From Workshops to Workflows: Boundary Infrastructure and the Transfer of Design Thinking into Everyday Work

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ABSTRACT

Organizations increasingly use design thinking to improve innovation and operational problem-solving, but limited evidence explains how workshop learning becomes sustained workplace practice, making transfer a critical challenge for management and operations. This study examines design thinking transfer as an operational embedding process in which training outputs become boundary infrastructure. Using a two-wave explanatory-sequential mixed-methods design, the study analyzes 315 matched survey responses, a primary-opportunity-confirmed sample of 264 professionals, an AI subgroup of 213 cases, and 16 explanatory interviews conducted in Greece and Cyprus. Results show that training design quality predicts boundary infrastructure, and that boundary infrastructure predicts design thinking transfer and mediates the training-to-transfer relationship. Cadence alignment, transfer climate, and digital guardrails emerge as direct enabling conditions rather than moderators. The study suggests that early workplace embedding is stronger when artifacts are maintained, owned, reused, and linked to operational decisions.

Keywords: Design thinking transfer, Boundary infrastructure, Training transfer, Operations management, Generative AI

1. Introduction

Design thinking has become a prominent approach to innovation, service improvement, user-centered problem-solving, and cross-functional collaboration. Organizations use it to reframe problems, involve users, create prototypes, and test assumptions before committing resources. Yet the growing use of design thinking has not resolved an important problem in management and operations research. The literature still reports conceptual breadth, uneven measurement, and limited evidence about how design thinking practices become sustained organizational routines [1]. As a result, the field has moved beyond the broad question of whether design thinking is valuable and toward the more precise question of when design thinking behaviors transfer into everyday work.

This question is especially important because organizations often invest in workshops, training programs, and innovation activities that create short-term energy but fail to produce durable practice. Recent research identifies a design thinking transfer gap between what employees know about design thinking and what they apply in organizational settings [2]. This gap matters for both theory and practice. If design thinking remains confined to workshops, pilot projects, or the memories of motivated participants, its organizational value remains fragile. If design thinking begins to become embedded in work routines, decision processes, and operational artifacts, it can support repeated problem framing, experimentation, user validation, and learning across projects.

An operations perspective makes this transfer problem more concrete. Organizations do not create value solely through training events. They create value through workflows, planning cycles, resource decisions, project reviews, process templates, digital systems, and accountability routines. For this reason, design thinking transfer should be examined as an operational embedding problem rather than as a training satisfaction problem. Fixson argues that design thinking research needs stronger links to operations management and more precise attention to process measures and organizational implementation [3]. This study responds to that call by examining whether design thinking moves from workshops into workflows and by identifying the mechanisms that support or weaken that movement.

Transfer-of-training research provides the first theoretical foundation for this study by explaining why learned behaviors persist only when training design and the work environment support application [4]. This logic is relevant to design thinking because its behaviors are socially distributed, artifact-based, and sensitive to local routines. The theoretical section develops this transfer logic more fully and defines design thinking transfer as the generalization and maintenance of design thinking behaviors in everyday work.

The second foundation is boundary infrastructure. Design thinking workshops usually generate artifacts, but these artifacts support transfer only when they remain active after the workshop. Boundary infrastructure research shows how artifacts, routines, and governance arrangements can become a durable system for collaboration over time [5]. This study, therefore, examines whether artifacts such as maps, blueprints, prototypes, templates, and decision logs can form a reusable, decision-linked work infrastructure.

A third foundation concerns AI-supported design work. Generative AI is increasingly used in design-related tasks, but recent evidence suggests that its value depends on how it is sequenced and governed [6], [7]. This study, therefore, examines digital guardrails as safeguards that protect human framing, divergent exploration, review, and learning.

Despite these theoretical advances, existing research has not yet provided a clear empirical account of how design thinking training becomes routinized in everyday organizational work. Three gaps remain. First, design thinking research has paid limited attention to the mechanisms linking training design to later workplace behavior. Second, the role of design artifacts has often been treated descriptively rather than tested as a mediating infrastructure through which transfer occurs. Third, the growing use of generative AI in design work has not been sufficiently connected to design thinking transfer, particularly in relation to safeguards that preserve human-led exploration and critical judgment.

This study addresses these gaps through a two-wave explanatory sequential mixed-methods study of professionals connected to Greece and Cyprus. The quantitative phase uses matched survey data to test whether training design quality predicts design thinking transfer through boundary infrastructure and whether absorptive capacity, cadence alignment, transfer climate, leadership support, AI-supported design work, and digital guardrails shape transfer outcomes. The qualitative phase uses 16 explanatory interviews to compare high-transfer and low-transfer cases and to interpret why some practices persisted while others decayed after the initial training or structured innovation activity.

This study makes three contributions. First, it advances design thinking research by treating transfer as operational embedding rather than workshop completion. This reframing responds to the need for more precise process-level evidence on how design thinking becomes sustained organizational practice [1], [3]. Second, it contributes to transfer and operations research by specifying boundary infrastructure as the mechanism through which training outputs become reusable work-system resources. Boundary infrastructure is defined here as a maintained configuration of artifacts, ownership roles, update routines, repositories, and decision links that allows design thinking practices to travel across people, projects, and work cycles. This definition distinguishes it from individual boundary objects, organizational routines, knowledge integration mechanisms, and routinization outcomes. Third, the study contributes to emerging research on AI-supported design by showing that generative AI use should be evaluated based on its governance conditions rather than solely on use frequency. Digital guardrails matter because they preserve human-led framing, divergence, review, documentation, and learning when AI enters design-related work.

2. Literature Review

2.1 Design Thinking Transfer as An Operational Embedding Problem

Design thinking research has moved beyond general claims about usefulness toward the more specific problem of workplace application and early embedding. This section develops that problem theoretically by treating transfer as an operational embedding process. In this study, design thinking transfer refers to the generalization and maintenance of design thinking behaviors in everyday work, including problem reframing, structured divergence, prototyping, stakeholder validation, and continued use across work cycles.

This definition connects design thinking research with transfer of training theory and operations management. Transfer research shows that learned behaviors are more likely to persist when training design and the work environment support application [4]. An operations perspective adds that the application depends on the routines, artifacts, reviews, and decision points through which work is actually governed [3]. Design thinking transfer is therefore not only a matter of whether participants understand the method. It is a matter of whether the method becomes visible, repeatable, and maintainable within the work system.

This framing leads to the model’s central argument. Training design quality can create transfer potential, but transfer is more likely to appear in everyday work when workshop outputs become embedded in work infrastructure. Boundary infrastructure, absorptive capacity, cadence alignment, and digital guardrails are therefore examined as conditions that explain how design thinking moves from a temporary activity toward recurring organizational practice.

2.2 Boundary Infrastructure as A Distinct Theoretical Construct

Boundary infrastructure is used in this study to describe a work-system arrangement rather than a single artifact, a general routine, or an implementation outcome. Boundary object theory explains how artifacts support coordination by being adaptable to different viewpoints while remaining robust enough to maintain identity across them [8]. Infrastructure studies further suggest that infrastructure is embedded in practice, linked to conventions of use, learned through participation, and sustained through an installed base [9]. Recent boundary-infrastructure research further shows that boundary infrastructure is not a single object but a coherent system of technical and organizational objects that actors can use across boundaries [5]. In this study, that logic is transferred from large-scale interorganizational collaboration to design thinking transfer inside everyday organizational work. This logic is necessary but not sufficient for explaining design thinking transfer. A journey map, service blueprint, prototype, or decision log may function as a boundary object during a workshop, but it does not become boundary infrastructure unless it is preserved, updated, owned, reused, and connected to operational decisions.

Boundary infrastructure differs from the four adjacent concepts. It differs from boundary objects because its unit of analysis is not the artifact alone, but the governed configuration that keeps artifacts usable across work cycles [8], [9]. It differs from organizational routines because routines refer to recurring and recognizable patterns of interdependent action, while boundary infrastructure refers to artifact-centered arrangements that make design thinking practices visible, portable, and revisable [10]. It differs from knowledge integration mechanisms because knowledge-integration research explains how knowledge is transferred, translated, and transformed across boundaries, while boundary infrastructure specifies the concrete artifact, repository, stewardship, and decision-linkage arrangements through which such knowledge can be activated in everyday work [11]. It also differs from routinization, which refers to the repeated embedding of a practice into everyday work, while boundary infrastructure is the enabling arrangement that makes repeated use more likely [12].

