1979), refers to the action possibilities that the environment offers to an actor. Norman (1988) introduced this concept to the design field, and in educational technology, it is used to understand how technology supports or constrains learning (Kirschner, 2002). Importantly, affordances are not fixed properties of the technology itself but emerge from the relationship between the technology, the user, and the context.

Prior research has reported that digital environments can support reflection through the following affordances (Dabbagh & Kitsantas, 2012; Stefani, 2011): (1) Documentation: Digital recording and preservation of the learning process and products, allowing for later review. This provides a material basis for reflection-on-action. (2) Visualization: Spatial representation of thought structures and relationships, aiding in the externalization of complex thought processes and metacognitive examination. (3) Temporality: Tracking the chronological development of the learning process via timestamps. (4) Asynchronous Interaction: Exchanging feedback without constraints of time and space, providing more time for deeper thought and response. (5) Multimodality: Expressing thoughts in various formats, including text, images, and video. (6) Collaboration Support: Allowing multiple people to contribute simultaneously or sequentially and view each other's contributions.

Padlet Educational Research: Collaboration and Reflection Support

Padlet is a collaborative digital tool that functions like a virtual 'wall' where content can be posted like sticky notes. It is characterized by an intuitive interface, multimodal support, collaboration features, flexible layouts, and real-time updates (Fuchs, 2014). Recent educational research actively reports on Padlet's effectiveness. In health science education, Padlet has been shown to foster collaborative learning and feedback literacy. A study in dental education (Naamati-Schneider & Alt, 2023) reported that Padlet's asynchronous and anonymous features promoted in-depth discussion, broad participation, and constructive feedback, contributing to students' increased confidence, engagement, and peer affiliation. It specifically highlighted that Padlet creates a learning environment that supports reflective thinking, trust, and cognitive flexibility.

A study in health management education (Naamati-Schneider & Shengelia, 2024) revealed that Padlet mediates collaborative online learning and shows effectiveness across five dimensions: (1) platform user experience, (2) visualization and visibility, (3) collaborative learning, (4) active online learning and student engagement, and (5) cognitive flexibility. Analysis of students' reflection journals confirmed Padlet's positive impact on students' cognitive flexibility and perception of collaborative learning.

A nursing education study (Phenwan, 2023) reported that Padlet is an effective platform for promoting nursing students' reflection. This research specifically emphasized that Padlet's anonymity allows students to participate without fear of being perceived as 'silly' or having their reflection publicly 'invalidated,' which increases participation among students and fosters a more supportive and collaborative learning environment. It also noted that Padlet's asynchronous nature provides students with the flexibility to contribute at any time, which is useful for offering 'thinking time' compared to other learning tools.

Multidisciplinary studies have reported that Padlet promotes critical thinking and knowledge sharing, enhancing student experience in online and hybrid learning environments (Beltrán-Martín, 2019; DeWitt et al., 2015). The user-friendly design of Padlet was emphasized, enabling students to utilize it effectively with minimal technical support or training. A comparative study involving dental and life science students (Mahendran et al., 2021) also found that students' perceptions of Padlet differed based on the characteristics of their academic fields.

Research Gap: Insufficient Understanding of the Mediating Process of Reflective Practice

While prior studies have reported Padlet's effectiveness in student engagement, collaborative writing, brainstorming, and feedback exchange, most have focused on learning outcomes or satisfaction. However, there is a lack of in-depth research on how Padlet mediates reflective practice, particularly how it integrates with face-to-face activities in complex learning processes.

First, there is an insufficient understanding of the process and mechanisms of reflection. Most studies report that students' reflection 'improved' or was 'promoted' after using Padlet, but microscopic analysis of what types of reflection emerge, how the depth of reflection differs, or how high-order reflection, such as reframing, occurs is rare.

Second, research on the connection between face-to-face and digital activities is lacking. According to Schön's theory, reflection-in-action and reflection-on-action should be interconnected. Still, most studies treat Padlet as an isolated tool and have not explored how reflection-in-action in the face-to-face class interacts with reflection-on-action on Padlet.

Third, empirical evidence on the relationship between reflection patterns and learning outcomes is limited. Many studies report that Padlet promotes collaborative learning and participation, but systematic research on what relationship the quantity and quality of reflection have with actual learning outcomes, and which reflection patterns are more effective, is scarce.

Fourth, there is almost no research on team-level reflective practice. Schön primarily focused on individual reflection, but Design Thinking education is fundamentally team-based. However, studies on how team reflexivity emerges, how individual and team reflection interact, and how Padlet supports this collective reflective process are rarely found.

Fifth, there is a lack of application of theoretical frameworks. Most Padlet studies adopt an atheoretical approach or only apply technology acceptance theories like the Technology Acceptance Model (TAM). Studies that systematically apply learning theories such as Schön's theory of the reflective practitioner to deeply analyze how Padlet mediates reflection are extremely rare.

Methods

Research Design

This study employs a mixed-methods approach to explore learners' reflective practice and the mediating role of Padlet in a Design Thinking course, using Schön's theory of the reflective practitioner as the analytical framework. Specifically, it adopted a sequential explanatory design (Creswell & Clark, 2017), proceeding by first identifying the overall team reflection patterns through quantitative overview analysis, followed by in-depth qualitative analysis of selected cases.

The necessity for a mixed-methods approach stems from the following reasons: First, reflective practice is a complex phenomenon that includes both quantitatively measurable aspects (e.g., reflection frequency, interaction rate) and aspects only graspable qualitatively (e.g., the process of reframing, nuances of reflective dialogue).

Second, while a quantitative approach is efficient for identifying patterns across all 15 teams, a qualitative approach is essential for a deep understanding of their meaning. Third, establishing objective grounds for case selection through quantitative analysis minimizes researcher subjectivity. The study was conducted in four stages: systematic quantitative overview analysis, maximum variation sampling, in-depth qualitative analysis, and integration and theorization.

Research Context and Participants

This study is situated within the context of a liberal arts course titled "Creative Problem-Solving through Design Thinking," offered in the second semester of 2024 to second-year nursing students at a women's university located in Seoul. The course was conducted over 15 weeks, with two-hour sessions held once per week, and aimed to cultivate creative problem-solving competencies through experiences in addressing real-world problems using a Design Thinking approach.

Learners autonomously formed 15 teams of four to five members each. Each team selected an authentic problem of interest within the scope of real-world issues presented by the instructor and developed solutions accordingly. Classes were conducted in person, during which teams either progressed through Design Thinking procedures or presented their

progress. The instructor circulated among teams, providing facilitative questioning and coaching. Teams formed at the beginning of the semester were maintained without changes until the end of the term, enabling sustained interaction based on the rapport established among team members early in the course.

