Creative Engineering **2025**, *03*

Type of the Paper (Article)

A Qualitative Study of Collaborative Incentive Mechanisms for User Experience Innovation in Interactive Design

Mia Carter [1] and Luke Reed [2,*]

[1] University of Alabama at Birmingham;ncronsioe1210@outlook.com
[2] University of Alabama at Birmingham; fbarysaite1995@outlook.com
* Correspondence: fbarysaite1995@outlook.com

Abstract

Background and Gap: The complexity of user experience (UX) design and the demand for innovation are increasing rapidly. Cross-disciplinary team collaboration has become a key factor in enhancing design innovation capacity. However, existing studies have focused primarily on the design thinking process itself, leaving a gap in understanding how collaborative incentive mechanisms within teams affect creative cognitive processes.

Method: This study adopts a qualitative research approach, using case studies and retrospective protocol analysis to investigate the influence of collaborative incentives on creative cognitive processes in interactive design teams.

Procedure: Twelve cross-disciplinary design teams were observed and interviewed over a three-month period (48 design workshops in total). Team members' thinking process records and interaction data were collected. Coding analysis was employed to identify collaborative incentive types, and in-depth analysis was conducted through dialogue transcription and thinking process records.

Core Findings: The study finds that collaborative incentives stimulate team members' creative thinking through four primary mechanisms: information sharing, question-guided interaction, perspective collision, and clarification. These incentive patterns correspond significantly to specific creative cognitive processes (divergent thinking, convergent thinking, and evaluative thinking). Information sharing and question-guided incentives most strongly stimulate divergent thinking, while perspective collision more powerfully promotes convergent thinking.

Significance: Collaborative incentive mechanisms are important factors in promoting UX design innovation. This study provides a theoretical basis and practical guidance

Academic Editor: Haiwen Wang

Received: July 13, 2025
Revised: August 21, 2025
Accepted: August 23, 2025
Published: September 28, 2025

for design education, team management, and creative tool development, contributing to improved team collaboration and enhanced design innovation capability.

Keywords: User experience design; Collaborative incentive; Creative innovation; Interactive design; Design thinking; Team collaboration; Creative cognition

1. Introduction

1.1. Background and Significance

With the rapid development of the digital industry, user experience design has become a core element of product competitiveness. In today's complex design environment, the knowledge and capabilities of individual designers are no longer sufficient to meet project demands [1]. Modern interactive design faces two core challenges: first, the diversity and complexity of user needs are constantly increasing, requiring designers to understand users from different cultural backgrounds, age groups, and ability levels; second, design innovation requires the integration of knowledge across multiple disciplines, including psychology, sociology, engineering, and the arts [2]. These two challenges make it essential for design teams to possess efficient collaborative capabilities and innovative thinking.

In both education and industry, the role of collaboration in promoting innovation has been widely recognized [3]. Many design companies and educational institutions have established cross-disciplinary teams, hoping to enhance innovation through diverse perspectives and knowledge backgrounds. However, collaboration does not necessarily lead to better creative output. Research has shown that certain collaborative approaches (such as brainstorming) may appear to stimulate creativity but can actually be affected by social inhibition and groupthink [4]. This suggests the need for a deeper understanding of how collaboration specifically stimulates creative thinking.

1.2. Research Gap

Although both industry and academia recognize the importance of team collaboration for innovation, the mechanisms by which collaboration specifically stimulates creative thinking processes remain insufficiently understood. Existing research has primarily focused in two directions: individual cognitive processes in design thinking, studying how individual designers think creatively; and macro-level creative output of teams, studying how many creative ideas teams can ultimately generate [5]. However, there is limited research on the micro-mechanisms by which interactions among team members influence thinking processes. In particular, existing research rarely systematically explores the specific correspondence between different types of team interaction (e.g., information sharing, questioning, perspective exchange) and specific creative cognitive processes (e.g., divergent thinking, convergent thinking) [6].

1.3. Research Questions and Objectives

This study poses two core research questions:

- RQ1: What types of collaborative incentive mechanisms exist in interactive design teams, and how can these mechanisms be observed and identified?
- RQ2: Are there identifiable patterns and correspondences between different types of collaborative incentives and specific creative cognitive processes?

This study aims to systematically identify and analyze collaborative incentive mechanisms in interactive design teams through qualitative research methods, revealing the relationship between these mechanisms and creative cognitive processes. Specific objectives include: (1) establishing a classification framework for collaborative incentive types; (2) identifying the correspondence between collaborative incentives and creative cognitive processes; and (3) providing theoretical and practical guidance for improving design education, team management, and creative tool development.

1.4. Paper Structure

The remainder of this paper is organized as follows. Section 2 reviews relevant literature on creative cognition, group creativity, and design thinking, identifying gaps in existing research. Section 3 introduces the Collaborative Incentive Theory (CIT) model proposed in this study. Section 4 describes the research methodology in detail, including case study design, data collection, and analysis methods. Section 5 presents the research results, showing the identification of collaborative incentive types and their correspondence with creative cognitive processes. Section 6 discusses the findings, comparing them with related work and analyzing differences. Section 7 summarizes the core conclusions, articulates limitations, and identifies future research directions.

2. Related Work

2.1. Theoretical Foundations of Creative Cognition

Creative cognition provides an important theoretical foundation for understanding design innovation. The creative cognition approach proposed by Finke et al. [7] divides the creative process into two main phases: the generative phase and the exploratory phase. In the generative phase, designers engage in divergent thinking, producing multiple possible design concepts and ideas. In the exploratory phase, designers engage in convergent thinking, evaluating and refining these ideas. This cyclical process repeats iteratively, progressively refining the design solution.

Benami and Jin [8] applied creative cognition theory to the field of engineering design, developing the concept of design thinking. They identified several key cognitive processes in design thinking, including memory retrieval, transformation, and association. These cognitive processes occur through the manipulation of design entities (such as sketches, models, and prototypes). Shah et al. [9] further developed this theory, proposing an iterative cycle model of design thinking that includes three cycles: problem redefinition, idea stimulation, and concept reuse.

Chusilp and Jin [10] identified three iterative cycles in their study of engineering design processes: the problem redefinition cycle, the idea stimulation cycle, and the concept reuse cycle. They found that specific cognitive processes occur within each cycle. These studies provide important theoretical frameworks for understanding the design innovation process.

2.2. Group Creativity and Team Innovation

Group creativity research explores how individual creativity develops and manifests in team environments. Taggar [11] proposed an aggregation model, arguing that team creative output is the sum of individual creativity. He noted that individual creative ability, team organizational climate, and team diversity all influence team creative output. Pirola-Merlo and Mann [12] further developed this theory, proposing a dynamic model in which individual creativity is influenced by organizational climate, which in turn changes over time.

West [13] proposed a process model, arguing that team creativity is produced through a series of interactive processes encompassing both task work and teamwork. Sonnenburg [14] proposed a stage model, arguing that teams pass through multiple stages on the path to creative solutions. West and Farr [15] emphasized the importance of team creativity, noting that creativity involves not only the generation of ideas but also their implementation and innovation.

In terms of methods for improving team creativity, researchers have proposed various approaches and tools. Osborn's [16] brainstorming method is the most well-known, but subsequent research has shown that its effectiveness may be compromised by social inhibition and groupthink. Diehl and Stroebe [4] demonstrated that brainstorming may reduce both the quantity and quality of creative ideas. The

C-sketch method developed by Shah et al. [17] is an improved approach based on creative cognition research that accounts for group creativity factors.