The theoretical value of this distinction is that it explains how design thinking moves from episodic training to operational practice. Transfer-of-training theory explains why learned behaviors are more likely to generalize and persist when training design, work support, and opportunity to perform are favorable [4], [13], [14]. Design thinking research also shows that the approach is artifact-mediated, collaborative, and difficult to operationalize consistently across organizational contexts [1], [3]. Boundary infrastructure adds a mechanism that is especially relevant to this problem. In this view, training does not transfer only through individual motivation or memory. It transfers when workshop outputs become governed work objects that are repeatedly reactivated through ownership, updating, version control, repository access, and decision use.

2.3 Training Design Quality and Boundary Infrastructure

Transfer of training theory argues that learning transfer depends on more than participant exposure. Training design, individual characteristics, and the work environment jointly shape whether learned behaviors are generalized and maintained after training [13], [14]. Meta-analytic evidence further shows that transfer improves when training includes realistic practice, behavioral modeling, goal setting, and opportunities to apply learning in the work environment [4]. In this study, training design quality refers to the extent to which design thinking or structured innovation training uses realistic work examples, emphasizes transferable principles, includes behavioral practice, and ends with enactment planning.

In design thinking, training design quality is especially important because workshops normally produce artifacts as well as learning. These artifacts may include journey maps, service blueprints, prototypes, playbooks, templates, decision logs, and assumption maps. If such outputs remain isolated workshop materials, their transfer value is limited. If they become stored, updated, stewarded, versioned, reused, and linked to decisions, they can support transfer across people, projects, and time.

Boundary object theory provides the conceptual basis for this argument. Boundary objects allow actors from different communities to coordinate because they are flexible enough for local use and stable enough to maintain shared meaning [8]. Innovation management research shows that boundary objects support knowledge integration by helping different actors process information, align cognition, and learn across functional boundaries [15]. More recent work extends this logic from isolated boundary objects to boundary infrastructure, where multiple artifacts, routines, and governance arrangements become a coherent system that supports collaboration over time [5]. In design thinking transfer, this means that workshop outputs become useful when they are not merely archived but incorporated into the work infrastructure.

Training design quality should therefore predict boundary infrastructure strength. Training that uses realistic examples, requires behavioral practice, and closes with clear enactment plans is more likely to produce artifacts that can be carried into work routines. By contrast, generic training may generate awareness without producing reusable and governed work objects.

Hypothesis 1. Training design quality is positively associated with boundary infrastructure strength.

2.4 Boundary Infrastructure and Design Thinking Transfer

Boundary infrastructure should also support the direct transfer of design thinking. Design thinking behaviors are difficult to maintain when they remain dependent on individual memory or enthusiasm. Artifacts reduce this dependence by making practices visible and reusable. A current service blueprint can remind a team to validate user pain points before redesigning a process. A decision log can preserve the reasoning behind a prototype. A versioned playbook can help new members understand how a team frames problems and tests solutions. A backlog item derived from a journey map can connect design work with implementation.

This logic shifts the transfer of design thinking from individual intention to organizational infrastructure. The same behavior is more likely to persist when it is embedded in a template, review document, repository, or operating routine. Boundary infrastructure, therefore, functions as a carrier of learned practice. It allows design thinking to move across projects and work cycles, even when participants change roles or when the initial workshop loses salience.

The relationship also fits the broader knowledge integration literature. Innovation requires specialized actors to coordinate across knowledge boundaries, and boundary objects help this coordination by creating shared reference points [8]. When such objects become part of a durable infrastructure, they can support repeated coordination rather than one-time communication [5], [15]. Design thinking transfer is therefore expected to be stronger when artifacts remain active and connected to decisions.

Hypothesis 2. Boundary infrastructure strength is positively associated with the transfer of design thinking.

2.5 Absorptive Capacity and Design Thinking Transfer

Absorptive capacity explains why units differ in their ability to apply new knowledge. The construct refers to the capacity to acquire, assimilate, transform, and exploit knowledge [16]. Later work distinguishes between potential and realized absorptive capacity, showing that organizational units need both the ability to recognize and understand knowledge and the ability to transform and apply it [17]. This distinction is important for the transfer of design thinking, as a unit may understand its language without embedding its practice.

In this study, absorptive capacity is treated as a unit-level capability. Units with stronger absorptive capacity should be better able to recognize the value of design thinking methods, connect them to existing routines, adapt them to local work conditions, and apply them to products, services, or processes. Such units are more likely to translate workshop learning into operating forms that survive beyond the training event.

Absorptive capacity is not expected to replace boundary infrastructure. Rather, it should support transfer by helping units interpret and use design thinking knowledge. A unit that understands new methods but lacks active artifacts may struggle to maintain them. A unit that has artifacts but lacks translation capacity may fail to adapt them to local work. The theory, therefore, expects absorptive capacity to have a positive direct relationship with the transfer of design thinking.

Hypothesis 3. Unit absorptive capacity is positively associated with the transfer of design thinking.

2.6 Boundary Infrastructure as A Mediating Mechanism

The quality of training design should influence the transfer of design thinking, partly through boundary infrastructure. This mediation logic is central to the study. Training can improve participant understanding, but understanding alone does not guarantee transfer. For learning to become an organizational practice, it must be integrated into the material and procedural systems of work. Boundary infrastructure provides that mechanism.

High-quality training is more likely to produce artifacts that are work-relevant and actionable. Those artifacts can then serve as vehicles for applying design thinking practices after training. For example, a workshop that ends with an enactment plan and a versioned service blueprint provides a team with a concrete deliverable to revisit during future reviews. The artifact keeps the practice available after the training event and gives colleagues a shared basis for action.

This mechanism connects the transfer-of-training theory with boundary infrastructure. Transfer theory explains why training design matters [4], [13]. Boundary object, innovation management, and boundary infrastructure research explain how artifacts enable knowledge integration across roles and routines [5], [8], [15]. These perspectives suggest that the quality of training design should affect the transfer of design thinking through the boundary infrastructure it creates and activates.

Hypothesis 4. Boundary infrastructure mediates the relationship between training design quality and the transfer of design thinking.

2.7 Cadence Alignment as A Contextual Condition

Organizations operate through recurring rhythms. Teams plan, review, prioritize, and adjust work through meetings, sprint cycles, project gates, portfolio reviews, service improvement routines, and budget or resource decisions. These rhythms shape whether design thinking artifacts are used or ignored. An artifact may be well designed, but it will not support transfer if it has no recurring place in the work cycle.

Cadence alignment refers to the extent to which design thinking activities and artifacts align with existing work rhythms. When design thinking practices are scheduled into planning and review routines, they gain legitimacy and become recurring. A journey map reviewed during a monthly service meeting is more likely to remain active than one stored outside the decision process. A prototype discussed during a project checkpoint is more likely to shape implementation than one presented only at the end of a workshop.

The original model treats cadence alignment as a condition that should strengthen the relationship between boundary infrastructure and transfer. This expectation extends the operations view, which holds that design thinking should be connected to the processes and rhythms through which work is governed [3]. It also follows the boundary infrastructure logic that artifacts become more consequential when routines and governance arrangements repeatedly activate them [5]. Boundary infrastructure provides the carrier of practice, while cadence alignment provides recurring moments for use. When cadence alignment is high, the positive effect of boundary infrastructure on transfer should be stronger.

Hypothesis 5. Cadence alignment positively moderates the relationship between boundary infrastructure and the transfer of design thinking.

2.8 AI-Supported Design Work and Digital Guardrails

Generative AI is increasingly present in design-related work, including idea generation, insight summarization, visualization, prototyping, documentation, and concept refinement. This creates a new condition for the transfer of design thinking. AI can help teams elaborate and document ideas, but recent evidence also shows risks. Recent evidence shows that generative AI can narrow collective idea diversity in brainstorming and can increase fixation when users rely too early on AI-generated material during ideation [6]. Related human-AI design research suggests that AI can support broader exploration when deliberately configured to provide diverse inspiration and when users retain control over the design process [7]. The implication is that AI use should not be treated as uniformly beneficial or harmful. Its transfer value depends on how it is sequenced and governed.

In this study, digital guardrails are expected to strengthen the relationship between AI-supported design work and transfer. AI-supported work should contribute more to transfer when teams use guardrails that protect human divergence, require review, and connect AI outputs to traceable artifacts. Without such guardrails, AI may encourage premature convergence, generic outputs, or polished documentation that substitutes for learning.

Hypothesis 6. Digital guardrails positively moderate the relationship between AI-supported design work and the transfer of design thinking.