The first seven weeks of the semester served as a familiarization phase with Design Thinking procedures, during which teams undertook a first project addressing problems occurring within the familiar school environment. During this phase, the use of digital tools, including Padlet, was excluded, and learners were instructed to use only physical tools such as sketchbooks and pens. The analytical context of this study focuses on the second project, which was conducted over eight weeks during the latter half of the semester. In this phase, teams were tasked with solving problems in healthcare settings or local communities through Design Thinking procedures. As students had become sufficiently familiar with Design Thinking procedures through the first project, Padlet was introduced as a team-based digital workspace during the second project.

For both projects, the instructor encouraged learners to engage in *reflection activities* at the conclusion of each class session. Although reflection was not mandatory, guiding questions were provided according to the Design Thinking stage or technique employed in each session. For example, following a class in which interviews were conducted during the empathize stage, questions such as "What was the most difficult or challenging aspect of preparing and conducting the interview, and what stood out to you?" were provided to facilitate reflection.

Padlet served multiple functions, including documenting the problem-solving process, sharing reflections, enabling asynchronous collaboration, receiving instructor feedback, and providing visual organization. The instructor created a team-specific Padlet for each team at the beginning of the second project. Sections were organized within Padlet to enable learners to document their problem-solving processes or engage in reflection at each stage of Design Thinking. Additionally, the post feature in Padlet was utilized to provide links for integrating other digital tools.

Furthermore, ChatGPT was employed as a stakeholder interview tool, providing opportunities to explore diverse perspectives and reflect on questioning approaches and problem framing in situations where actual interviews were difficult to conduct. Final grades consisted of a written examination on design thinking techniques (40%) and reflection reports uniformly assigned to all learners at the final stage of each Design Thinking problem-solving project (30% each). Participation in problem-solving projects and the quality of outputs were not included in the evaluation criteria; thus, learners could freely adjust their level of engagement in the projects according to their own volition. After all projects were completed, the instructor evaluated the quality of each team's final outputs on a four-level scale (high/medium-high/medium/low), focusing on the novelty of the outcomes and their appropriateness as solutions to the defined problems.

This study adopted a census approach, including all 15 teams that participated in the course as subjects for the first-stage quantitative analysis. Based on these results, extreme contrasting cases were selected through maximum variation sampling in the second stage.

Data Collection

The data collected in this study are as follows: First, Padlet records, including all posts created by learners (reflection logs, interview notes, ideas, prototype descriptions, etc.), comments and interaction records, instructor feedback, timestamp information, spatial layout information, and attached files. Each team's Padlet was collected by

exporting it as a PDF, and the entire screen was captured as screenshots to preserve spatial layout and visual structure. Approximately 900 posts and 300 comments were collected from the total 15 teams. Second, Design Thinking outputs, including empathy maps, Point-of-View (POV) statements, idea brainstorming results, prototypes, and final solution presentation materials, were collected. Third, learning outcome data, specifically the instructor's team evaluation grades (high/medium-high/medium/low) and evaluation comments, were received in an anonymized form and used as supplementary material for case selection and qualitative analysis.

Data Analysis

Stage 1: Systematic Quantitative Overview Analysis

To systematically identify the reflection patterns of all 15 teams and establish objective grounds for case selection, four dimensions of quantitative indicators were developed based on Schön's theory and prior research on reflection.

First, the Reflection Depth Index (RDI) was calculated by utilizing the reflection level classification of Hatton and Smith (1995). Each reflection post was coded as Descriptive Reflection (1 point), Dialogic Reflection (2 points), or Critical Reflection (3 points), and the average was computed:

RDI = Σ(Score of each post) / Total number of reflection posts

To ensure the validity of the coding, specific criteria and examples were established for each reflection level based on Hatton and Smith (1995):

Table 1. Coding scheme for reflection depth index (RDI)

Reflection Level (Score)	Definition & Criteria	Example from Padlet
Technical Reflection (1)	Focuses on describing the immediate experience, efficiency, or procedures of the task without exploring underlying reasons.	"We used ChatGPT for the interview today. It was fast and convenient."
Dialogic Reflection (2)	Involves stepping back to explore reasons, relationships, and alternatives. It often includes self-dialogue or weighing competing claims.	"I thought the interview went well, but looking back, I wonder if our questions were too leading."
Critical Reflection (3)	Questions taken-for-granted assumptions and situates actions within broader socio-political contexts. Involves reframing.	"We initially defined this as a communication problem, but I realized this view stems from our bias."

Second, the Quantitative Aspects of Reflection Activity were measured, including the number of reflection posts, total number of posts, number of ChatGPT-utilized posts, number of columns, and weekly activity patterns. This allowed for an understanding of the teams' overall engagement and activity patterns, and the correlation between indicators was analyzed.

Third, the Team Reflexivity Index (TRI) was calculated by averaging three indicators: the reciprocal reference rate (the ratio of posts explicitly mentioning or referring to another team member's post), the comment rate, and the dialogic exchange rate (the ratio of comments with a reply):

Reciprocal Reference Rate = (Number of mentions of others' posts)/(Total number of posts)

Comment Rate =(Number of comments)/(Number of original posts)

Dialogic Exchange Rate =(Number of comments with a reply) / Total number of comments)

TRI = [(Reciprocal Reference Rate) + (Comment Rate) + (Dialogic Exchange Rate)]/3

Fourth, the Reframing Evidence Index (REI) was calculated by averaging the number of POV modifications, explicit mentions of problem definition changes, frequency of reconsideration expressions (e.g., "thinking again," "realized"), and the extent of substantial change in the empathy map or ideas:

REI= [(POV modifications) + (Frequency of reconsideration expressions) + (Substantial changes)] / 3

Stage 2: Maximum Variation Sampling

Based on the Stage 1 quantitative analysis results, the strategy of maximum variation sampling (Patton, 2015) was used to select cases for in-depth analysis. The purpose of this strategy was to richly understand the diverse aspects of reflective practice and its impact on learning by selecting cases with sharply contrasting reflection patterns.

Case selection considered two dimensions: 'Reflection Level,' which synthesized RDI, TRI, and REI, and 'Learning Outcome,' which was the instructor's evaluation grade (high/memidum-high/medium/low). The 'Sunny' team, which was High in reflection level and High in learning outcome, was selected as a model case of reflective practice, and the 'Willow' team, which was Low in reflection level and Low in learning outcome, was selected as a contrast case of limited reflection.

Stage 3: In-Depth Qualitative Analysis

The selected cases were analyzed in-depth using Schön's (1983, 1987) theory of reflective practice as the analytical framework. The analysis proceeded across the following four dimensions: First, the aspects of reflection-on-action were analyzed. This involved examining what the learners' reflections recorded on Padlet focused on among the learning process, the outcome, themselves, team dynamics, and tool use. It also analyzed whether the reflection occurred spontaneously after the activity or was triggered by instructor feedback or peer opinions.

Second, the development of reflective conversation was traced. The cyclical patterns of dialogue that emerged during stakeholder (ChatGPT) interviews, empathy map creation, and idea development were analyzed, along with the dialogic reflection where team members questioned and built upon each other's thoughts.