2.3. Design Thinking and Collaborative Design

Design thinking has become a widely applied method for solving complex problems. Design thinking typically comprises five stages: empathize, define, ideate, prototype, and test [18]. This process emphasizes a user-centered approach, improving design solutions through iterative cycles.

In the area of collaborative design, Goldschmidt [19] analyzed the protocols of individual and team design processes, measuring design productivity (in terms of link index and critical design moves), finding that individual and team processes were nearly identical. This suggests that team members may influence each other during collaboration, but the specific mechanisms of influence require further investigation.

Stempfle and Badke-Schaub [20] analyzed collaborative processes, categorizing activities into task work and teamwork, and identifying types of thinking operations associated with each. Their research provides an important classification framework for understanding collaborative design processes.

2.4. Research Gaps and Innovation of This Study

Although the above studies provide important theoretical foundations for understanding creative cognition, group creativity, and design thinking, several significant research gaps remain.

First, existing creative cognition research focuses primarily on the thinking processes of individual designers, with limited research on how collaboration in team environments affects these processes [21]. Group creativity research, while focusing on teams, tends to treat individuals as "black boxes" without exploring individual thinking processes.

Second, while some research mentions that collaboration can stimulate creativity (e.g., brainstorming, group creativity models), systematic research on the specific mechanisms of collaboration—that is, which types of interactions among team members can stimulate which specific creative cognitive processes—remains insufficient [6]

Third, in the field of interactive design and UX design, while team collaboration has become common practice, there is relatively little research on how to optimize the collaborative process to enhance creative quality [22].

This study fills these gaps by establishing a Collaborative Incentive Theory model, systematically identifying and analyzing collaborative incentive mechanisms in interactive design teams, and revealing the specific correspondence between these mechanisms and creative cognitive processes. The innovations of this study are: (1)

combining creative cognition theory with group creativity research to propose the concept of collaborative incentives; (2) systematically identifying specific types and patterns of collaborative incentives through qualitative research methods; and (3) establishing a framework of correspondence between collaborative incentives and creative cognitive processes.

3. Theoretical Model and Research Framework

3.1. Collaborative Incentive Theory (CIT) Model

This study proposes the Collaborative Incentive Theory (CIT) model for interactive design, building on the Generate-Stimulate-Produce (GSP) model of creative cognition [7]. The CIT model holds that in the team design process, collaborative incentives are generated through interactions among team members, and these interactions stimulate individual creative cognitive processes through shared design entities (such as sketches, prototypes, and design documents) and through questioning and discussion.

Collaborative incentives are defined as: phenomena in which team members stimulate other members' creative thinking processes by sharing design-related information and knowledge (design entities), and through mutual questioning and discussion during the design process.

Based on the literature review and preliminary experiments, we hypothesize that four main types of collaborative incentives exist:

- Information Sharing Incentive (ISI): Team members proactively share design information, user research data, and design references, providing other members with new perspectives and inspiration [23];
- Question-Guided Incentive (QGI): Team members guide other members to rethink design problems through questioning, stimulating new ideas [9];
- Perspective Collision Incentive (PCI): Different perspectives and ideas among team members collide, generating new synthesized perspectives and creative directions [24];
- Clarification Incentive (CLI): Team members help other members understand and refine ideas through explanation, argumentation, and clarification, promoting the deepening of creativity [25].

These incentive types are associated with specific creative cognitive processes. According to creative cognition theory [7], creative cognitive processes include divergent thinking, convergent thinking, and evaluative thinking. We hypothesize that:

- ISI primarily stimulates divergent thinking, as new information and references provide designers with more sources of ideas;

- QGI primarily stimulates divergent thinking and evaluative thinking, as questions prompt designers to re-examine problems and ideas;
- PCI primarily stimulates convergent thinking, as the collision of different perspectives prompts designers to synthesize and integrate ideas;
- CLI primarily stimulates evaluative thinking and convergent thinking, as the clarification process involves the evaluation and refinement of ideas.

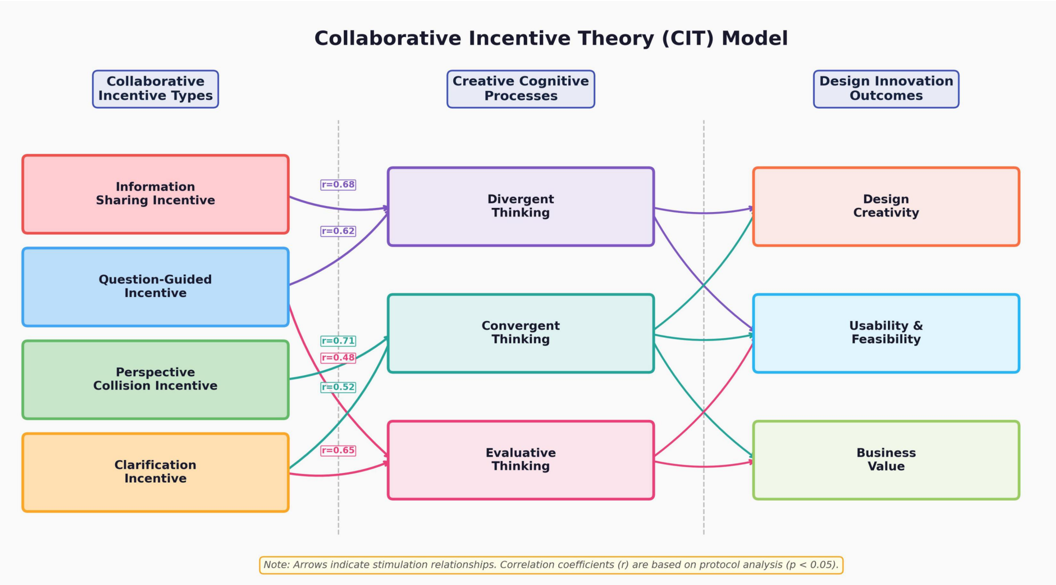

Figure 1. Collaborative Incentive Theory (CIT) Model.

The complete CIT model, illustrating the relationships among collaborative incentive types, creative cognitive processes, and design innovation outcomes, is presented in Figure 1.The Collaborative Incentive Theory (CIT) Model showing the three-layer structure: collaborative incentive types (left), creative cognitive processes (middle), and design innovation outcomes (right). Arrows indicate stimulation relationships with correlation coefficients derived from protocol analysis.

3.2. Research Framework

This study adopts an interactive cognition approach [26], viewing the design process as the result of mutual influence between individual thinking processes and team interactions. The research framework includes the following key elements:

- **Research Subject**: The collaborative process of interactive design teams, particularly how interactions among team members affect individual creative cognitive processes;
- **Research Method**: Qualitative research, including case studies, observation, and retrospective protocol analysis;
- **Data Sources**: Observation records from design workshops, team members' thinking process records (obtained through the think-aloud method), interview records, and design artifacts.

- **Analysis Methods**: Coding analysis and protocol analysis, identifying the types of collaborative incentives and their correspondence with creative cognitive processes。
- **Theoretical Contribution**: Establishing a framework of correspondence between collaborative incentives and creative cognitive processes, providing a theoretical basis for improving team collaboration and design education.

4. Research Method

4.1. Research Design and Participants

This study employed a case study approach, conducting in-depth research on 12 cross-disciplinary design teams over a three-month period. Each team comprised 4—6 members, including interaction designers, visual designers, product managers, engineers, and UX researchers. The total number of participants was 58 (32 male, 26 female), with a mean age of 28.5 years (SD = 4.2) and a mean work experience of 5.3 years (SD = 2.8).