2.9 Theoretical Model

The proposed model links training design quality to the transfer of design thinking through boundary infrastructure. Absorptive capacity is expected to support transfer by enabling units to interpret and apply design thinking knowledge. Cadence alignment is expected to strengthen the boundary infrastructure for transferring relationships by creating repeated opportunities for artifact use. Digital guardrails are expected to strengthen AI-supported design work by protecting human-led exploration and critical review. These relationships position design thinking transfer as a work-system outcome rather than a workshop outcome.

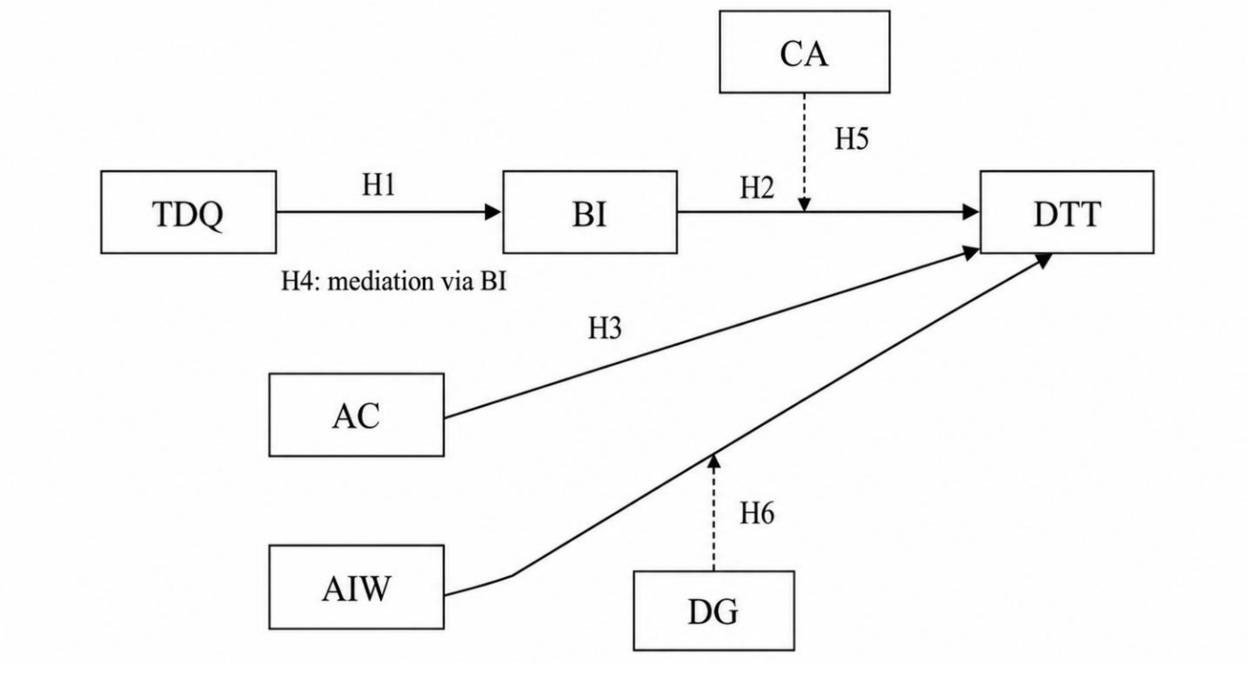

Figure 1. Hypothesized empirical model

Notes. TDQ = training design quality. BI = boundary infrastructure. AC = absorptive capacity. CA = cadence alignment. AIW = AI-supported design work. DG = digital guardrails. DTT = design thinking transfer.

Source: By author.

3. Research Design

The study used an explanatory sequential mixed-methods design. The quantitative phase tested the hypothesized model using a two-wave survey. The qualitative phase then used interviews to explain the quantitative results, focusing on the organizational mechanisms that supported or constrained the transfer of design thinking.

This design was appropriate because the research question concerned both statistical relationships and the organizational mechanisms behind them. The survey tested whether training design quality, boundary infrastructure, absorptive capacity, cadence alignment, transfer climate, leadership support, AI-supported design work, and digital guardrails predicted design thinking transfer. The interviews then compared high-transfer and low-transfer cases to examine how design thinking artifacts, work rhythms, leadership expectations, and AI-use practices shaped the maintenance or decay of design thinking behaviors.

3.1 Research Context

The empirical context was Greece and Cyprus. These settings were selected because they provided access to professionals working in innovation, service improvement, process redesign, and AI-supported design-related activities. The two-country context also allowed the study to examine design thinking transfer in a focused Mediterranean setting while avoiding the comparability problems that would follow from a broader, multi-continent design.

The study focused on professionals working in or with organizations connected to Greece or Cyprus. Eligible respondents included founders, co-founders, managers, innovation officers, product owners, service designers, operations or process-improvement professionals, consultants, incubator or accelerator participants, SME employees, startup employees, university innovation staff, and professionals involved in innovation or organizational development.

3.2 Participants and Sampling

Participants were recruited through professional, academic, and innovation-related networks connected to Greece and Cyprus. The recruitment channels included LinkedIn, entrepreneurship and innovation networks, startup and SME communities, university networks, incubator and accelerator contacts, professional associations, and direct outreach to relevant professionals.

Eligibility required respondents to be at least 18 years old, to have a professional or organizational connection to Greece or Cyprus, and to have used or received training in at least one structured innovation practice during the previous 24 months. Eligible practices included design thinking, service design, lean startup, agile innovation, customer discovery, structured innovation, prototyping, user-centered design, and business model innovation.

Wave 1 produced 420 eligible complete responses. Wave 2 produced 315 matched two-wave responses, giving a retention rate of 75.0 percent. The primary analysis used the opportunity-confirmed matched sample of 264 respondents. This sample was selected because respondents had a practical opportunity to apply design thinking during the Wave 2 interval. This decision reduced the risk of interpreting non-use as failed transfer when respondents had no occasion to apply the practice.

The full matched sample of 315 respondents was retained for robustness checks. The AI-specific analysis used the opportunity-confirmed AI subgroup of 213 respondents, with the full AI subgroup retained for robustness checks. Table 1 summarizes the survey sample flow.

Table 1. Survey sample flow

Stage	Sample Size	Use in Analysis
Wave 1 eligible complete responses	420	Baseline survey pool
Matched two-wave responses	315	Full matched robustness sample
Opportunity-confirmed matched responses	264	Primary transfer model
Opportunity-confirmed AI subgroup	213	AI-specific primary model
Interview opt-ins in primary sample	63	Qualitative sampling pool within the primary sample
Interview opt-ins in matched sample	74	Broader qualitative sampling pool
Explanatory interviews completed	16	Qualitative explanatory phase

3.3 Measures

The questionnaire measured nine focal constructs. All construct items used a seven-point agreement scale, where 1 represented strongly disagree, and 7 represented strongly agree. Training design quality measured the extent to which prior design thinking or structured innovation training used realistic work examples, behavioral practice, transferable principles, enactment planning, and links to existing work responsibilities.

Boundary infrastructure measured the extent to which design thinking outputs were stored, updated, stewarded, versioned, reused, and linked to decisions, metrics, or operational documents. The construct captured whether artifacts such as journey maps, blueprints, prototypes, playbooks, decision logs, and templates remained active after the initial workshop or project. Absorptive capacity measured the unit’s ability to recognize useful external knowledge, understand relevant new methods, combine new knowledge with existing routines, transform ideas into workable practices, and apply knowledge to improve products, services, or processes.

Cadence alignment measured whether design thinking activities were scheduled within existing work cycles, reviewed during regular meetings, given time windows for testing and refinement, fitted to decision timing, and connected to recurring operational or innovation milestones. The transfer climate measured whether the work environment provided opportunities, peer support, supervisor encouragement, legitimacy, and tolerance for structured experimentation.

Leadership support measured whether managers asked for visible evidence of design thinking use, allocated time for reframing, prototyping, or user validation, supported continued use beyond the initial activity, rewarded maintenance across work cycles, and maintained support despite leadership changes. AI-supported design work measured whether generative AI was used to support design-related tasks, including insight summarization, visualization, prototyping, concept development, documentation, and idea generation.

Digital guardrails measured whether teams used explicit safeguards around generative AI, including human-first ideation, diversity-oriented prompting, critical review of AI outputs, documentation of AI-generated material, avoidance of AI as the first source of problem definitions, and explicit rules for when AI should and should not be used. Design thinking transfer measured the extent to which respondents used design thinking behaviors beyond the initial training or workshop context. The items captured problem reframing, structured divergence, prototyping, stakeholder validation, continued use after the initial project, and routinization in the respondent's unit.