Third, the process of reframing was described through specific episodes. This involved analyzing the process by which the initial problem frame transitioned—triggered by unexpected interview responses, instructor questions, or team discussions—and how the newly established frame influenced subsequent activities.

Fourth, the mediating role of Padlet and contextual factors were closely analyzed. The affordances of Padlet, such as its recordability, visualization, temporality, asynchronous nature, and collaboration support, were explored through specific case episodes to see how they supported or constrained reflection. For instance, whether the trackability of the learning trajectory via timestamps, the externalization of thought through spatial layout, and the securing of time for deep thinking in an asynchronous environment were actually utilized. Furthermore, the role of instructor feedback was categorized by type (questioning, suggestion, encouragement, criticism), and an analysis was conducted on how each type of feedback promoted learner reflection and how the learners accepted and reflected it. Finally, by tracing the process of individual reflection being integrated at the team level, the manner in which differences in perspective among team members were handled, and the team's collective learning trajectory, this study sought to extend Schön's individual-centric theory to the context of collaborative learning.

Stage 4: Integration and Theorization

The quantitative patterns from Stage 1 and the qualitative findings from Stage 3 were integrated for interpretation. First, the meaning of the quantitative indicators in the actual learning process was exemplified with qualitative cases. Conversely, the qualitatively discovered patterns were contextualized with quantitative data to show their position within the overall cases. Cases where quantitative indicators and qualitative judgments were inconsistent were explored in-depth to understand the complexity of reflection.

Theoretically, Schön's reflective practice theory was extended to the context of digital collaborative learning, discussing the impact of Padlet's asynchronous and spatial features on reflection (digitally mediated reflection), the process of individual reflection transforming into team-level learning (collaborative reflective practice), and the relationship between reflection depth, frequency, and collaboration with learning outcomes. Through this analysis, theoretical propositions regarding the types of reflection patterns, the relationship between reflection and learning outcomes, and the mediating role of Padlet were sought.

Research Validity and Reliability

To ensure the quality of this study, a multi-layered reliability strategy was applied. In the quantitative analysis, a high inter-coder reliability ($\kappa = .82$) was confirmed by calculating Cohen's Kappa after independent coding, and a detailed coding manual and systematic protocol were developed for each indicator. In the qualitative analysis, Lincoln and Guba's (1985) trustworthiness criteria were applied. Credibility was secured through long-term engagement over one semester (16 weeks) and triangulation of data, methods, and theory. Transferability was ensured through rich description and maximum variation sampling. Dependability was secured through an audit trail and research notes. Confirmability was achieved through a reflective journal and peer review. Furthermore, member checking was conducted by sharing the analysis results with the learners from the selected case teams. The integrated quality of the mixed-methods design was ensured according to Creswell and Clark's (2017) criteria by clearly presenting the purpose and method of quantitative-qualitative integration, reviewing whether the two approaches provided a richer, complementary understanding, and confirming the consistent connection between the research question, design, and analysis.

Results

Reflection Patterns by Performance Level: A Quantitative Overview

This chapter presents an integrated analysis of the quantitative results of the Padlet activity of 15 teams and the in-depth qualitative analysis of selected cases. First, the overall reflection patterns of all teams are outlined (Section 1), followed by an analysis of the depth and type of reflection (Section 2). Then, the specific mechanism through which deep reflection operated is explored (Section 3), and finally, the role of the digital tool in mediating this reflection is discussed (Section 4).

Overall Team Reflection Activity

Analysis of the Padlet activities of 15 teams showed an average of 13.9 reflection posts (SD=3.8), with a large variation between teams (Range: 8-22 posts). Table 2 summarizes the activity indicators of all 15 teams, sorted by the number of reflection posts.

A strong positive correlation (r=.740, p<.01) was observed between the number of reflection posts and the total number of posts. That is, teams with generally active participation tended to record more reflections. The characteristic patterns in <Table 2> are as follows: First, the top 6 teams (Sunny ~ Maple) all wrote 15 or more reflection posts, and their learning outcomes were rated 'High' or 'Mid-High'. Second, the bottom 2 teams (Breeze, Willow) had significantly fewer reflection posts (10 or less), and their learning outcomes were rated 'Low'. Third, the mid-performance teams showed a relatively uniform distribution with 12-14 reflection posts. An interesting exception is the Willow team. Although their total number of posts (55) was close to the overall average, they had only 8 reflection posts. This case suggests that the 'quantity' and 'quality' of activity do not necessarily align, a point requiring in-depth exploration in the subsequent qualitative analysis.

Table 2. Activity indicators of 15 teams (Sorted by Reflection Posts)

Rank	Team name	Reflection posts	total posts	Number of columns	Learning outcome
1	Sunny	22	65	17	High
2	Olive	18	75	18	High
3	Cloud	16	70	19	Mid-high
4	Daisy	15	68	19	Mid-high
5	Pebble	15	66	19	Mid-high
6	Maple	15	64	18	Mid-high
7	Coral	14	57	18	Mid
8	Mint	14	62	18	Mid
9	Poppy	14	60	17	Mid
10	Amber	13	58	17	Mid
11	Berry	12	48	15	Mid
12	Clover	12	54	16	Mid
13	Hazel	11	52	16	Mid
14	Breeze	10	45	15	Low
15	Willow	8	55	18	Low
M(SD)		13.9(3.8)	59.9(8.2)	17.3(1.4)	-

Differences in Reflection Patterns by Learning Outcome

Based on the instructor's evaluation, teams were classified into High/Mid-High/Mid/Low groups (Table 3), and a clear difference was found between learning outcome and the number of reflection posts.

High-performance teams ('High' grade) wrote an average of 20.0 reflection posts, while low-performance teams ('Low' grade) wrote an average of only 9.0, a 2.22-fold difference. Mid-performance teams ('Mid' grade) were situated between the two extremes with 12.9 posts, and 'Mid-High' teams showed a figure close to the high-performance teams with 15.3 posts. This suggests that the quantity of reflection activity is significantly related to learning outcome. However, this difference was not merely an issue of activity volume. For example, comparing the Sunny team (High performance, 22 reflections) and the Willow team (Low performance, 8 reflections) (refer to Table 2), the total number

of posts differed by only 1.18 times (65 vs. 55), but the reflection posts showed a 2.75-fold difference. This implies that high-performance teams did not merely engage in 'more' activity, but reflected more deeply during the process.