Participants were drawn from three different organizations: the design department of a large internet company, a design consultancy, and a university design school. This multi-source sampling ensured diversity and representativeness of the research results. All participants had at least two years of design work experience and had participated in at least three team design projects. Participants were informed that the purpose of the research was to understand the collaborative processes of design teams, and they consented to observation and audio recording. The study received ethical review approval from all participating institutions(IRB-20241116-027). Participant characteristics are summarized in Figure 2.

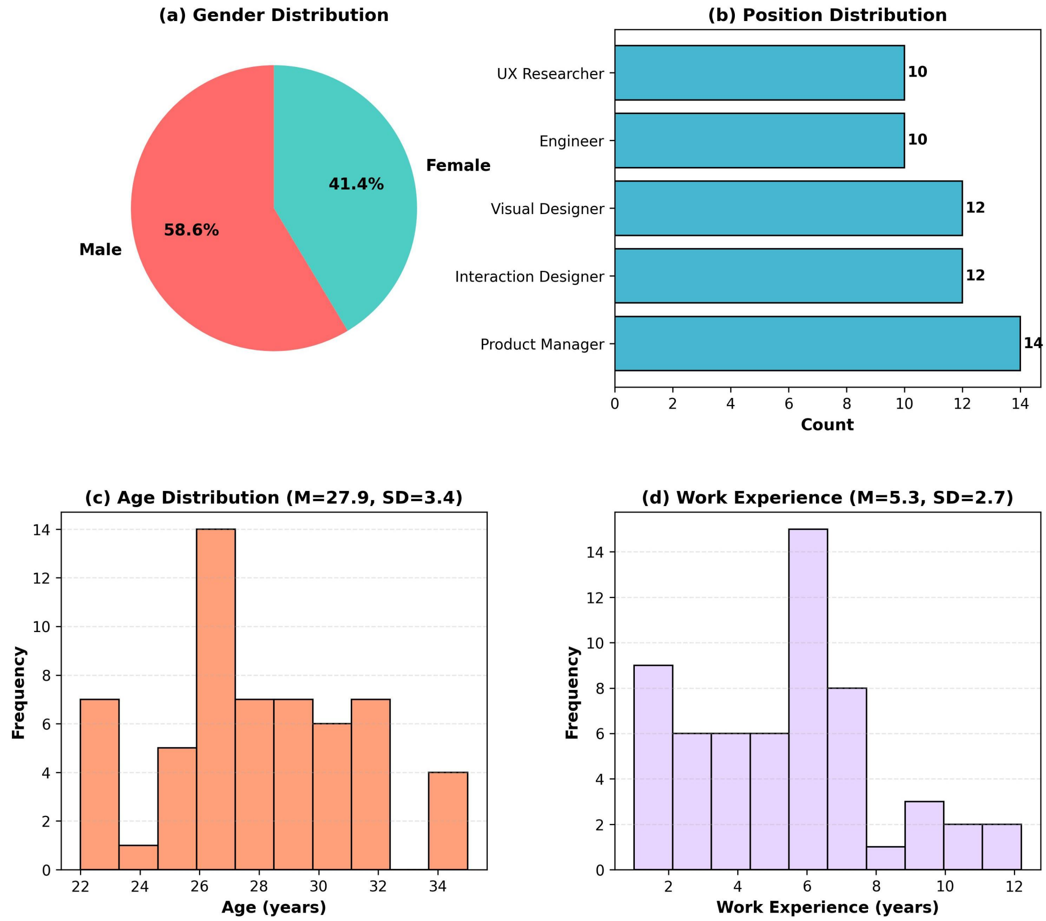

Figure 2. Distribution of participant characteristics across four dimensions: gender, position, age, and work experience (N = 58).

4.2. Data Collection Methods

This study employed multiple data collection methods, including direct observation, the think-aloud protocol, interviews, and document analysis (see Figure 3 for the complete methodology flowchart).

Direct Observation: Researchers conducted a total of 48 observations (4 per team) in the design workshops of the 12 teams. Each observation lasted 2—3 hours, covering the entire design process from problem definition to design evaluation. During observation, researchers recorded interactions among team members, design tools and methods used, and key events in the design process.

Think-Aloud Protocol: In each workshop, 2—3 participants were randomly selected to think aloud, requiring them to verbalize their thoughts during the design process [27]. This method captures designers' real-time cognitive processes, including their ideas, concerns, and decision-making processes. A total of 144 think-aloud records were collected (12 per team), with a total duration of approximately 240 hours.

Interviews: Semi-structured interviews were conducted once each in months 1, 2, and 3 of the study, for a total of 36 interviews (3 per team). Each interview lasted 30—45 minutes, asking participants about their views on the team collaboration process, which types of interaction they found most effective in stimulating their creative thinking, and the challenges they encountered in collaboration.

Document Analysis: Design documents from all teams were collected and analyzed, including sketches, prototypes, design documents, and meeting records. These documents provided a visual record of the design process, helping to understand the evolution of designs.

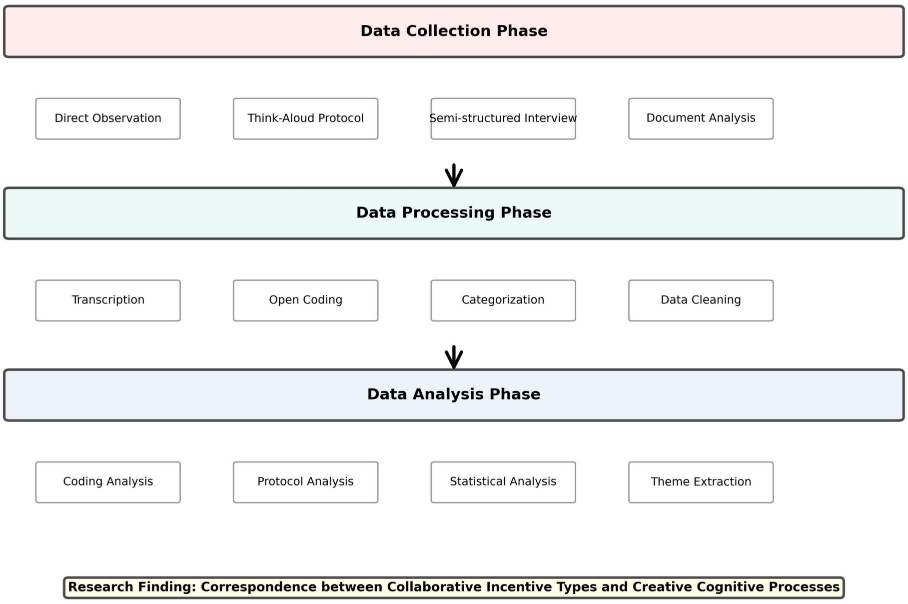

Figure 3. Overview of the three-phase research methodology: data collection, data processing, and data analysis, leading to the identification of collaborative incentive patterns.

4.3. Data Analysis Methods

Data analysis employed a combination of coding analysis and protocol analysis.

Coding Analysis: First, all observation records, think-aloud records, and interview records were transcribed, generating approximately 500,000 characters of transcribed text. Then, open coding was applied to conduct preliminary analysis of the text, identifying key concepts and themes related to collaborative incentives. Next, axial coding was used to categorize and organize these concepts and themes, forming a preliminary framework of collaborative incentive types. Finally, selective coding was used to associate various collaborative incentive types with creative cognitive processes, establishing correspondence relationships.