The survey also collected control variables, including country connection, sector, organization type, organization size, respondent role, professional experience, team size, prior formal design thinking training, time since last structured innovation activity, frequency of design thinking use, frequency of generative AI use, and work mode. Table 2 reports the construct structure used in the survey. Training design quality and transfer climate were informed by transfer-of-training research [4], [13], [14]. Absorptive capacity was adapted from the absorptive capacity literature [16], [17]. Boundary infrastructure, cadence alignment, digital guardrails, and design thinking transfer were developed for this study from the theoretical model and refined through instrument review before data collection.

Table 2. Construct structure and measurement basis

Construct	Items	Measurement Basis	Example Domain
Training Design Quality	5	Adapted to structured innovation training	Realistic examples, behavioral practice, enactment planning
Boundary Infrastructure	6	Developed for this study	Artifact ownership, updating, reuse, versioning, decision linkage
Absorptive Capacity	5	Adapted from absorptive capacity theory	Recognizing, assimilating, transforming, and applying knowledge
Cadence	5	Developed for this study	Fit with reviews, meetings, milestones, and

Alignment			decision timing
Transfer Climate	5	Adapted from training transfer research	Opportunity, peer support, supervisor support, legitimacy
Leadership Support	5	Adapted to design thinking transfer	Evidence expectations, resource support, and continued use
AI-Supported Design Work	5	Developed for this study	AI use for summarization, visualization, prototyping, documentation, and ideas
Digital Guardrails	6	Developed for this study	Human-first ideation, review, documentation, and AI use boundaries
Design Thinking Transfer	7	Developed for this study	Reframing, divergence, prototyping, validation, routinization

The newly developed measures were constructed through a theory-first item-generation procedure consistent with established construct validation guidance [18], [19]. The initial domain definitions were derived from the theoretical model and from prior research on design thinking, training transfer, boundary objects, boundary infrastructure, absorptive capacity, and AI-supported design work [1] to [17]. Items were written to capture observable work-system properties rather than general favorable attitudes toward innovation. Boundary infrastructure items captured artifact stewardship, updating, versioning, reuse, accessibility, and decision linkage. Cadence alignment items captured fit with meetings, planning cycles, review windows, milestones, and decision timing. Digital guardrail items captured human-first ideation, diversity-oriented prompting, critical review, documentation, avoidance of AI-led problem definition, and explicit AI-use boundaries. Design thinking transfer items captured continued use of reframing, structured divergence, prototyping, stakeholder validation, and application beyond the original workshop or project.

Because several constructs were developed for this study, content validity was treated as a substantive concern rather than inferred from reliability coefficients alone [18], [19]. The item pool was reviewed against the conceptual definitions before data collection to reduce ambiguity and improve domain coverage. This review assessed whether each item reflected the intended construct, whether the wording referred to observable workplace conditions, and whether adjacent constructs could be distinguished semantically. No claim is made that this procedure substitutes for a formal multi-rater expert panel or an independent pilot validation study. It provides initial content-validity support for the present empirical test, while future research should conduct independent expert assessment, cognitive pretesting, pilot testing, and scale replication. This limitation is important because boundary infrastructure, cadence alignment, digital guardrails, and design thinking transfer are related in practice but theoretically different. Boundary infrastructure concerns the governance and maintenance of artifacts. Cadence alignment concerns the timing and recurrence of artifact use within work rhythms. Digital guardrails concern the governance of AI-supported design work. Design thinking transfer concerns the continued use of design thinking behaviors after the initial learning or innovation activity.

3.4 Data Collection Procedure

Wave 1 measured the predictors, the mediator, the moderators, the controls, and respondent background variables. Wave 2 was administered approximately four to six weeks later and measured design thinking transfer outcomes and recent behavioral indicators. Data were collected between November 2025 and January 2026 using Google Forms. The temporal separation improved the ordering of predictor and outcome measurement and reduced same-time response effects, but it did not establish experimental causality or capture long-term routinization. The four-to-six-week interval is therefore interpreted as evidence of short-term workplace application and early embedding rather than as definitive evidence of sustained organizational institutionalization.

Wave 2 also recorded whether respondents had an opportunity to apply design thinking during the interval between surveys. This variable was later used to define the primary transfer analysis sample and the robustness sample. The AI-related section was shown only to respondents who reported generative AI use in work or design-related activities. This skip logic avoided forcing respondents without AI exposure to answer questions about AI-supported design work or digital guardrails.

3.5 Quantitative Analysis

The quantitative analysis used partial least squares structural equation modeling. This approach was appropriate because the model was prediction-oriented, included newly developed or adapted constructs, and examined transfer as an operational outcome shaped by multiple organizational conditions [20]. Discriminant validity was assessed using the HTMT criterion, as it provides a stricter test of construct separation in variance-based structural equation modeling [21]. Common-method risk was addressed through temporal separation and diagnostic checks, as same-source survey designs can inflate observed relationships if not carefully managed [22].

The final analysis file was screened before model estimation. Eligibility, duplicate responses, Wave 1 and Wave 2 matching, AI section skip logic, Wave 2 opportunity status, missing values, and attention check performance were inspected. Wave 1 contained 420 eligible complete responses. Wave 2 produced 315 matched responses, yielding a 75.0 percent retention rate. The primary model used 264 opportunity-confirmed cases because transfer could not be meaningfully interpreted when respondents had no practical opportunity to apply design thinking during the Wave 2 interval. The AI subgroup analysis used 213 opportunity-confirmed AI cases. No cases outside the eligibility and matching rules were included in the primary model.

The analysis proceeded in three stages. First, the measurement model was assessed through item loadings, Cronbach’s alpha, composite reliability, average variance extracted, HTMT, and collinearity diagnostics. Second, the confirmatory structural model tested the six hypotheses. The model examined the effect of training design quality on boundary infrastructure, the effect of boundary infrastructure on design thinking transfer, the effect of absorptive capacity on design thinking transfer, the indirect effect of training design quality on transfer through boundary infrastructure, the moderating role of cadence alignment in the boundary infrastructure to transfer relationship, and the moderating role of digital guardrails in the AI-supported design work to transfer relationship. Third, an exploratory refined model was estimated after the confirmatory tests. This model examined whether theoretically important contextual and digital conditions also showed direct associations with design thinking transfer. This step was reported separately from the confirmatory hypothesis tests to distinguish hypothesis testing from post hoc model refinement.

Bootstrapping with 5,000 resamples was used to assess the significance of path coefficients and indirect effects. Robustness checks compared the primary opportunity confirmed sample with the full matched sample, examined Greece and Cyprus separately, tested the AI subgroup, and assessed whether key paths remained stable when controls were included. Common-method risk was addressed procedurally through temporal separation between predictors and outcomes and statistically through collinearity diagnostics.

3.6 Qualitative Phase

The qualitative phase used 16 explanatory interviews selected from the interview opt-in pool within the matched survey dataset. Table 1 reports 63 interview opt-ins in the primary opportunity-confirmed sample, while the broader matched survey pool contained 74. The interview sample was purposive rather than random. Cases were selected to compare high- and low-transfer respondents across Greece and Cyprus and to include both AI- and non-AI-use cases where possible. The interview sample included four high-transfer Greece cases, four low-transfer Greece cases, four high-transfer Cyprus cases, and four low-transfer Cyprus cases. This structure allowed systematic comparison across country context and transfer level. The goal was not statistical generalization. The goal was to explain the mechanisms behind the survey results.

Interviews followed a semi-structured protocol and were analyzed from anonymized transcripts. Each transcript was reviewed for relevance to the explanatory purpose of the qualitative phase. Coding focused on the mechanisms identified in the survey results, including artifact maintenance, cadence fit, leadership evidence expectations, digital guardrails, absorptive capacity, and transfer maintenance or decay. Reporting followed qualitative transparency principles for interview-based studies [23]. Excerpts were selected when they provided concise evidence of a theme, illustrated a high transfer and low transfer contrast, or clarified an unexpected quantitative result.

3.7 Qualitative Analysis and Integration

The qualitative material was analyzed through a focused thematic approach. The initial code families were derived from the theoretical model and quantitative results. These code families included boundary infrastructure, cadence alignment, leadership and transfer climate, absorptive capacity, digital guardrails, and transfer maintenance or decay.

The analysis compared high-transfer and low-transfer cases to identify recurring contrasts. High-transfer cases were examined for evidence of living artifacts, ownership, reuse, versioning, decision linkage, recurring review cycles, leadership expectations for evidence, and guarded AI use. Low-transfer cases were examined for artifact decay, static documentation, weak ownership, misfit with work cadence, general rather than evidence-based leadership support, and premature or uncritical AI use.