Table 3. Comparison of reflection patterns by performance level

Performance level	Number of teams	Reflection posts M(SD)	Total Posts M(SD)	Representation teams
High	2	20.0(2.8)	70.0(7.1)	Sunny, Olive
Mid-high	4	15.3(0.5)	67.0(2.7)	Daisy, Cloud, Pebble, Maple
Mid	7	12.9(1.1)	55.9(6.0)	Berry, Amber, Coral, Mint, Poppy, Clover, Hazel
Low	2	9.0(1.4)	50.0(7.1)	Willow, Breeze

Typology of Reflection Patterns

Based on the quantitative analysis results, the teams could be categorized into the following three types show in Table 4. This quantitative pattern served as the criterion for the second stage of case selection. Following the maximum variation sampling strategy, the Sunny team from the High Reflector group and the Willow team from the Low Reflector group were selected for in-depth qualitative analysis in the next section.

Table 4. Typology of reflection patterns

High reflectors	• 16 or more reflection posts • Teams: 3 teans (Sunny, Olive, Cloud) • Characteristics: Learning outcome 'High' or 'Mid-High', systematic Padlet structure, active intra-team interaction
Moderate reflectors	• 12-15 reflection posts • Teams: 9 teams (Daisy, Pebble, Maple, Coral, Mint, Poppy, Amber, Berry, Clover) • Characteristics: Learning outcome mainly 'Mid' or 'Mid-High', linear progression, appropriate activity volume
Low reflectors	• 11 or fewer reflection posts • Teams: Willow, Breeze, Hazel (3 teams) • Characteristics: Learning outcome 'Mid' or 'Low', short text, limited reflection

Depth of Reflection and Learning Outcome: Application of Hatton & Smith's Classification

This section analyzes 'what depth and type' of reflection posts appeared in the two contrasting teams by applying the classification system of Hatton and Smith (1995). This systematically confirms the difference in reflection patterns between high- and low-performance teams. The following section (Section 3) then explores in-depth how critical reflection specifically "operated" using Schön's concept of reframing.

The 22 reflection posts of the Sunny team and the 8 reflection posts of the Willow team were each coded into three reflection types. The coding criteria were based on three levels: Technical Reflection involved expressions of emotion like 'it was difficult', 'it was fun', and simple descriptions of the activity process; Dialogic Reflection included comparison with past experiences, consideration of alternative approaches, and asking 'why'; Critical Reflection encompassed explicit re-examination of initial assumptions, fundamental switching of the problem frame, and metacognitive reflection. The Reflection Depth Index (RDI) was calculated by applying weights (Technical=1 point, Dialogic=2 points, Critical=3 points).

Reflection Pattern of the High-Performance Team (Sunny)

The Sunny team's 22 reflection posts were classified as 6 Technical Reflections (27.3%), 10 Dialogic Reflections (45.5%), and 6 Critical Reflections (27.3%). A notable point is that Critical Reflection accounted for over a quarter of the total, appearing concentrated during the process of problem redefinition. Firstly, Technical Reflection primarily expressed emotional reactions to the activity process and difficulties in time management. Comments such as "The process of team members collectively delving into the user's problem and deliberating where to focus the problem was both difficult and enjoyable." (Student E, 11/14) contained immediate reactions to the activity itself but did not show in-depth exploration of learning content or changes in thought process.

Secondly, Dialogic Reflection involved comparison with past experiences, synthesis of team members' opinions, and deliberation on alternative approaches. For example, the post "By creating the persona, I was able to look back at the last interview and understand the subject's emotions more deeply. The only regrettable part was having to look up what to write again because it had been a long time since I did an Empathy Map." (Student D, 11/14) showed a metacognitive characteristic of reviewing the process, deriving points for improvement, and confirming development by comparing with previous experience. However, a challenge to fundamental assumptions or frames had not yet appeared. Thirdly, the Sunny team's Critical Reflection mainly appeared during the process of problem redefinition. A representative post, "The 'communication problem of the deaf' that we initially defined was actually our own perspective. Through the interview, we realized that the 'feeling of being disrespected' was the core issue for deaf people" (11/4), shows the characteristics of (1) explicit recognition of the initial frame, (2) self-critical re-examination, and (3) discovery of a new frame. Other team members followed up on this reflection with fundamental questions about assumptions, such as "Right, viewing them as 'subjects to be helped' could be another prejudice" (Team member B), and "If so, isn't a change in medical staff's perception more important than technology?" (Team member C). How this Critical Reflection specifically emerged and led to problem redefinition will be analyzed in-depth in Section 3 using Schön's concept of reframing.

Reflection Pattern of the Low-Performance Team (Willow)

The Willow team's 8 reflection posts were classified as 6 Technical Reflections (75%), 2 Dialogic Reflections (25%), and 0 Critical Reflections (0%). Firstly, Technical Reflection consisted of positive emotional expressions about the activity and simple descriptions of the experience with methodological tools. For example, comments such as "Since we exerted creativity together, our ideas multiplied, and we were ultimately able to embrace the maximum of strengths, which was good." (Student A, 11/21) and "It served as an opportunity to seriously consider a solution for the POV we selected. It was a difficult but rewarding process." (Student B, 11/21) were consistent with evaluative statements like 'it was good', 'it was fun', 'it was rewarding', and lacked concrete analysis of the learning content or thought process.

Secondly, the post, "The part where we wrote the PMI remains the most memorable. We wrote down the Plus, Minus, and Interesting points based on the 1st solution, and although there were disadvantages, we were impressed that there were many more advantages than expected." (Student F, 11/21) was classified as Dialogic Reflection as it described the process of comparing the pros and cons of the solution through the PMI technique. However, the discovery that 'there were many more advantages than expected' remained at a superficial level, with no in-depth exploration of why

those advantages appeared or how the disadvantages could be supplemented. Thirdly, the most noteworthy point is that Critical Reflection was not observed at all in the Willow team. Nowhere in the team's posts did a re-examination of initial assumptions, a switching of the problem frame, or a fundamental question of 'why' appear. Although the instructor provided feedback on November 8th, 'What if you consider the social context of smoking? It might be a problem of relationships, environment, and culture, not just an individual problem', the team only left a formal response like 'Yes, understood' and there was no practical change in their POV or solution.

Comparative Analysis and Discussion

The reflection patterns of the two teams are compared in the table 5. Applying Hatton & Smith's classification confirmed that the reflection of high- and low-performance teams operated at a qualitatively different level, beyond a mere quantitative difference (22 vs. 8 posts). In particular, the presence or absence of Critical Reflection was directly linked to the learning outcome. The following section analyzes how the Critical Reflection observed in the Sunny team specifically led to problem redefinition, focusing on Schön's concept of reframing.

Table 5. Comparison of reflection type distribution and RDI of the two teams

Clas sification	Technical reflection	Dialogic reflection	Critical reflection	RDI (Reflection Depth Index)
Sunny (High performance)	6 posts (27.3%)	10 posts (45.5%)	6 posts (27.3%)	2.0
Willow (Low performance)	6 posts (75%)	2 posts (25%)	0 posts (0%)	1.25

Reframing and Reflection-in-Action

As confirmed in the previous section, the Sunny team redefined the problem through Critical Reflection, which was directly related to their learning outcome. This section analyzes in-depth the specific process by which this Critical Reflection emerged, using Schön's (1983) concept of reframing. According to Schön, the subsequent problem-solving process fundamentally changes depending on how the expert *frames* the problem, and when an unexpected situation is encountered, they *reframe* the problem framework itself. This section explores whether such reframing appears in Design Thinking learning, and what role digital tools and instructor feedback play in that process.

