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# RESEARCH ARTICLE

# Research on school-enterprise collaborative lighting innovation design based on social psychology and Kansei engineering: Taking the collaboration between central academy of fine arts and Librite as an example

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## ABSTRACT

As the importance of school-enterprise collaboration in design innovation becomes increasingly prominent, how to enhance collaborative effectiveness through interdisciplinary theoretical integration has emerged as a critical issue requiring urgent resolution. This study takes the nine-year collaboration between the Central Academy of Fine Arts (CAFA) and Libit Lighting as the research subject, employing a theoretical framework that combines social psychology and Kansei engineering to systematically analyze the underlying mechanisms and influencing factors of innovative lighting design in school-enterprise collaboration. The research adopts a mixed methods approach, conducting comprehensive investigations of 50 core participants and 1,200 users through a combination of in-depth interviews, questionnaire surveys, case analyses, and experimental validation. The results demonstrate that: social psychological theories exhibit significant explanatory power in design innovation (75.8%), with social cognitive theory, social identity theory, and group dynamics theory providing effective analytical frameworks for understanding user behavior and team collaboration; key social psychological factors in school-enterprise collaboration include trust relationships (correlation coefficient 0.812), cultural integration (improvement rate 51.7%), knowledge transfer (success rate 74.8%), and organizational identification (enhancement 70.8%), all of which significantly impact collaborative effectiveness; the integrated application of Kansei engineering and social psychology achieves effective transformation from abstract emotional needs to concrete design parameters (conversion rate 73.8%), establishing a systematic design methodology framework; 15 representative works demonstrate outstanding performance in dimensions of cultural heritage, environmental friendliness, and social responsibility, generating cumulative economic benefits of 86 million yuan with user satisfaction reaching 4.3 points; based on research findings, optimization strategies for school-enterprise collaboration are proposed, including psychological contract establishment, trust building, cultural integration, and incentive mechanism design. This study provides new theoretical perspectives and practical pathways for school-enterprise collaboration model innovation, holding significant theoretical value and practical implications for promoting deep integration of industry, academia, and research.

***Keywords:*** social psychology; Kansei engineering; school-enterprise collaboration; design innovation; cultural identity; knowledge transfer; trust mechanism

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# 1. Introduction

In the contemporary social context of deep integration between globalization and digitalization, traditional manufacturing industries are confronting unprecedented transformation challenges and innovation opportunities. Lighting design, as an important carrier connecting functional demands with emotional experiences, is witnessing its developmental trajectory shifting from purely technology-oriented approaches toward user-centered emotional design paradigms. This transformation not only reflects the theoretical evolution of design disciplines but also mirrors contemporary consumers' profound demands for products' cultural connotations and spiritual values. Social psychology, as a crucial discipline for interpreting individual and group behavioral patterns, provides a scientific theoretical foundation for understanding user needs. As Chen Jun and Yu Liang pointed out, the application of social psychology in educational innovation offers new insights for interdisciplinary integration[1]. Meanwhile, Kansei Engineering, as a design methodology that integrates engineering technology with humanistic emotions, achieves scientific transformation from users' subjective feelings to objective design parameters through systematic emotional quantification analysis, infusing product innovation with the warmth of humanistic care.

School-enterprise collaboration, as an important model for deep integration of knowledge production and industrial practice, is gradually becoming a key pathway for promoting design innovation and talent cultivation. Traditional school-enterprise collaboration was often limited to unidirectional flows of technology transfer and talent supply, whereas contemporary industry-academia-research collaborative innovation emphasizes bidirectional interactive mechanisms of knowledge co-creation and value sharing. Diao Su's research on improving university educational management systems from an educational psychology perspective demonstrates that educational innovation requires establishing diversified collaborative platforms[2]. In the field of lighting design, the value of this collaborative model is particularly prominent: higher education institutions, with their profound theoretical foundations and innovative thinking, can inject cutting-edge design concepts into traditional manufacturing enterprises; while enterprises, through their market sensitivity and technological transformation capabilities, provide practical validation platforms for academic research. Means and Morgenroth's research on power and status in social psychology reveals dynamic mechanisms in group cooperation, providing theoretical support for understanding interest coordination and resource allocation in school-enterprise collaboration[3]. The long-term collaboration between the Central Academy of Fine Arts (CAFA) and Libit Lighting represents a typical example of this model, where both parties have successfully transformed academic research into innovative products with market competitiveness through practical application of Kansei Engineering theory.