The quantitative and qualitative strands were integrated through comparison and explanation. The survey results identified the statistical pattern, and the interviews explained why that pattern occurred. This integration followed an explanatory sequential mixed-methods logic, in which qualitative evidence is used to interpret quantitative findings and clarify mechanisms [24]. The integration focused on three issues. First, the interviews explained why boundary infrastructure mediated the relationship between training design quality and the transfer of design thinking. Second, they clarified why absorptive capacity had a significant but modest effect. Third, they explained why cadence alignment and digital guardrails appeared as direct enabling conditions rather than moderators.

3.8 Ethical and Data-Handling Considerations

Participation was voluntary, and respondents were informed of the study's purpose before participating in the survey. The survey did not request confidential business information, trade secrets, customer names, or sensitive personal data. Responses were analyzed for academic purposes and reported in aggregate form. Participant identifiers were anonymized before analysis. The locked analysis dataset used neutral participant IDs and did not include personally identifying information in the manuscript tables or case descriptions. Interview excerpts were selected and reported in a manner that protected the respondents' and the organization's anonymity.

4. Results

4.1 Sample and Analytical Basis

The primary analysis used the opportunity-confirmed matched sample of 264 respondents, while the full matched sample of 315 respondents was retained for robustness checks. The AI specific model used the opportunity confirmed AI subgroup of 213 respondents. Table 3 reports the sample profile. Respondents were mainly based in Greece and Cyprus and represented technology, professional services, education, manufacturing, retail, the public sector, tourism, and related service contexts. This composition was appropriate because the study examined the transfer of design thinking in settings where innovation, process redesign, service improvement, and digital work practices are operationally relevant.

Table 3. Primary sample profile

Characteristic	Category	n	%
Country connection	Greece	150	56.8

Characteristic	Category	n	%
	Cyprus	98	37.1
	Both Greece and Cyprus	14	5.3
	Other organizational connection	2	0.8
Sector	Technology or software	70	26.5
	Professional services	45	17.0
	Education or training	32	12.1
	Manufacturing	29	11.0
	Retail or e-commerce	20	7.6
	Public sector	19	7.2
	Tourism or hospitality	17	6.4
	Health or social care	12	4.5
	Creative industries	11	4.2
	Financial services	6	2.3
	Other	3	1.1
Organization type	SME	85	32.2
	Startup	63	23.9
	Consultancy	34	12.9
	Large firm	32	12.1
	Public organization	16	6.1
	Incubator or accelerator	13	4.9

Characteristic	Category	n	%
	Nonprofit organization	11	4.2
	University or research organization	8	3.0
	Other	2	0.8
Organization size	1 to 9 employees	70	26.5
	10 to 49 employees	82	31.1
	50 to 249 employees	62	23.5
	250 or more employees	39	14.8
	Not sure	11	4.2
Respondent role	Middle manager	42	15.9
	Founder or co-founder	40	15.2
	Innovation or transformation role	37	14.0
	Consultant	34	12.9
	Product or service design role	33	12.5
	Operations or process-improvement role	27	10.2
	Employee or team member	21	8.0
	Senior manager	15	5.7
	University or incubator role	11	4.2
	Other	4	1.5
Prior formal DT training	Yes	155	58.7
	No	77	29.2

Characteristic	Category	n	%
	Not sure	32	12.1
AI section shown	Yes	213	80.7
	No	51	19.3
Interview opt-in	Yes	63	23.9
	No	201	76.1

Note. Primary sample includes opportunity-confirmed matched respondents, n = 264.

4.2 Measurement Validation

The measurement model showed adequate reliability and validity before the structural paths were interpreted. As shown in Table 4, Cronbach's alpha values ranged from .830 to .912. Composite reliability ranged from .880 to .930, and average variance extracted ranged from .591 to .682. These values support the internal consistency and convergent validity of the constructs.

The strongest reliability value was observed for design thinking transfer. This was acceptable because the construct captures a coherent behavioral outcome involving continued use, generalization, reframing, structured divergence, prototyping, stakeholder validation, and routinization.

Table 4. Measurement model results

Construct	n	Items	Cronbach's alpha	Composite reliability	AVE	Loading range	Decision
TDQ	264	5	.830	.880	.595	.744 to .794	Retain
BI	264	6	.893	.919	.656	.784 to .839	Retain
AC	264	5	.853	.895	.630	.779 to .804	Retain
CA	264	5	.875	.910	.668	.787 to .854	Retain
TC	264	5	.837	.885	.606	.723 to .825	Retain
LS	264	5	.837	.886	.608	.759 to .803	Retain
AIW	213	5	.883	.915	.682	.815 to .843	Retain

Construct	n	Items	Cronbach's alpha	Composite reliability	AVE	Loading range	Decision
DG	213	6	.860	.897	.591	.737 to .820	Retain
DTT	264	7	.912	.930	.655	.792 to .827	Retain

Note. AIW and DG are reported for the AI subgroup with confirmed opportunities (n = 213).

Discriminant validity was also satisfactory. Collinearity diagnostics did not indicate problematic overlap among predictors. In the confirmatory model, VIF values ranged from 1.023 to 1.380. In the AI subgroup model, VIF values ranged from 1.078 to 1.489. These values were low and did not indicate problematic collinearity, consistent with standard PLS SEM reporting expectations [20]. These diagnostics do not eliminate common method bias, but they complement the temporal separation between predictors and outcomes.

Table 5 shows that all HTMT values remained below conservative thresholds. The highest value in the primary construct matrix was .562 between training design quality and boundary infrastructure. This association is theoretically expected because higher-quality training is more likely to produce reusable, well-governed artifacts. However, the value was insufficient to suggest redundancy. The AI-specific constructs were also distinct. AI-supported design work and digital guardrails were related but clearly separable, which confirms that the study should not treat AI use and AI governance as the same phenomenon.

Table 5. HTMT discriminant validity matrices

Panel A. Main Construct HTMT Matrix

Construct	TDQ	BI	AC	CA	TC	LS	DTT
TDQ	1.000						
BI	.562	1.000					
AC	.167	.105	1.000				
CA	.333	.307	.280	1.000			
TC	.136	.142	.145	.277	1.000		
LS	.119	.222	.160	.206	.372	1.000	
DTT	.527	.546	.296	.477	.393	.300	1.000

Panel B. AI Subgroup HTMT Matrix

Construct	AIW	DG	DTT
AIW	1.000		
DG	.331	1.000	
DTT	.342	.364	1.000

Note. TC = Transfer Climate; LS = Leadership Support. All values are below conservative HTMT thresholds, supporting discriminant validity.

4.3 Descriptive Pattern

The descriptive statistics in Table 6 indicate a moderate level of design thinking transfer in the primary sample. The design thinking transfer mean was 5.018, suggesting that respondents generally reported continued use of design thinking behaviors after the initial training or structured innovation activity. Boundary infrastructure had a lower mean of 4.218. This gap is analytically important. It suggests that respondents may continue using some design thinking behaviors even when artifact systems are only partially developed. However, the correlations indicate that stronger boundary infrastructure is associated with higher transfer, supporting the central mechanism tested in the structural model.

The correlation pattern also shows that design thinking transfer was associated with boundary infrastructure, training design quality, cadence alignment, transfer climate, leadership support, and absorptive capacity. These associations suggest that transfer is associated with multiple conditions rather than a single predictor. The structural model clarifies which conditions remain significant when considered together.

Table 6. Descriptive statistics and correlations

Construct	M	SD	TDQ	BI	AC	CA	TC	LS	DTT
TDQ	4.424	0.841	1.000						
BI	4.218	0.944	.484	1.000					
AC	4.401	0.905	.140	.052	1.000				
CA	4.280	0.965	.283	.270	.242	1.000			
TC	4.353	0.879	.107	.114	.124	.237	1.000		
LS	4.296	0.885	.084	.188	.136	.177	.310	1.000	

Construct	M	SD	TDQ	BI	AC	CA	TC	LS	DTT
DTT	5.018	0.938	.459	.494	.261	.426	.344	.262	1.000

Note. Primary sample n = 264.

4.4 Confirmatory Hypothesis Testing

The confirmatory model provides strong support for the central infrastructure-mediated transfer mechanism. Table 7 summarizes the hypothesis tests. H1 predicted that training design quality would be positively associated with boundary infrastructure strength. This hypothesis was supported, $\beta = .484$, $p < .001$. This result shows that design thinking training is more likely to generate usable organizational infrastructure when it includes realistic work examples, transferable principles, behavioral practice, and enactment planning. Training quality, therefore, matters not only because it improves participant understanding, but because it shapes the artifacts and routines that remain after the training event.