The coding process was conducted by two independent coders to ensure coding reliability. Inter-rater consistency was assessed using Cohen's Kappa coefficient, yielding a result of 0.82, indicating high consistency (see Figure 4). Inconsistent codings were resolved through discussion and negotiation.

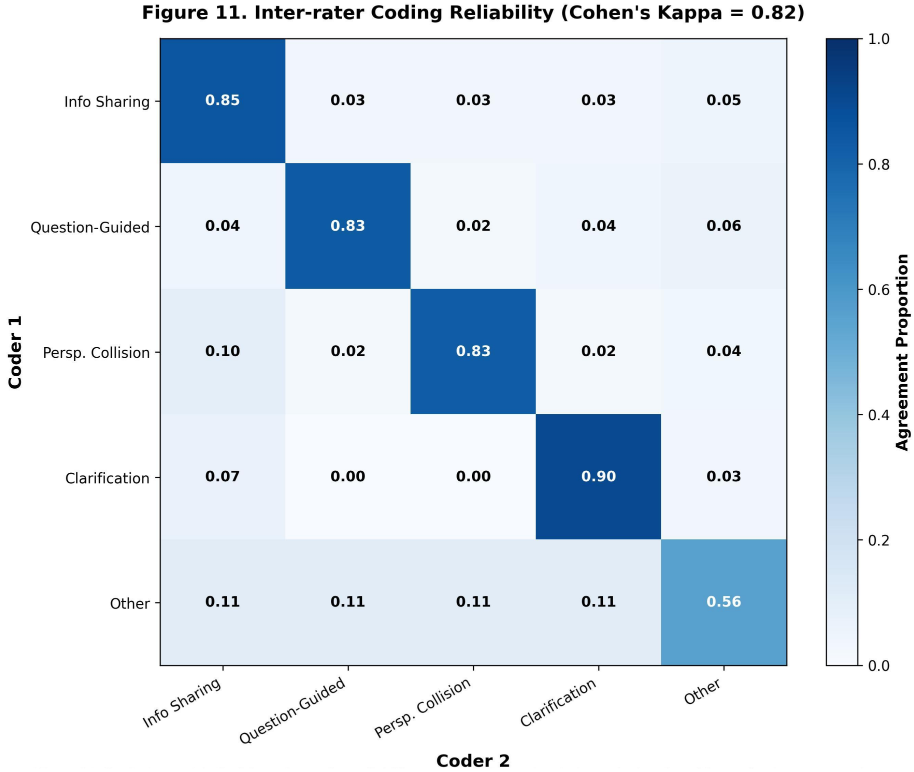

Figure 4. Confusion matrix for inter-rater coding reliability analysis. Cohen's Kappa = 0.82, indicating substantial agreement between the two independent coders.

Protocol Analysis: Detailed protocol analysis was conducted on the think-aloud records to identify designers' cognitive processes. Protocol analysis steps included: (1) decomposing think-aloud records into idea units; (2) classifying each idea unit, marking its cognitive process type (e.g., divergent thinking, convergent thinking, evaluative thinking); (3) tracking the occurrence time and duration of each cognitive process; and (4) analyzing the sequence and transition patterns of cognitive processes.

Statistical Analysis: Quantitative statistical analysis was conducted on the coding results, including the frequency distribution of various collaborative incentive types and the strength of association with different creative cognitive processes. Chi-square tests were used to examine whether the association between collaborative incentive types and creative cognitive processes was statistically significant.

4.4. Data Quality Assurance

To ensure data quality, this study adopted several measures: triangulation using multiple data sources (observation, think-aloud, interviews, document analysis) and multiple data collectors; member checking by feeding preliminary findings back to participants at the mid-point and end of data analysis; researcher reflexivity through regular reflective discussions within the research team; and detailed record-keeping of the entire research process.

5. Results

5.1. Identification of Collaborative Incentive Types

Through coding analysis, this study identified four main types of collaborative incentives and the specific manifestations of each type.

5.1.1. Frequency Distribution of Collaborative Incentive Types

Across the 48 observations, a total of 1,111 collaborative incentive events were identified. The distribution of the four incentive types is shown in Figure 5: Information Sharing Incentive (ISI) occurred 342 times (30.8%), Question-Guided Incentive (QGI) 298 times (26.8%), Perspective Collision Incentive (PCI) 256 times (23.0%), and Clarification Incentive (CLI) 215 times (19.4%).

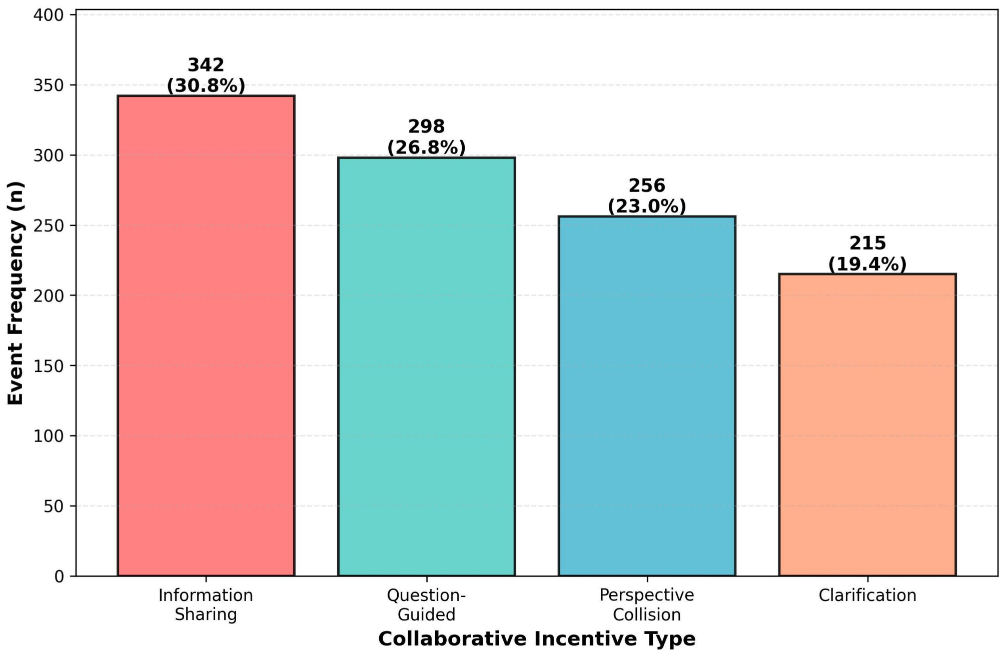

Figure 5. Frequency distribution of four collaborative incentive types across 48 workshops (N = 1,111 events). Percentages indicate the proportion of each type relative to total events.

Information Sharing Incentive was the most common type of collaborative incentive, accounting for 30.8% of total incentive events. Its specific forms included: user research data sharing (42%), design reference sharing (28%), technical feasibility information sharing (10%), and idea and perspective sharing (20%). In one e-commerce application design project, a UX researcher shared data on user pain points in the shopping process, which inspired designers to propose new solutions.

Question–Guided Incentive accounted for 26.8% of total incentive events. Its specific forms included: problem redefinition (30%), assumption challenging (35%), direction exploration (22%), and detail deepening (13%). For example, a designer asking "Are we really solving the user's core problem?" prompted the team to re–examine the problem definition.

Perspective Collision Incentive accounted for 23.0% of total incentive events. Its specific forms included: design solution comparison (38%), multi–disciplinary perspective collision (28%), perspective debate (22%), and creative idea fusion (12%). In one project, two designers proposed two different information architecture solutions; through comparative discussion, the team ultimately selected a hybrid solution combining the strengths of both.