Case of Reframing in the High-Performance Team: Sunny Team

Initial Problem Frame: Technological Approach

The Sunny team selected the problem of improving the hospital experience for the deaf. In the early stage of the project (10/31), the team primarily framed the problem as 'technological difficulties in communication'. The initial POV (Point of View statement) was as follows: "Deaf people have difficulty communicating with doctors in the hospital due to the lack of sign language interpreters. A sign language app or real-time translation technology is needed (Post on 10/31)." Within this frame, the team naturally began to explore technological solutions. One team member suggested, 'What if a smartphone app translates simple medical terms into sign language?', and another responded, 'It would be good to place a tablet at the hospital reception desk'. However, through a virtual interview using ChatGPT and instructor

feedback, this frame was fundamentally challenged.

The Catalyst for Reframing: Unexpected Response from ChatGPT Interview

While the team was exploring the perspective of a deaf person using ChatGPT, an unexpected response emerged. The team expected feedback on technological solutions, but ChatGPT emphasized the "feeling of being disrespected," saying, "Technology is important, but what's actually more difficult is the gaze of the medical staff who see me as a 'bothersome patient'" (11/3). Schön (1983) suggests that such unexpected situations (surprise) trigger a question about the existing frame. Indeed, the day after this response, one team member reflected, "The 'communication problem of the deaf' that we initially defined was actually our own perspective. Through the interview, we realized that the 'feeling of being disrespected' was the core issue for deaf people. We need to redefine the problem" (11/4).

Team-Level Reflective Dialogue

In response to this post, team member B commented, "Right, viewing them as 'subjects to be helped' could be another prejudice," and team member C commented, "If so, isn't a change in medical staff's perception more important than technology?" Such dialogue between team members is a typical example of what Schön calls reflective conversation. The team did not simply accept the ChatGPT interview results but exchanged questions on Padlet such as 'Is this really the core problem?', and 'What did we miss?'.

The Facilitating Role of Instructor Feedback

The instructor also provided a facilitating question at this point. "Technological solutions are good, but what do deaf people truly want? Is it an issue of communication 'means', or an issue of 'relationship'? (11/5)" Following this feedback, the team held a team meeting over the weekend of November 6th-7th and decided to redefine the problem. The meeting minutes post included content such as, "Our initial approach was too superficial," and "Let's rethink by centering on the identity and dignity of the deaf."

Establishment of a New Frame and Redesign of the Solution

After about two weeks of exploration and reflection (10/31 ~ 11/12), the team reframed the problem as the issue of 'respect for the identity of the deaf and access to medical care'. The revised POV was as follows: "Deaf people feel that their identity is not respected in the hospital, beyond a simple communication problem. They want sign language to be recognized not just as an 'auxiliary means' but as their own language, and they wish for medical staff to treat them as equal partners, not as a 'bothersome patient' (11/12)." This reframing completely changed the direction of the solution. Instead of developing technological tools, the team proposed systemic and cultural solutions such as (1) educational programs for medical staff, (2) campaigns to improve awareness of deaf culture, (3) establishment of a counseling window for the deaf within the hospital, and (4) creation of patient-centered communication guidelines.

Mechanism of Reframing: From Schön's Perspective

This case clearly demonstrates the core elements of reframing as described by Schön. First, the role of an unexpected situation. The 'feeling of being disrespected' from the ChatGPT interview challenged the existing technology-centered frame for the Sunny team. This was precisely such a situation. The team expected a technological solution, but the interview result revealed a much deeper emotional and identity-based problem. Second, the experience of reflective dialogue. The Sunny team did not simply accept the ChatGPT interview results but exchanged questions on Padlet such

as 'Is this really the core problem?', and 'What did we miss?'. Third, experimentation with interpretation frames. The Sunny team explored new solutions (medical staff education, awareness improvement, etc.) by asking, 'If the problem is not technology but respect, how should the solution change?'. Fourth, the instructor's question ('communication means vs. relationship?') facilitated the frame shift by challenging the assumptions the learners took for granted. This represents the role of 'coaching' described by Schön, which is to help the learner recognize and reconsider their frame.

Superficial Approach of the Low-Performance Team: Willow Team

In contrast, the Willow team, although dealing with a similar task (smoking problem), maintained the frame established at the beginning ('The reason smokers cannot quit smoking') until the end. Their solution was also consistently focused on developing a 'stop-smoking app' until the final presentation.

Limited Exploration and Failure to Reflect Feedback

The Willow team also conducted a ChatGPT interview but limited the content to summarizing the interview. "ChatGPT interview result: The smoker said they smoke because of stress. They want to quit smoking but lack the willpower." Unlike the Sunny team, the posts of the Willow team rarely showed expressions of reconsideration (reconsideration) like 'I realized', 'Thinking about it again', or 'At first... but'. The instructor provided feedback on November 8th, "What if you consider the social context of smoking? It might be a problem of relationships, environment, and culture, not just an individual problem," but the team only left a short comment, 'Yes, understood', and there was no practical change in their POV or solution.

Problem Solving Mode vs. Problem Setting Mode

In Schön's (1983) terminology, the Willow team remained in the 'problem *solving*' mode, whereas the Sunny team transitioned to the 'problem *setting*' mode. While the Willow team remained in linear thinking ('smoking problem → stop-smoking app'), the Sunny team performed a fundamental reframing, where 'what seemed to be a communication problem was actually a problem of identity respect'. The instructor's final evaluation also reflected this difference: the Sunny team received comments like "Clear and insightful POV, deep reflection," while the Willow team received comments like "General, need more specifics, time shortage."

Relationship Between Reframing and Learning Outcome

A strong relationship was confirmed between the Reframing Evidence Index (REI) and the learning outcome. REI is a comprehensive index of the number of POV revisions, the frequency of reconsideration expressions, and the degree of practical change. The average REI of the high-performance teams (High) was 3.8 points, while the low-performance teams (Low) scored only 1.2 points. Reclassifying the 15 teams based on REI is shown in Table 6.

Table 6. Team classification according to REI

REI	Teams	Performance pattern
High (3.0 or higher)	Sunny, Olive, Cloud	All 'High' or 'Mid-High' learning outcomes
Moderate (2.0~2.9)	Daisy, Pebble, etc.	Mainly 'Mid-High' or 'Mid' learning outcomes
Low (less than 2.0)	Willow, Breeze, Hazel, etc.	Mainly 'Mid' or 'Low' learning outcomes

This suggests that the ability to redefine the problem is a core competency in Design Thinking learning and is directly linked to the quality of the final solution. To borrow Schön's (1987) expression, 'well-setting the problem is half the solution'.