H2 predicted that boundary infrastructure would be positively associated with the transfer of design thinking. This hypothesis was supported, $\beta = .290$, $p < .001$. This result indicates that design thinking transferred more strongly when workshop outputs were made reusable, updated, stewarded, and linked to decisions. Journey maps, blueprints, prototypes, playbooks, templates, and decision logs functioned as carriers of practice across people, meetings, projects, and time.

H3 predicted that absorptive capacity would be positively associated with the transfer of design thinking. This hypothesis was supported, but the effect was modest, $\beta = .136$, $p = .008$. This finding qualifies the role of absorptive capacity. Units that recognized, understood, transformed, and applied new knowledge were more likely to transfer design thinking. However, absorptive capacity was weaker than the artifact-based mechanism. This suggests that general learning capability helps, but it does not substitute for visible and reusable work infrastructure.

H4 predicted that boundary infrastructure would mediate the relationship between training design quality and the transfer of design thinking. This hypothesis was supported. The indirect effect was positive and statistically significant, $\beta = .142$, 95 percent CI [.088, .202]. This mediation result indicates that training design quality does not translate into everyday work only because participants learn useful methods. It supports transfer because training outputs are converted into infrastructure that can be found, reused, updated, and connected to decisions.

H5 predicted that cadence alignment would moderate the relationship between boundary infrastructure and the transfer of design thinking. This hypothesis was not supported ($\beta = .059$, $p = .251$). This result does not mean that cadence alignment is irrelevant. Rather, it means that cadence alignment did not operate as the expected interaction-based amplifier of boundary infrastructure. The exploratory refined model later suggests that cadence alignment may be better interpreted as a direct enabling condition.

H6 predicted that digital guardrails would moderate the relationship between AI-supported design work and the transfer of design thinking. This hypothesis was not supported ($\beta = -.019$, p

= .705). Again, this does not mean that digital guardrails are unimportant. It means that they did not strengthen the AI-transfer relationship in the hypothesized conditional form. The exploratory refined model later suggests that digital guardrails may operate as a direct enabling condition among AI-using teams.

Table 7. Confirmatory hypothesis tests

Hypothesis	Path or test	Estimate	p-value or CI	Result
H1	TDQ → BI	$\beta = .484$	$p < .001$	Supported
H2	BI → DTT	$\beta = .290$	$p < .001$	Supported
H3	AC → DTT	$\beta = .136$	$p = .008$	Supported, modest
H4	TDQ → BI → DTT	$\beta = .142$	95% CI [.088, .202]	Supported
H5	BI × CA → DTT	$\beta = .059$	$p = .251$	Not supported
H6	AIW × DG → DTT	$\beta = -.019$	$p = .705$	Not supported

Note. H1 uses BI as the dependent variable. H2, H3, and H5 are estimated in the opportunity-confirmed DTT model with TDQ, BI, AC, CA, TC, LS, and the BI × CA interaction. H6 is estimated in the AI opportunity-confirmed subgroup.

4.5 Comparison of Supported and Unsupported Effects

The hypothesis tests show a consistent infrastructure-mediated pattern. Training design quality predicted boundary infrastructure, boundary infrastructure predicted transfer, and the indirect pathway from training design quality to transfer through boundary infrastructure was supported. These results show that the strongest transfer mechanism was not training exposure alone, but the conversion of training outputs into reusable and governed work infrastructure.

The unsupported moderation results qualify this interpretation. Cadence alignment and digital guardrails did not strengthen the expected focal relationships in interaction form. The subsequent refined model was exploratory, so it should not be treated as confirmation of new hypotheses. Instead, it suggests a theoretically plausible direct-enabler interpretation that future studies should test. Boundary infrastructure appears to carry design thinking across people, projects, and time, while cadence alignment and digital guardrails may create conditions that help such practices recur and remain usable.

4.6 Refined Model

The refined model (Table 8) was estimated as an exploratory post hoc analysis after the confirmatory moderation tests were not supported. It should therefore be interpreted as model refinement rather than hypothesis confirmation. The purpose was to examine whether cadence alignment and digital guardrails, although not supported as interaction-based conditions, showed direct associations with transfer that were consistent with the qualitative evidence and the underlying work-system logic. In the primary refined model, training design quality, boundary infrastructure, absorptive capacity, cadence alignment, and transfer climate had significant direct associations with design thinking transfer. Boundary infrastructure remained the strongest mechanism, $\beta = .294$, $p < .001$. Cadence alignment was also significant, $\beta = .192$, $p = .001$, suggesting that recurring work rhythms may support transfer directly by giving design thinking repeated occasions for use. Transfer climate was significant, $\beta = .202$, $p < .001$, indicating that opportunity, peer support, supervisor support, and legitimacy remained important work-environment conditions.

Leadership support was not significant in the primary refined model after the other conditions entered, $\beta = .074$, $p = .123$. This result should not be interpreted as evidence that leadership is unimportant. Rather, it suggests that leadership may operate through more concrete work-system conditions such as climate, cadence, evidence expectations, or artifact governance. The qualitative findings support this interpretation by showing that general encouragement mattered less than managerial requests for visible evidence of design thinking use.

The AI subgroup refined model provides a similarly exploratory interpretation of the digital layer. AI-supported design work alone did not significantly predict transfer, $\beta = .090$, $p = .117$. Digital guardrails did, $\beta = .201$, $p < .001$. This pattern suggests that the transfer value of generative AI may depend less on AI use frequency than on governance practices that protect human-first framing, critical review, documentation, and avoidance of premature convergence. Because this interpretation comes from a refined model rather than the original confirmatory hypotheses, it should be treated as a theoretically grounded finding for future testing.

Table 8. Refined model results

Model	Path	Estimate	p value
Primary refined model	TDQ → DTT	$\beta = .215$	$p < .001$
	BI → DTT	$\beta = .294$	$p < .001$
	AC → DTT	$\beta = .134$	$p = .008$
	CA → DTT	$\beta = .192$	$p = .001$
	TC → DTT	$\beta = .202$	$p < .001$
	LS → DTT	$\beta = .074$	$p = .123$
AI subgroup refined model	TDQ → DTT	$\beta = .162$	$p = .007$

Model	Path	Estimate	p value
	BI → DTT	β = .247	p < .001
	AC → DTT	β = .164	p = .005
	CA → DTT	β = .204	p = .001
	TC → DTT	β = .197	p < .001
	LS → DTT	β = .118	p = .029
	AIW → DTT	β = .090	p = .117
	DG → DTT	β = .201	p < .001
	AIW × DG → DTT	β = -.019	p = .705

Note. Primary refined model R^2 = .450. AI subgroup refined model R^2 = .517.

4.7 Robustness Checks

Table 9 shows that the central results remained stable across robustness checks. In the full matched sample, boundary infrastructure remained significant, β = .230, p < .001. Training design quality also remained significant, β = .224, p < .001, and cadence alignment remained significant, β = .160, p = .009. Absorptive capacity weakened outside the opportunity-confirmed sample, β = .084, p = .095. This supports the primary sample decision because transfer is more meaningfully assessed among respondents who had an actual opportunity to apply design thinking.

Country-specific checks were used solely as robustness tests, not as formal country comparisons. Boundary infrastructure remained significant in both the Greece and Cyprus subsamples. Because measurement invariance was not established in the manuscript, differences in coefficient size between Greece and Cyprus should be interpreted as exploratory signals rather than comparative findings.

The AI robustness checks reinforced the refined interpretation. Digital guardrails remained significant in the AI-opportunity-confirmed subgroup, whereas AI-supported design work alone did not. This finding contrasts with a simple technology-use explanation. The relevant issue is not whether teams use AI, but whether AI use is sequenced, reviewed, and governed in ways that preserve design thinking behaviors.

Table 9. Robustness checks

Robustness test	Sample	Key result
Full matched sample	n = 315	BI → DTT, β = .230, p < .001
		TDQ → DTT, β = .224, p < .001
		CA → DTT, β = .160, p = .009
		AC → DTT, β = .084, p = .095
Greece opportunity-confirmed subsample	n = 150	BI → DTT, β = .309, p < .001
		AC → DTT, β = .178, p = .020
		TC → DTT, β = .195, p = .010
Cyprus opportunity-confirmed subsample	n = 98	TDQ → DTT, β = .273, p < .001
		BI → DTT, β = .243, p = .001
		CA → DTT, β = .279, p < .001
		LS → DTT, β = .135, p = .046
AI opportunity-confirmed subgroup	n = 213	DG → DTT, β = .201, p < .001
		AIW → DTT, β = .090, p = .117
		AIW × DG → DTT, β = -.019, p = .705

Note. Country-specific results should be interpreted cautiously unless measurement invariance is confirmed.