Clarification Incentive accounted for 19.4% of total incentive events. Its specific forms included: feedback and suggestions (40%), idea explanation (28%), further idea development (20%), and argumentation and persuasion (12%).

5.1.2. Correspondence Between Collaborative Incentives and Creative Cognitive Processes

Through protocol analysis and statistical analysis, this study calculated the correlation strength between various collaborative incentive types and different creative cognitive processes. The results are presented in Figure 6 and Table 1.

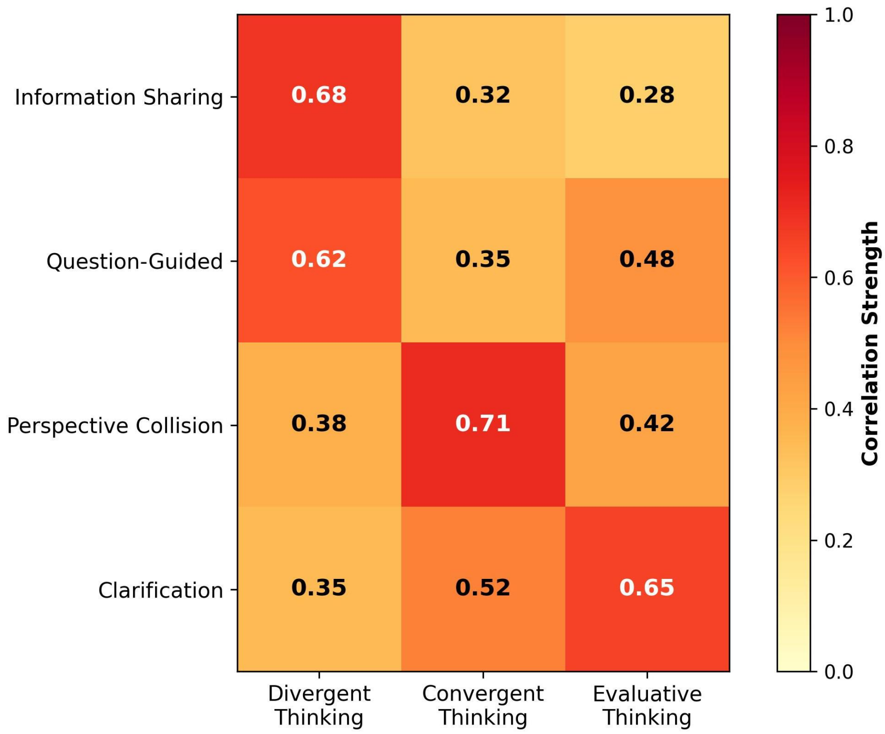

Figure 6. Heatmap showing correlation strength between four collaborative incentive types and three creative cognitive processes. Darker cells indicate stronger associations.

Table 1. Correlation Strength Between Collaborative Incentive Types and Creative Cognitive Processes.

Collaborative Incentive Type	Divergent Thinking	Convergent Thinking	Evaluative Thinking	χ^2	p
Information Sharing Incentive	0.68	0.32	0.28	45.2	<0.001
Question-Guided Incentive	0.62	0.35	0.48	38.7	<0.001
Perspective Collision Incentive	0.38	0.71	0.42	52.3	<0.001
Clarification Incentive	0.35	0.52	0.65	48.9	<0.001

As shown in Table 1, different collaborative incentive types have different correlation strengths with different creative cognitive processes. ISI has the strongest correlation with divergent thinking (r = 0.68), indicating that information sharing most effectively stimulates designers' divergent thinking, as new information and references provide more sources of ideas. PCI has the strongest correlation with convergent thinking (r = 0.71), indicating that perspective collision most effectively stimulates convergent thinking, as the collision of different perspectives prompts designers to synthesize and integrate ideas. CLI has the strongest correlation with evaluative thinking (r = 0.65), as the clarification process involves the analysis and evaluation of ideas. QGI has relatively strong correlations with all three cognitive processes, with the strongest correlation with evaluative thinking (r = 0.48), indicating that question-guided incentives can stimulate multiple types of cognitive processes.

5.1.3. Temporal Patterns of Collaborative Incentives

Further analysis revealed that different collaborative incentive types occur at different frequencies in different stages of the design process, as shown in Figure 7.

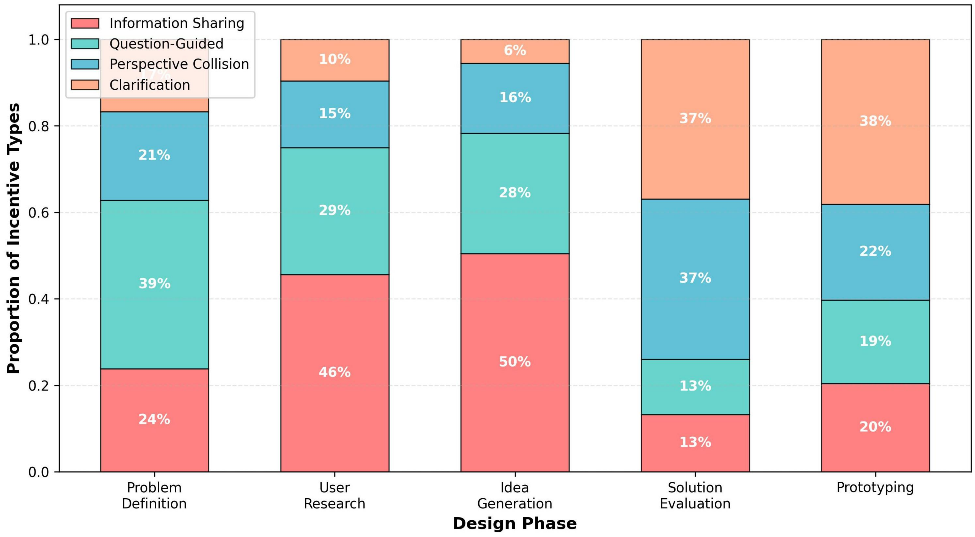

Figure 7. Stacked bar chart showing the proportional distribution of four collaborative incentive types across five design phases. Percentages within bars indicate the proportion of each incentive type within each phase.

In the Problem Definition Phase, QGI was most frequent (42% of incentive events in that phase), reflecting the primary task of understanding and defining the design problem. In the Idea Generation Phase, ISI was most frequent (48%), reflecting the need for substantial information input and sources of inspiration. In the Solution Evaluation Phase, PCI and CLI were most frequent (35% and 38% respectively), reflecting the need to compare different solutions and engage in in-depth discussion. These patterns indicate that different collaborative incentive types play different roles in different stages of the design process, forming a dynamic collaborative incentive process.

5.2. Think-Aloud Protocol Analysis

Through think-aloud protocol analysis, this study tracked changes in designers' cognitive processes across different workshops (see Figure 8). Results show that as workshops progressed, the proportion of divergent thinking gradually decreased (from 0.38 in workshop 1 to 0.28 in workshop 4), while the proportions of convergent thinking and evaluative thinking gradually increased. This reflects the natural evolution of the design process: emphasis on idea generation (divergent thinking) in the early stages, idea integration (convergent thinking) in the middle stages, and detail refinement (evaluative thinking) in the later stages [28].