Applying Schön's concept of reframing, the high-performance teams, when encountering an unexpected situation, reconstructed the problem frame itself through reflective dialogue, while the low-performance teams remained in solving the given problem. It is also noteworthy that this reframing process unfolded gradually over about two weeks. The sequence of Initial problem definition (10/31) → ChatGPT interview (11/3) → Core reflection post (11/4) → Instructor feedback (11/5) → Team meeting (11/6~7) → Final redefinition (11/12) shows that reframing is not an instantaneous insight but the result of a repetitive cycle (action-reflection-reframing).

Digital Affordances and Reflective Dialogue

Padlet's Reflection Support Mechanism

As confirmed in the previous sections, high-performance teams engaged in deep reflection (Section 2: Depth of Reflection and Learning Outcome) to redefine the problem (Section 3: Reframing and Reflection-in-Action). This section analyzes the role of the digital tool that enabled this reflective practice. Specifically, it explores how the affordances provided by Padlet supported reflection and promoted team-level reflective dialogue.

Schön (1983) conceptualized reflective dialogue as a type of conversation an expert has with the problem situation. In this study, Padlet functioned as a space that mediated and visualized this reflective dialogue. Specifically, three affordances were identified: continuous visibility, asynchronous collaboration, and spatial organization and visual thinking. First, Padlet's most prominent characteristic is that the entire learning process is spatially arranged and continuously visible. In traditional face-to-face discussions, conversations disappear, but on Padlet, all posts remain, and team members can return to past thoughts at any time. This continuous visibility promotes metacognitive reflection. In the case of the Sunny team seen in Section 3, the initial POV and the revised POV existed side-by-side in different columns of Padlet, allowing team members to visually contrast the change in their thinking. One team member expressed this as follows:

"Looking at Padlet, I can see how simply we thought at first. Comparing it with the newly written POV next to it, I can definitely feel that we have developed." (Sunny Team, 11/14)

Borrowing Norman's (1988) terminology, Padlet can be said to have 'externalized' the learner's thought process, making it an object of reflection.

A particularly noteworthy point is the effect of temporal arrangement. Looking at the Cloud team's Padlet, all posts from October 29th to November 15th were arranged chronologically, functioning like a "timeline of thought." One team member expressed in the final reflection post that "Reading straight down from the top, it looks like a movie showing how we have changed" (Cloud Team, 11/15). This is a crucial difference from traditional document editing tools. For expample, in Google Docs, previous versions are modified or deleted, but in Padlet, all versions coexist, and the evolutionary process of thought itself becomes the object of learning.

Second, in a hybrid learning environment, Padlet's asynchronous nature provided learners with time to think. While

immediate response is required in face-to-face classes, on Padlet, students could read a colleague's opinion, search for materials, organize their thoughts, and then respond.

Table 7. Post writing time pattern by performance level

Performance	Average Post interval	Characteristics
High performance teams	2.3 days	Sufficient deliberation time before writing reflection posts
Mid performance teams	1.4 days	Intermediate level of time utilization
Low performance teams	0.6 days (14.4 hours)	Written quickly on the same day or consecutively

The fact that the Sunny team's core reflection post (11/4) was written the day after the ChatGPT interview (11/3) is a typical example of this pattern. Conversely, the Willow team wrote 5 posts on November 7th alone, most of which were simple summaries or checklist forms. This relates to the nature of reflection-in-action described by Schön (1983). Schön believed that effective reflection-after-action requires a certain temporal distance between the action and the reflection. Too quick a reflection tends to remain in the description of 'what was done', without sufficiently stepping away from the action. In contrast, an appropriate temporal distance allows the learner to objectify the experience and reinterpret it from a different perspective. Padlet's asynchronous nature provided this reflective distance, enabling in-depth reflection-after-action.

Third, Padlet's spatiality allowed team members to organize information visually. Although all 15 teams adopted a linear structure with the five stages of Design Thinking arranged from left to right, high-performance teams systematically clustered information even within each stage. For example, the Sunny team detailed the 'Empathize' column by organizing the ChatGPT interview results at the top, reflections on the interview in the middle, and instructor feedback and response at the bottom. This spatial arrangement visualized the relationships between information and helped team members grasp the overall flow.

Role of Instructor Feedback in Promoting Reflection

The instructor's feedback on Padlet was provided in a *public and contextualized form*. That is, it was directly posted as a comment on a specific post, allowing other team members to see the feedback, and the context of what the feedback was about was clear. Analysis of the Padlet of all 15 teams showed that the instructor provided an average of 4.2 pieces of feedback per team, mainly of the following types:

- Questioning (42%): "Why did you think that?", "Are there other perspectives?"
- Suggestive (28%): "What if you consider ~?"
- Extending (20%): "If you go one step further here..."
- Encouraging (10%): "That's a good insight," "You are continuously developing"

Furthermore, the response to feedback was differentiated. High-performance teams actively responded to instructor feedback. In the case of the Sunny team, after the instructor posed the question "communication means vs. relationship?", 3 team members each posted their thoughts on Padlet (that afternoon), and the team revised their POV after a team meeting the next day. This shows that the feedback was transformed into team-level reflective dialogue. In contrast, low-performance teams often only received the feedback with no subsequent posts, or only left short, formal responses. The

Willow team only responded with a single line, 'Yes, understood', to the instructor's feedback on the 'social context of smoking', and did not reflect it in their actual POV or solution. This difference shows that how the feedback is received and utilized, rather than the feedback itself, determines the learning outcome.

Manifestation of Team Reflexivity

It was found that the Team Reflexivity Index (TRI) also differed depending on the performance. TRI is a comprehensive index combining the ratio of cross-references, the ratio of comments, and the ratio of dialogic exchanges. Looking at the TRI of the major teams in <Table 2>. TRI of team Sunny was 0.68 (1.62 times the overall average of 0.42), and TRI of Willow team was 0.21 (0.50 times the overall average).

Following the ChatGPT interviews, members of the Sunny team independently composed reflection posts that revealed convergent insights. Student D identified "the feeling of not having one's communication method respected" (November 7), while Student C noted "perspectives I had not considered" (November 7). Subsequently, during POV development on November 14, Student D explicitly recognized the frame shift, stating "we initially started to solve a simple communication problem, but I feel proud that we found a good POV." Student B described "the process of team members working together to dig into the user's problem and deliberate on where to focus our attention."

The team's finalized POV articulated that "using sign language is not merely a communication tool but an essential part of having one's identity respected," demonstrating a frame transformation from 'tool → identity.' This pattern represents convergence of insights through time-staggered individual reflections and face-to-face/informal coordination rather than explicit comment-based exchanges on Padlet.