4.8 Qualitative Explanatory Findings

The qualitative phase was used to explain the quantitative pattern. The 16 interviews contrasted high- and low-transfer cases across Greece and Cyprus and included both AI- and non-AI-use cases. The excerpts below are identified by anonymized participant ID, country group, transfer group, and AI exposure.

The first qualitative theme was that transfer occurs when artifacts become infrastructure. High transfer cases described design thinking outputs as living work objects rather than as workshop residues. In one Greek high transfer case, the participant explained that the journey map and onboarding blueprint were uploaded to a shared workspace, revised after initial assumptions proved inaccurate, and reviewed during monthly service improvement meetings. The participant summarized the transfer mechanism directly. “The blueprint had an owner, it was updated, and managers asked to see it” (P0110, Greece, high transfer, AI use). A Cypriot high transfer case showed the same mechanism in a non-AI setting. “It succeeded because the blueprint became a practical operating document, not a workshop memory” (P0307, Cyprus, high transfer, no AI use). These excerpts show that transfer depended on stewardship, updating, and decision use rather than on the presence of artifacts alone.

Low transfer cases showed the opposite pattern. Artifacts existed but remained disconnected from ownership, updating, and decisions. In one Greek low transfer case, the participant reported that workshop outputs were saved in a folder but were not reused. The participant concluded that “the workshop created energy but not responsibility” (P0047, Greece, low transfer, AI use). In a Cypriot low-transfer case, the journey map was sent as a PDF with no editable version, no owner, and no decision link. The participant stated that “it stayed as a workshop document” (P0240, Cyprus, low transfer, no AI use). These excerpts explain why boundary infrastructure mediated the relationship between training design quality and transfer. The decisive difference was not whether artifacts were created, but whether they became a maintained work infrastructure.

The second theme concerned cadence alignment. High transfer cases embedded design thinking practices into recurring reviews, planning cycles, approval routines, and project checkpoints. In one Greek high transfer case, the original journey map was converted into a checklist used before changes were approved for reporting. The participant explained that “the original workshop artifact changed form, but the practice survived” (P0132, Greece, high transfer, AI use). This case shows that the transfer did not require preserving the original artifact format. It required translating the artifact into a routine that the unit already used. By contrast, a Greek low transfer case showed how poor timing blocked transfer. “Our planning cycle had already closed, so the ideas had no route into the next quarter’s work” (P0079, Greece, low transfer, AI use). This contrast explains why cadence alignment emerged as a direct enabling condition. It gave design thinking repeated occasions for use.

The third theme concerned leadership support as evidence expectation rather than general encouragement. In high transfer cases, managers did not merely approve attendance at a workshop. They asked teams to show evidence of user input, updated maps, blueprints, feedback logs, or tested assumptions before making decisions. In the Greek high transfer case P0110, managers treated the artifact as legitimate because the team had to present the updated journey map when proposing process changes. In the Cypriot high transfer case P0260, the director asked what users said before approving the next iteration. These examples clarify why leadership support was not always a significant direct predictor in the primary refined model. Leadership mattered most when it changed what teams had to show during routine decisions.

The fourth theme concerned digital guardrails. High-transfer AI cases did not use AI as the primary source of problem definition. They used it after human framing, user input, or initial idea generation. A Cypriot high transfer participant described this sequencing clearly. “We first created ideas ourselves, then used AI to elaborate them. We did not accept AI output without checking it against user feedback" (P0095, Cyprus, high transfer, AI use). A Greek high transfer case showed the same logic. AI was used to draft alternative report explanations only after the team had agreed on the main user problem. The participant stated, "We decided not to use AI to define user needs" (P0132, Greece, high transfer, AI use). These excerpts explain why digital guardrails directly predicted transfer in the AI subgroup.

Low-transfer AI cases highlighted the risks of unguarded AI use. In one Cypriot low-transfer case, AI was heavily used to generate concepts and draft a presentation. The participant reflected that "AI was used almost from the start. Looking back, I think it shaped the ideas too quickly" (P0220, Cyprus, low transfer, AI use). The same participant summarized the failure by saying, "The team moved to presentation mode, not learning mode" (P0220, Cyprus, low transfer, AI use). A second low-transfer AI case showed that AI generated quick suggestions, but many were obvious and did not foster ownership. These cases show that AI use alone did not support transfer when it encouraged premature convergence or polished outputs without learning.

The fifth theme concerned absorptive capacity as translation capacity. High transfer cases converted design thinking into local operating forms. The strongest example was the Greek case, where a journey map was converted into an approval checklist. This translation allowed the practice to survive even after the original workshop format faded. Low transfer cases lacked this conversion mechanism. A Cypriot low transfer participant explained that "there was no system for converting training into action" (P0294, Cyprus, low transfer, no AI use). This excerpt clarifies why absorptive capacity was significant but modest in the quantitative model. Transfer required more than understanding the design thinking language. It required a local system to convert training into shared routines, artifacts, and decision-making practices during the observed application period.

4.9 Mixed-Methods Integration

The quantitative and qualitative findings converge around one central inference. Design thinking transfer depends on whether workshop outputs become boundary infrastructure. The survey results showed that boundary infrastructure mediated the relationship between training design quality and transfer. The interviews explained this mediation by showing the contrast between artifacts that became living work objects and artifacts that decayed into static records.

The mixed methods evidence also refines the original model. Cadence alignment and digital guardrails were hypothesized as moderators, but the quantitative interaction effects were not supported. The qualitative cases explain this pattern by showing that cadence alignment created recurring opportunities for artifact use, while digital guardrails shaped the timing, quality, and review of AI-supported design work. Both conditions, therefore, appeared more clearly as direct enablers than as interaction-based amplifiers. Overall, the mixed-methods evidence indicates that design thinking transfer is strongest when training outputs become maintained artifacts embedded in recurring work routines. Table 10 presents the joint display of mixed methods, linking the quantitative findings with the qualitative explanations and integrated inference.

Table 10. Mixed methods joint display

Quantitative finding	Qualitative explanation	Integrated inference
Training design quality predicted boundary infrastructure.	High transfer cases described artifacts designed around real work problems and later reused. P0300 linked later use to facilitator-led next steps and sponsor demand for user evidence.	Training design quality matters when it produces artifacts that survive beyond the training event and remain useful in operational work.
Boundary infrastructure predicted design thinking transfer.	High transfer cases showed artifact ownership, updating, meeting use, and decision linkage. P0110 and P0307 described blueprints as owned, updated, and used in review or approval discussions.	Boundary infrastructure functions as the primary carrier of design thinking transfer into everyday organizational practice.
Boundary infrastructure mediated the relationship between training design quality and transfer.	Low transfer cases described artifacts that were converted to static files, PDFs, slides, or personal notes. P0047 and P0240 showed that artifacts existed but had no owner or decision link.	Training transfers through living artifacts embedded in work processes rather than through workshop exposure alone.
Absorptive capacity had a significant but modest effect on transfer	High transfer cases translated design thinking into local routines, while low transfer cases retained learning at the individual level. P0132 translated a journey map into an approval checklist, while P0294 reported no system for converting training into action.	Absorptive capacity supports transfer when organizations convert learning into context-specific operational practices.
Cadence alignment was not supported as a moderator, but was significant as a direct enabler of transfer.	High transfer cases embedded design thinking activities into reviews, planning cycles, checkpoints, and decision routines. P0079 showed that transfer weakened when the planning cycle had already closed.	Cadence alignment creates recurring opportunities for design thinking use and supports repeated early workplace application.
Digital guardrails were not supported as a moderator but directly predicted transfer in the AI subgroup.	High-transfer AI cases used AI after human framing and problem definition, while low-transfer AI cases relied on AI too early or without sufficient review. P0095 used AI after team ideation, while P0220 described early AI	Digital guardrails may support transfer by governing the timing, oversight, and appropriate use of AI-supported design

use as moving the team to presentation mode. work.

Figure 2 presents the exploratory refined empirical model derived from integrating the survey and qualitative findings. The model retains the confirmatory-supported relationships and the exploratory direct-enabler relationships identified following the unsupported moderation tests. Cadence alignment, transfer climate, and digital guardrails are therefore presented as theoretically grounded relationships for future testing rather than as originally hypothesized effects.