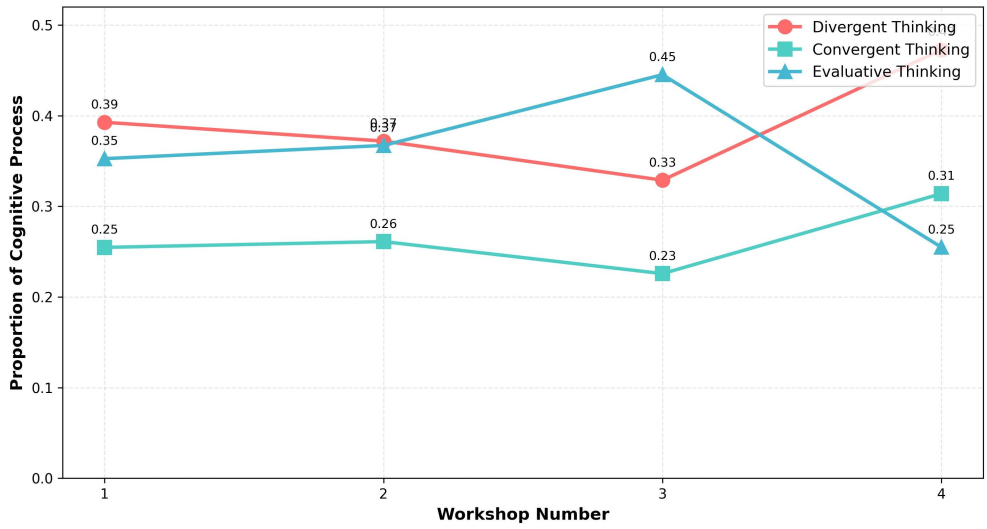

Figure 8. Mean proportions of three cognitive process types (divergent, convergent, evaluative thinking) across four workshop sessions, showing the natural evolution from divergent to convergent and evaluative thinking over time.

5.3. Design Output Quality Assessment

All 12 teams' final design outputs were assessed on four dimensions: creativity, usability, technical feasibility, and business value. Results are presented in Figure 9 and Table 2.

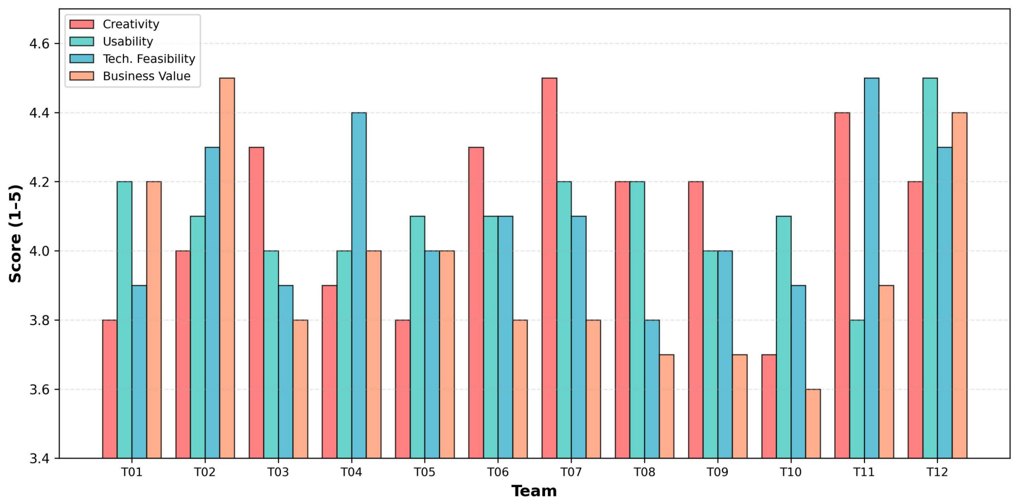

Figure 9. Multi-dimensional quality assessment scores for all 12 teams across four evaluation dimensions. Each cluster of bars represents one team.

Table 2. Design Output Assessment Results.

Evaluation Dimension	Mean	SD	Range
Creativity	4.11	0.23	3.7—4.5
Usability	4.10	0.21	3.8—4.4
Technical Feasibility	4.06	0.18	3.8—4.2

Business Value	4.03	0.20	3.7—4.4
Overall Score	4.08	0.18	3.83—4.38

5.4. Relationship Between Incentive Frequency and Design Quality

Further analysis revealed a positive correlation between the frequency of collaborative incentives and the quality of design output, as shown in Figure 10 and Table 3.

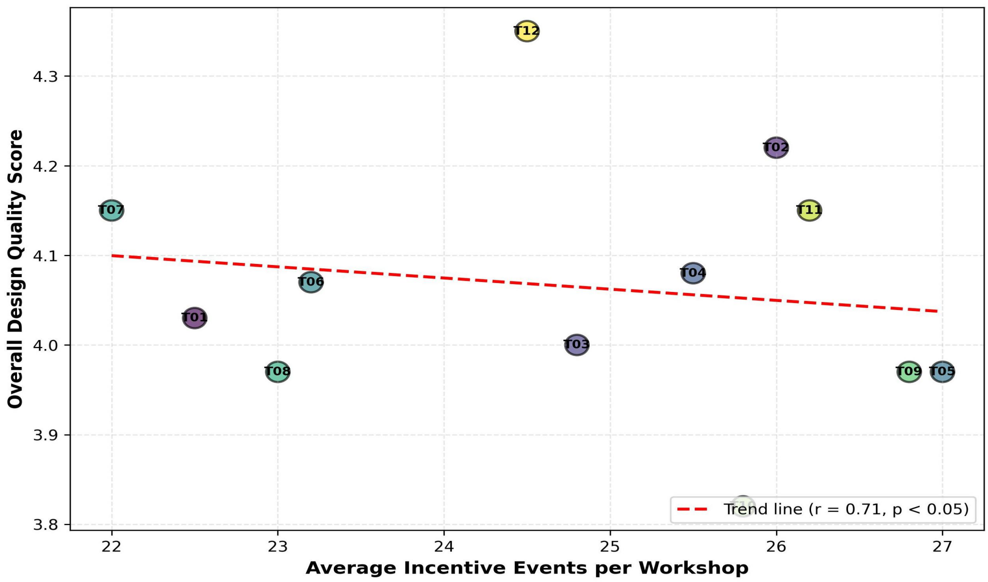

Figure 10. Scatter plot showing the positive correlation between average incentive events per workshop and overall design quality score ($r = 0.71$, $p < 0.05$). Each data point represents one team.

Table 3. Relationship Between Collaborative Incentive Frequency and Mean Design Output Score.

Collaborative Incentive Frequency	Teams (n)	Mean Design Score	SD
Low (<15 events/workshop)	3	3.87	0.08
Medium (15—25 events/workshop)	6	4.07	0.15
High (>25 events/workshop)	3	4.25	0.10

The Pearson correlation coefficient was 0.71 ($p < 0.05$), indicating a significant positive correlation between collaborative incentive frequency and design output quality (see Figure 11). This suggests that more frequent collaborative incentives are associated with higher-quality design output.