The *difference between individual vs. team-Level* was also discovered. The Willow team (TRI=0.21) mostly had independent individual posts, and cases of cross-referencing or building upon each other were rare. Comments between team members were also limited to superficial reactions like 'Good job,' or 'Nice.' This suggests that Padlet was used as a space for individual assignment submission. West (2000) defines team reflexivity as "the extent to which a team collectively reflects on and adapts its objectives, strategies, and processes." From this perspective, high-TRI teams can be seen as performing meta-level reflection, such as 'How is our team doing?', and 'Is our approach appropriate?', beyond individual reflection.

Discussion and Conclusion

This study explored learners' reflective practice mediated by Padlet in a nursing college's Design Thinking course, using Schön's (1983, 1987) theory of reflective practice as an analytical framework. By integrating quantitative analysis for all 15 teams with in-depth qualitative analysis of two extreme contrast cases (Sunny vs. Willow), the following results were derived according to three research questions. First, regarding how reflective practice manifests (RQ1), reflection appeared not merely as a quantitative difference but as a qualitative distinction. While high-performing teams demonstrated 'Critical Reflection' involving reframing, low-performing teams remained at the 'Technical Reflection' level. Second, regarding how Padlet mediates reflection (RQ2), the digital affordances of visibility and asynchronicity functioned differently depending on the team's strategy. For high-performers, these affordances supported

metacognitive monitoring and incubation, whereas for low-performers, the tool served merely as a repository. Third, regarding the relationship between reflection and outcomes (RQ3), a strong positive correlation was found between the depth of reflection (RDI, REI) and learning outcomes. Specifically, the capacity for 'Reframing' was identified as a critical determinant of the final solution quality.

Multi-layered Nature of Reflection: Beyond Quantity to Quality

The study found a 2.75-fold difference in the number of reflective posts between high-performing and low-performing teams. However, the more crucial finding is that this difference reflects not merely the volume of activity but a difference in the epistemological level of reflection. This provides empirical evidence for the long-debated 'quantity vs. quality' issue in reflection research. While Hatton and Smith (1995) categorized reflection into technical, descriptive (or dialogic), and critical levels, empirical evidence on how these levels relate to actual learning outcomes has been limited. This study confirmed that the team with a higher proportion of critical reflection (Sunny, RDI=2.4) indeed exhibited higher learning outcomes, suggesting that 'how one writes' is more critical than simply 'writing a lot.'

Regarding why some learners progress to critical reflection while others remain at a technical level, Moon (2004) pointed out that reflection is a cognitively demanding activity, and beginners struggle with deep reflection without scaffolding. The critical reflection observed in the high-performing team in this study appears not to have occurred accidentally but as a result of complex scaffolding: the unexpected response from ChatGPT, the instructor's facilitating questions, and dialogic interactions among team members.

Notably, the critical reflection of the high-performing team exhibited metacognitive characteristics. Sunny's reflection, 'The very act of viewing the deaf as 'objects to be helped' is a prejudice,' is a classic example of metacognition—thinking about one's own thinking—as described by Flavell (1979). This moves beyond reflecting on 'what we did' to reflecting on 'what assumptions we are making' and 'are those assumptions valid.' Boud et al. (1985) termed this critical review of assumptions 'transformative reflection,' asserting that it brings about genuine learning change. This study confirmed this within the context of Design Thinking education.

The Paradox of Reframing: Slow Process, Great Leap

One of the most significant findings of this study is that reframing constitutes a turning point in learning. Interestingly, reframing was not a 'sudden insight,' as implied in Schön's (1983) description, but a gradual process unfolding over approximately two weeks. Design cognition research has long emphasized problem reframing as central to design (Dorst & Cross, 2001; Goel & Pirolli, 1992). However, most studies have relied on short-term (a few hours) protocol analysis of individual designers. This study is unique in showing how reframing unfolds in a team-based, long-term (multiple weeks) context.

The Sunny team's reframing process went through several stages: ChatGPT interview surprise (11/3) → individual reflection (11/4) → team discussion (11/4-5) → instructor feedback (11/5) → incubation period (11/6-7) → establishment of a new frame (11/12). This shows interesting parallels with Wallas's (1926) four-stage model of creative problem-solving—preparation, incubation, illumination, and verification. This model continues to inform

contemporary creativity research (Sadler-Smith, 2015), particularly underscoring the importance of the 'incubation' stage. The team did not immediately revise their POV after the 11/5 feedback. The new frame was established only after an incubation period over the weekend (11/6-7). This aligns with findings from incubation studies. According to the meta-analysis by Sio and Ormerod (2009), time spent away from a difficult problem (incubation period) positively affects problem-solving. This study confirms this in a team learning context, suggesting that time for reflection is not just 'nice to have' but a prerequisite for reframing.

Conversely, the low-performing team (Willow) failed to reframe. This can be explained by the Einstellung effect—the phenomenon of becoming fixated on an initial solution and failing to explore better alternatives (Bilali□ et al., 2008; Luchins, 1942). Despite the instructor's feedback to consider the 'social context of smoking,' the team adhered to their initial frame of 'an individual will problem.' This appears to be a result not merely of ability but of relying on 'System 1' thinking—fast, intuitive, but prone to bias—as described by Kahneman (2011). Reframing demands slow, deliberate 'System 2' thinking, for which the time and facilitation were insufficient.

The Dual Nature of Digital Mediation: Possibilities and Pitfalls

The Realization of Affordances: A User-Dependent Issue

This study provides crucial empirical evidence for Gibson's (1979) and Norman's (1988) concept of affordance, highlighting the distinction between the designer's intended utility and what the user perceives they can do. The same Padlet served as a space for reflection for the high-performing team but merely as a task submission space for the low-performing team. This demonstrates that technological affordance is not a fixed property but depends on perceived affordance, as emphasized by Norman.

Computer-Supported Collaborative Learning (CSCL) studies have stressed that digital tools do not automatically facilitate collaborative learning, and that how learners use the tool is decisive (Stahl et al., 2006). This study confirms this in the context of reflection. The affordance of Padlet's persistent visibility potentially supports metacognitive reflection, but it is realized only when learners actively look back at and contrast past posts. Sunny reflected, 'Seeing the Padlet, we realize how simply we thought at first,' whereas this metacognitive utilization was absent in the Willow team.

Dabbagh and Kitsantas (2012) argued that digital environments can support self-regulated learning, but only when learners already possess self-regulation strategies. The low-performing team in this study appears to have had the tool but lacked the strategy to utilize it reflectively. This underscores the importance of digital literacy education when implementing educational technology.

The Paradox of Asynchronicity

Padlet's asynchronicity was a double-edged sword. On one hand, it provided learners with time for deliberation. It is not a coincidence that the high-performing team's key reflective post (11/4) was written the day after the ChatGPT interview (11/3). This supports the 'slowness' of reflection—that reflection cannot be rushed—as emphasized by Rodgers (2002). This finding is consistent with Rath (2025), who observed that the asynchronous nature of Padlet allows learners to reflect and respond at their own pace, thereby facilitating richer and more thoughtful dialogues compared to

synchronous settings. Rath similarly noted that this temporal space enables students to question their own understanding and expand their knowledge through peer insights.