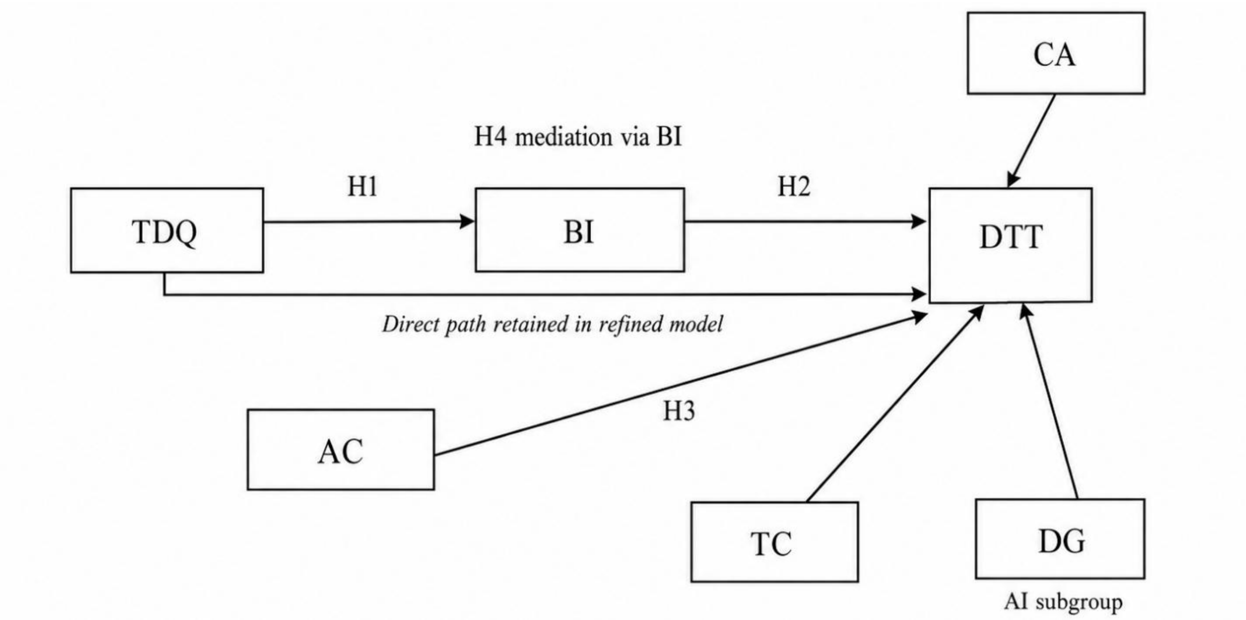

Figure 2. Refined empirical model

Note. The figure reports the exploratory refined model. Unsupported interaction paths and the non-significant AI-supported design work direct path are omitted.

5. Discussion

The findings support a cautious interpretation of design thinking transfer as an early operational embedding process. The two-wave design strengthens temporal ordering because predictors and outcomes were not measured at the same time, but the evidence remains associational rather than causal. Within that boundary, the results suggest that training design quality is linked to later transfer, partly because workshop outputs serve as boundary infrastructure. The theoretical significance is not that boundary infrastructure replaces transfer-of-training theory. Rather, it specifies an artifact-centered and work-system mechanism through which transfer can occur when design thinking outputs are maintained, owned, reused, and connected to operational decisions.

The findings extend research on the design thinking transfer gap [2] by explaining why knowledge may fail to become practice. The gap arises when workshop outputs remain disconnected from ownership, updating, and decision-making. It narrows when artifacts become living work objects that structure later action.

The study also responds to the operations-oriented call to connect design thinking with process measures and implementation conditions [3]. The findings show that design thinking transfer is governed by the work system rather than by workshop completion alone. The results refine the transfer-of-training theory by adding an artifact-based mechanism. Prior transfer research emphasizes training design, work environment, support, and opportunity to perform [4]. The findings are consistent with that logic, but they further suggest that design thinking transfer also depends on material and procedural carriers. Learned behaviors persist when they are embedded in objects that can be found, revised, reused, and connected to decisions. Boundary infrastructure, therefore, provides a concrete bridge between learning transfer and operational embedding.

The findings also extend boundary object and boundary infrastructure research [5], [8], [9], [15]. Boundary objects support coordination across knowledge communities, but this study shows that design thinking artifacts become consequential only when they are maintained as infrastructure. The difference is practical. A workshop artifact may support temporary communication, while boundary infrastructure supports repeated coordination across projects and time.

Absorptive capacity was significant but modest, which supports the construct while qualifying its role in design thinking transfer. The evidence suggests that absorptive capacity matters most when it becomes translation capacity. Units transfer design thinking more effectively when they convert new knowledge into local operating forms rather than leaving it as individual understanding.

The unsupported moderation findings refine the model but do not confirm the original conditional hypotheses. Cadence alignment was expected to strengthen the relationship between boundary infrastructure and transfer, yet the interaction was not significant. The exploratory refined model and the qualitative evidence instead suggest a direct-enabler interpretation. Cadence alignment appears to matter because it gives design thinking a recurring place in reviews, checkpoints, product meetings, service improvement routines, and resource discussions. In this interpretation, cadence alignment does not amplify boundary infrastructure only when the infrastructure is already strong. It creates repeated opportunities to enact design thinking practices.

The AI results should be interpreted with the same caution. Digital guardrails did not moderate the relationship between AI-supported design work and transfer as hypothesized. However, the exploratory refined model suggests that guardrails may directly support transfer among AI-using teams by governing when AI enters the process, how outputs are reviewed, and whether human framing occurs before AI-supported elaboration. This interpretation aligns with recent evidence that generative AI can narrow idea diversity when used as an early brainstorming source [6], while also recognizing that AI can support exploration when deliberately configured and critically reviewed [7]. The contribution is therefore not that AI automatically improves the design thinking transfer. It is that AI-related transfer depends on governance practices that protect human-led inquiry, review, and learning.

The managerial implication is direct. Organizations should design for transfer before the workshop begins by assigning artifact owners, defining update routines, linking artifacts to decision points, and embedding artifact use into existing cadences. This turns design thinking outputs from workshop evidence into operational infrastructure.

The AI implication is equally direct. Organizations should govern generative AI as a support tool rather than as the first source of problem definitions or solutions. Human framing and initial divergence should precede AI use, while AI outputs should be reviewed, documented, and connected to design reasoning.

The study has limitations that should guide interpretation. The two-wave design strengthens temporal ordering, but the four-to-six-week interval is too short to demonstrate long-term routinization or institutionalization. The findings, therefore, speak to early workplace application and initial embedding rather than definitive sustained transfer. The study also relies on respondent reports, which may reflect perceptual bias, common-source effects, and respondents' general innovation orientation. Temporal separation, opportunity-confirmed sampling, HTMT assessment, and collinearity diagnostics reduce some risks, but they do not eliminate alternative explanations. Future studies should use longer time horizons, multisource data, repository records, meeting agendas, artifact version histories, project management systems, and decision logs to examine whether design thinking artifacts are actually updated, reused, and linked to decisions over time. The measurement system also requires further validation because several constructs were developed for this study. Future research should replicate the scales, test measurement invariance across countries and sectors, examine criterion validity using behavioral or trace data, and assess whether shorter measures preserve content coverage, reliability, and discriminant validity.

Future studies should also use digital trace data to strengthen the operational measurement of transfer. Repositories, version logs, project systems, meeting agendas, decision records, and prototype histories could show whether artifacts are actually updated and reused. Field experiments could test whether artifact stewardship, cadence integration, and AI guardrail protocols improve transfer over time.

6. Conclusions

This study provides initial empirical support for the argument that design thinking transfer depends on converting workshop outputs into boundary infrastructure. Training design quality was associated with stronger boundary infrastructure, and boundary infrastructure was associated with later design thinking transfer. The evidence suggests that design thinking was more likely to persist during the observed period when artifacts were maintained, owned, reused, and linked to operational decisions. The study also offers an exploratory refinement of the digital layer. AI use alone did not explain transfer, while digital guardrails showed a direct association with transfer among AI-using respondents. These findings should be interpreted as evidence of early workplace embedding rather than definitive proof of long-term routinization. Future research should test the model over longer periods, across additional contexts, and using objective trace data.

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Conflicts of Interest

The authors confirm that there are no conflicts of interest.

Data availability

The anonymized data supporting the findings of this study are available from the author upon reasonable request.

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