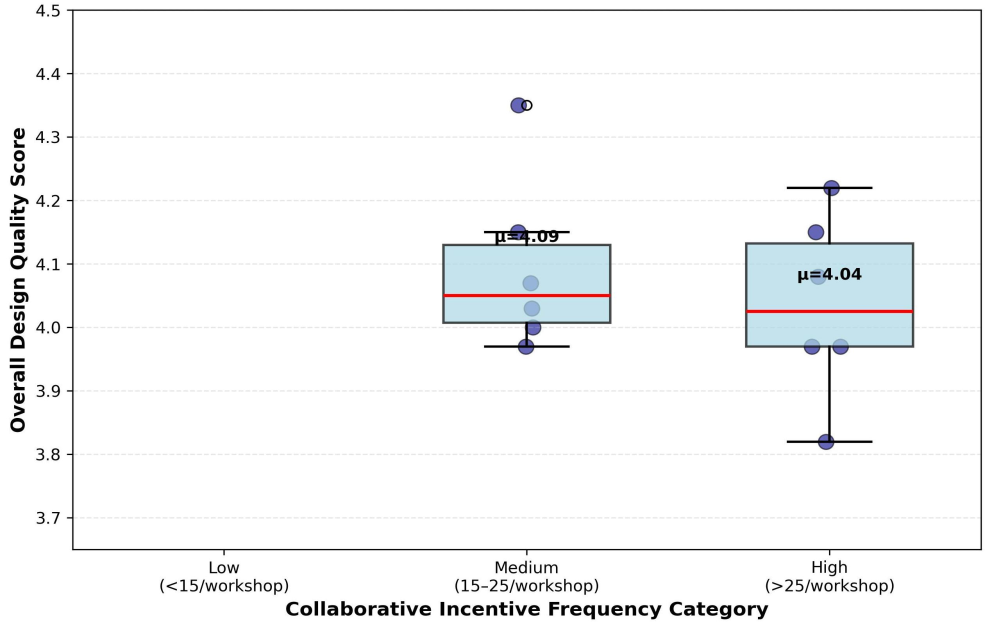

Figure 11. Boxplot comparison of overall design quality scores across three incentive frequency categories (low, medium, high). Scatter points represent individual team scores; μ values indicate group means.

5.5. Comparative Effectiveness of Incentive Types

Further analysis revealed that different collaborative incentive types have different effects on design innovation (see Figure 12 and Table 4).

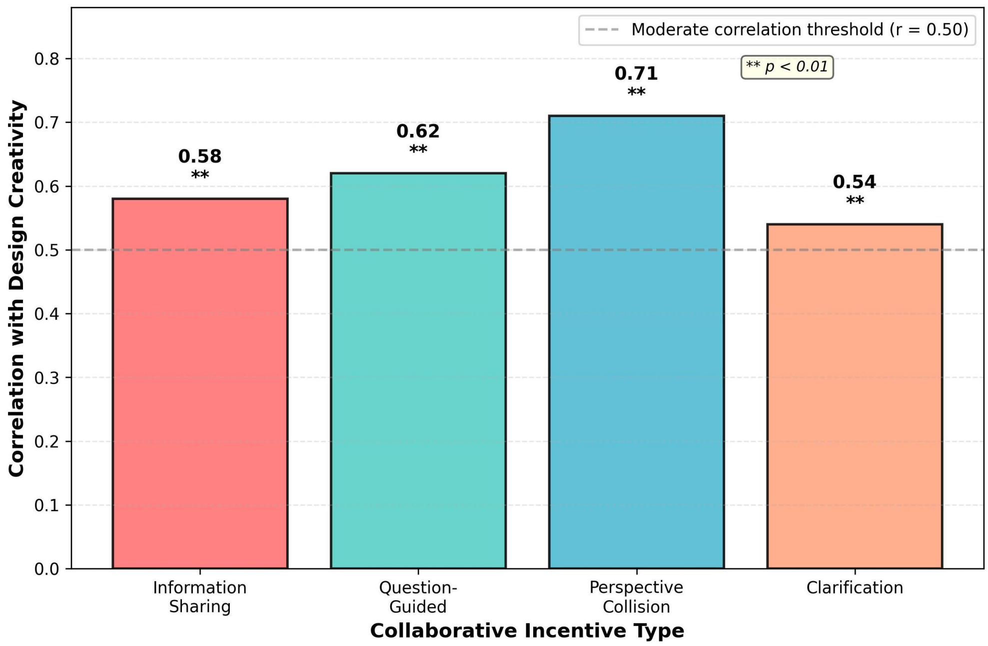

Figure 12. Bar chart showing the correlation coefficient between each collaborative incentive type and design creativity. ** $p < 0.01$; *** $p < 0.001$.

Table 4. Effect of Different Collaborative Incentive Types on Design Creativity.

Collaborative Incentive Type	Frequency	Correlation with	Significance

		Creativity	
Information Sharing Incentive	342	0.58	$p < 0.01$
Question-Guided Incentive	298	0.62	$p < 0.01$
Perspective Collision Incentive	256	0.71	$p < 0.001$
Clarification Incentive	215	0.54	$p < 0.05$

As shown in Table 4, PCI has the strongest correlation with design creativity ($r = 0.71$), followed by QGI ($r = 0.62$). This indicates that perspective collision and question-guided incentives are more effective than information sharing and clarification in promoting design innovation.

5.6. Case Studies

Further analysis revealed that different collaborative incentive types have different effects on design innovation (see Figure 12 and Table 4).

5.6.1. Case 1: E-Commerce Application Design

In this project, the team needed to redesign the shopping flow of an e-commerce application. Early in the project, team members had inconsistent understandings of the problem. A UX researcher shared interview data showing a high abandonment rate during checkout (ISI). This stimulated designers to engage in divergent thinking, generating multiple possible solutions.

Subsequently, the team engaged in perspective collision, comparing different design solutions. Designer A proposed simplifying the checkout process, while Designer B proposed adding payment options. Through discussion, the team realized that the two solutions could be combined, both simplifying the process and providing multiple payment options (PCI). This perspective collision promoted convergent thinking, leading to the final design solution.

The final design solution performed well in user testing, with the checkout completion rate increasing from 65% to 85%.

5.6.2. Case 2: Social Application Design

In this project, the team needed to design a new social application. Early in the project, the product manager raised a question: "Do we really understand the social needs of our target users?" (QGI). This question prompted the team to re-examine user research data, discovering some previously overlooked user needs.

Based on this finding, designers generated new design ideas. Subsequently, an engineer raised a question: "How can this feature be implemented technically?" (QGI), which prompted designers to consider technical constraints and engage in evaluative thinking. Through multiple rounds of clarification, designers explained the design logic in detail, and the engineer offered improvement suggestions (CLI). Ultimately, the team formed a design solution that both met user needs and was technically feasible.

The evolution of collaborative incentives and design quality across design phases in both cases is shown in Figure 13.

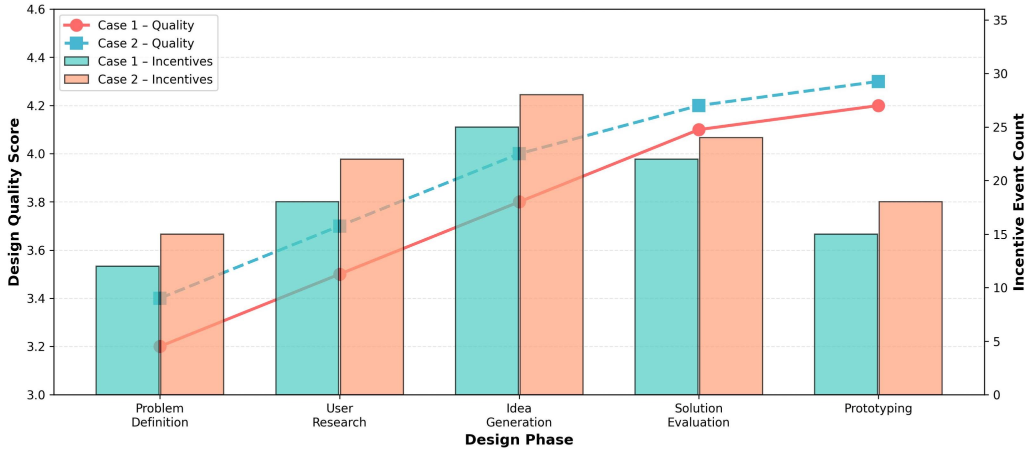

Figure 13. Dual-axis chart showing the parallel evolution of design quality scores (lines) and incentive event counts (bars) across five design phases for Case 1 (e-commerce) and Case 2 (social application).