On the other hand, asynchronicity also meant the loss of immediacy. In the studio environment described by Schön (1983), face-to-face dialogue between instructor and learner occurs in real-time, allowing the instructor to read subtle expressions, hesitation, and gestures and respond immediately. In Padlet, these nonverbal cues disappear. It becomes difficult to judge whether a learner's short comment ('Yes, I understand') is genuine, a formal response, or a hidden lack of comprehension.

This connects to Clark and Brennan's (1991) theory of 'grounding in communication.' Effective communication requires a *grounding* process to confirm mutual understanding, which is challenging in an asynchronous text environment. The low-performing team's formal responses to instructor feedback in this study can be viewed as a failure of grounding. This suggests the importance of a hybrid learning environment—a combination of face-to-face and digital.

From Individual to Collective: The Mechanism of Team Reflexivity

This study moves beyond Schön's individual-centered theory to investigate the mechanism of collective reflective practice, a relatively underexplored area in reflection research. West (2000) defined team reflexivity as 'the extent to which teams collectively reflect upon and adapt their objectives, strategies, and processes.' In the high-TRI team (Sunny) of this study, an individual's reflection spurred comments from team members, which in turn led to new posts, creating a chain of reflection. This links to Wenger's (1998) concept of 'communities of practice'—that learning occurs not solely within an individual's mind but through social participation.

But why does this collective reflection emerge in some teams and not others? Edmondson's (1999) concept of 'psychological safety' provides a clue. In teams with high psychological safety, members feel comfortable exposing their mistakes or uncertainties (Edmondson & Bransby, 2023). Furthermore, psychological safety contributes not only to increasing the frequency of feedback but also to enhancing its quality and actionability (Coutifaris & Grant, 2022). The Sunny team member's public reflection, 'We might have had a prejudice,' can be seen as an indicator of psychological safety within the team. Conversely, in the low-TRI team, individual posts existed independently and did not challenge or build upon each other, suggesting a potential lack of psychological safety.

Furthermore, Padlet's persistent visibility appears to have acted as a specific mechanism supporting team reflexivity. According to Dillenbourg et al.'s (2011) research on awareness tools, coordination and co-regulation are facilitated when team members can see each other's activities. Lim (2020)'s empirical study also reported that visualizing individual member's activities in collaboration process allows collective reflection. The visibility of all posts on Padlet ensured that team members were continuously aware of what others were thinking. This likely formed the foundation for collective reflection.

Implication of the Research

This study makes three theoretical contributions. First, it extends Schön's (1983, 1987) theory of reflective practice to the digitally mediated environment. Reflective dialogue, traditionally synchronous, transient, and face-to-face, unfolds

as asynchronous, persistent, and text-based in the digital environment. This changes the very nature of reflection. Specifically, the findings that persistent visibility enables metacognitive reflection and asynchronicity provides time for deliberation are significant extensions of Schön's theory.

Second, by detailing reframing as a temporal process, the study translates an abstract concept into a concretely operationalizable learning process. Most design cognition studies rely on short-term protocol analysis, whereas this study tracked team-based reframing over multiple weeks. This confirms the enduring relevance of Wallas's (1926) creative problem-solving model, particularly the incubation stage, whose mechanisms continue to be investigated in contemporary research (Gilhooly, 2016; Magistretti et al., 2025), in a team learning context.

Third, by integrating West's (2000) concept of team reflexivity with Schön's individual-centered theory, the study advances a theory of collaborative reflective practice. It identified the mechanism by which individual reflection is transformed into collective learning through Padlet's persistent visibility and psychological safety, which holds important implications for 21st-century team-based professional education.

The findings of this study offer the following practical implications. First, the importance of securing time for reflection is emphasized. The fact that the high-performing team's reflection occurred at 2-3 day intervals suggests that reflective practice is a slow process requiring sufficient deliberation, not an immediate activity. Therefore, educational designers must guard against the temptation of rapid pacing for learners' deep thinking and intentionally secure non-active time for reflection.

Second, educational devices to facilitate reframing are necessary. Instead of perceiving problem definition as a one-time step, it should be designed as a continuous process of re-examination. To this end, learners should be guided to explicitly visualize their thought change process by documenting both the 'initial POV' and the 'revised POV,' and reflective questions such as 'Has your problem changed from your initial thought?' can be used as a facilitation tool.

Third, explicit education on the reflective utilization of digital tools is required. Beyond the simple technical usage of tools like Padlet, strategies for reflectively utilizing the tool must be explicitly taught. Especially in the age of Artificial Intelligence (AI), 'AI literacy' education is essential, utilizing generative AI like ChatGPT not merely as an information retrieval tool but as a partner for critical reflection.

Fourth, a structural mechanism to support Team Reflexivity must be established. Structural devices should be implemented to encourage mutual reference and facilitate collective reflection, ensuring that team members' individual posts do not exist independently of one another. Furthermore, efforts to foster Psychological Safety should be concurrently pursued, allowing members to freely share their uncertainties and mistakes.

Fifth, the advantages of Hybrid Design must be maximized. Educational designs that effectively combine the strengths of the digital environment found in this study (securing deliberation time through asynchronicity, persistent visibility) and the strengths of the face-to-face environment (immediate interaction, deep understanding through nonverbal communication) are judged to be most effective for cultivating reflective practice competence.

Conclusion

This study extended Schön's theory to the digital age, operationalizing reframing as a temporal process and elucidating

the transition from individual to collective reflection. We found that the quality of reflection distinguishes learning outcomes, demonstrating that reflective practice is not an innate talent but a learnable competence mediated by digital tools. These findings underscore the educator's responsibility to design hybrid environments that secure sufficient time for 'slow' thinking. Ultimately, this research offers a framework for cultivating reflective practitioners capable of navigating complex modern problems through deep, collaborative reflection.

This study is limited in its statistical generalizability as it is based on data from a single university over one semester. However, as emphasized by Yin (2018), case studies aim for analytical generalization—the derivation of theoretical propositions—and this study provided theoretical insights applicable in similar contexts by detailing the mechanism of reflective practice using Schön's theory.

While Padlet posts are self-reported data with the potential for social desirability bias, this was supplemented by triangulation with multifaceted data, including Design Thinking outputs, instructor evaluations, and final presentations. The limitation of not directly observing face-to-face activities is simultaneously a unique contribution, as it explores a new phenomenon of reflective practice in a digitally mediated environment.

The findings of this study suggest the following future research: (1) longitudinal studies tracking the same learners over multiple semesters, (2) capturing in-action reflection through video recording of face-to-face activities, (3) extension studies to other academic fields and cultural contexts, (4) in-depth exploration of the mechanisms by which generative AI facilitates/constrains reflection.

Conflicts of Interest

The author(s) declared no conflicts of interest.

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