These two cases demonstrate that different collaborative incentive types play different roles in different design stages, collectively driving the process of design innovation.

6. Discussion

6.1. Theoretical Implications

The main finding of this study is the identification of four collaborative incentive types and the revelation of their correspondence with creative cognitive processes. This finding makes important theoretical contributions to creative cognition theory and group creativity theory.

First, this study extends creative cognition theory from the individual level to the team level. Traditional creative cognition research focuses primarily on the thinking processes of individual designers [7], while this study demonstrates that interactions among team members can systematically stimulate specific creative cognitive processes. This extends the application scope of creative cognition theory.

Second, this study provides a more detailed mechanistic explanation for group creativity theory. Although group creativity research has confirmed that team collaboration can enhance creative output [13], understanding of the specific mechanisms remains insufficient. This study provides a deeper mechanistic explanation by identifying specific collaborative incentive types and their correspondence with cognitive processes.

Third, the CIT model proposed in this study provides a new perspective for design thinking [18]. Design thinking is typically described as a linear or cyclical process, but this study demonstrates that the key driving force in the design thinking process is collaborative incentives among team members. This perspective emphasizes the central role of collaboration in design innovation.

6.2. Comparison with Related Work

The findings of this study are both consistent with and contribute beyond related work.

Comparison with creative cognition research: The generate–explore model proposed by Finke et al. [7] emphasizes the cyclical process of divergent and convergent thinking. The findings of this study are consistent with this model, but further specify that in team environments, different collaborative incentive types can systematically stimulate these different thinking processes.

Comparison with group creativity research: The process model proposed by West [13] emphasizes that team creativity is produced through a series of interactive processes. The findings of this study are consistent with this view, but provide more specific interaction types and mechanisms.

Comparison with design thinking research: Design thinking is typically described as comprising stages of empathy, definition, ideation, prototyping, and testing [18]. The findings of this study indicate that collaborative incentives play a key driving role in these stages, with different types playing different roles in different stages.

Comparison with brainstorming research: Osborn's [16] brainstorming method aims to stimulate creativity through free expression of ideas. However, Diehl and Stroebe [4] demonstrated that brainstorming may reduce the quantity and quality of creative ideas. The findings of this study provide an explanation: brainstorming, while including ISI, lacks other types of incentives (such as PCI and CLI), and may therefore be less effective than more comprehensive collaborative incentive approaches.

6.3. Difference Analysis and Attribution

Some findings of this study are not entirely consistent with initial expectations, requiring further analysis.

Expected vs. actual differences: In the initial hypothesis, we expected ISI to have the strongest stimulating effect on divergent thinking. The actual results confirmed this ($r = 0.68$), but the stimulating effect of PCI on convergent thinking ($r = 0.71$) was stronger than expected. This may be because in team environments, the collision of different perspectives not only promotes the synthesis of ideas but also promotes mutual understanding and consensus formation among team members, thereby more effectively driving convergent thinking [29].

Effect of incentive frequency: The study found a positive correlation between incentive frequency and design quality. However, this relationship may not be linear. In some cases, excessive collaborative incentives may lead to decision delays or information overload [30]. Further research needs to explore the optimal frequency of collaborative incentives.

Effect of individual differences: Although this study focuses on team-level collaborative incentives, individual differences (such as individual creative ability and openness) may also affect the effectiveness of collaborative incentives [11]. Further research needs to consider these individual factors.

6.4. Limitations

Although this study provides valuable findings, it also has several limitations.

Sample size and diversity: This study included only 12 teams with 58 participants. Although participants came from different organizations and backgrounds, the sample size is relatively small, potentially limiting the generalizability of the results. Further research needs to expand the sample size.

Specificity of the research environment: Data collection in this study was conducted primarily in design workshop environments. Although workshops are a common working mode for design teams, collaborative incentive patterns may differ in everyday work environments. Further research needs to be conducted in more diverse work environments.

Limitations of research methods: This study primarily employed qualitative research methods. Although qualitative research can provide in-depth understanding, it lacks quantitative statistical validation. Further research could combine quantitative methods to provide more rigorous validation of the findings.

Time span limitations: The data collection period for this study was three months. Over longer time spans, collaborative incentive patterns and effects may change. Further research needs to conduct longitudinal studies.

Cultural and contextual factors: The participants in this study were primarily from China. In different cultural contexts, collaborative incentive patterns and effectiveness may differ [31]. Further research needs to conduct cross-cultural comparisons.

6.5. Practical Applications and Implications

The findings of this study have important practical implications for design education, team management, and creative tool development.

Design education: The findings indicate that design education should emphasize the importance of team collaboration and teach students how to engage in effective collaborative incentives. In particular, teachers can design specific collaborative activities to stimulate different types of creative cognitive processes in students.

Team management: The findings indicate that managers of design teams should create conditions that promote different types of collaborative incentives. For example, regular information-sharing meetings can promote divergent thinking, while design review meetings can promote perspective collision and clarification.

Creative tool development: The findings can guide the development of creative support tools. For example, tools can be developed to promote information sharing (e.g., design reference libraries), question-guided interaction (e.g., question prompt systems), perspective collision (e.g., design solution comparison tools), and clarification (e.g., feedback and annotation tools).

7. Conclusion

7.1. Core Conclusions

This study systematically identified four types of collaborative incentives in interactive design teams (Information Sharing Incentive, Question-Guided Incentive, Perspective Collision Incentive, and Clarification Incentive) through qualitative research methods, and revealed their correspondence with creative cognitive processes. The main conclusions are:

1. Existence and observability of collaborative incentives: This study confirms the existence of collaborative incentives in design teams and demonstrates that these incentives can be systematically observed and identified;
2. Correspondence between collaborative incentives and creative cognitive processes: Different collaborative incentive types have significant correspondences with different creative cognitive processes. ISI primarily stimulates divergent thinking, PCI primarily stimulates convergent thinking, and CLI primarily stimulates evaluative thinking;
3. Dynamic nature of collaborative incentives: Collaborative incentives play different roles in different stages of the design process, forming a dynamic collaborative incentive process;
4. Effectiveness of collaborative incentives: The frequency of collaborative incentives has a significant positive correlation with the quality of design output ($r = 0.71$, $p < 0.05$), indicating that effective collaborative incentives can enhance the quality of design innovation.

7.2. Theoretical Contributions

This study makes important contributions to creative cognition theory, group creativity theory, and design thinking theory: extending creative cognition theory from the individual to the team level; providing a more detailed mechanistic explanation for group creativity theory; and emphasizing the central role of collaborative incentives in driving the design thinking process.

7.3. Practical Applications

The findings of this study can be applied in design education (designing collaborative activities to cultivate team collaboration and creative thinking), team management (creating conditions that promote different types of collaborative incentives), and creative tool development (developing tools to support and promote different types of collaborative incentives).

7.4. Limitations and Future Research Directions

Future research should: expand the sample size and diversity; conduct cross-cultural research to explore the influence of cultural factors on collaborative incentives; conduct longitudinal studies to explore long-term changes in collaborative incentive patterns; combine quantitative methods to provide more rigorous validation of the qualitative findings; conduct intervention studies to test the actual effects of CIT-based interventions on design innovation; and explore the application of collaborative incentive theory in other creative domains (e.g., engineering, architecture, literary creation).

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