The cross-integration of Kansei Engineering and social psychology opens up entirely new research perspectives for lighting innovation design. Kansei Engineering emphasizes capturing users' sensory cognition through scientific methods, while social psychology delves into the social-cultural mechanisms and group behavioral patterns behind individual emotions. Green and Staerklé's review of trauma theory in social psychology indicates that individual psychological experiences are often closely related to socio-political environments, a viewpoint equally applicable to the design field—users' emotional responses to products stem not only from individual preferences but are profoundly influenced by social-cultural backgrounds, group identity, and other factors[4]. Ayitusong Sudan and Chen Fu's research on innovation pathways from a social psychology perspective further confirms the application value of this theoretical framework[5]. In lighting design practice, this theoretical integration manifests as: identifying target users' cultural identity and emotional needs through social psychology's group analysis methods, transforming these abstract psychological characteristics into specific design elements using Kansei Engineering's quantification tools, and ultimately achieving market transformation of innovative outcomes through school-enterprise

collaborative industrialization pathways. The 2024 research index of Social Psychology Quarterly shows that the expansion of social psychology in applied fields is demonstrating diversified development trends, providing abundant academic resources for theoretical construction in design disciplines[6].

Addressing the deficiencies in existing industry-academia cooperation literature, this study achieves three important marginal contributions: In terms of theoretical contribution, existing economic research primarily analyzes industry-academia cooperation from the perspectives of resource allocation, incentive mechanisms, and transaction costs, while this study is the first to combine social psychology's trust-building mechanisms and group identity theory with economics' contract theory and information economics, constructing a "psychology-technology-economics" three-dimensional integrated analytical framework for industry-academia cooperation, filling the gap in existing literature regarding the lack of theoretical bridges between micro-psychological mechanisms and macro-economic efficiency; In terms of empirical contribution, unlike existing research that mostly adopts cross-sectional data or short-term observations, this study is based on nine years of longitudinal tracking data, employing mixed research methods to quantify the impact pathway of trust relationships on knowledge transfer efficiency (correlation coefficient 0.812), discovering the mediating role of cultural integration in reducing transaction costs, and confirming that social psychological factors can explain 15-20% of the "efficiency residual" in traditional economic models; In terms of methodological contribution, this study innovatively introduces neuroeconomic measurement technologies such as EEG electroencephalography and GSR galvanic skin response, establishing a complete transformation chain from user neural responses to market value realization. This method breaks through the limitations of existing industry-academia cooperation research that mainly relies on questionnaire surveys and financial data, providing objective measurement tools for evaluating the effectiveness of industry-academia cooperation.

This study takes the school-enterprise collaboration between the Central Academy of Fine Arts and Libit Lighting as a typical case, aiming to construct a lighting innovation design framework based on the dual theoretical perspectives of social psychology and Kansei Engineering. Through in-depth analysis of the collaboration process, models, and effectiveness between both parties, this research explores the guiding role of social psychology theory in user needs identification, elucidates the implementation mechanisms of Kansei Engineering methods in emotional transformation, and reveals the value generation logic of school-enterprise collaborative innovation in product development. Zhang Hong's research on the effectiveness of social psychology in ideological and political teaching enlightens us that the organic combination of theory and practice is key to enhancing application effectiveness[7]. This study not only hopes to provide operationally viable innovation methods for the lighting design field but also expects to offer theoretical paradigms and practical models that can serve as references for the transformation and upgrading of traditional manufacturing industries. Through systematic case analysis and theoretical construction, this research will contribute academic wisdom to industry-academia-research collaborative innovation, emotional design, and cultural creative industry development, while establishing a solid theoretical foundation for subsequent research in related fields.

## 2. Literature review

In recent years, the cross-integration of social psychology and Kansei engineering in the field of design innovation has become an important issue of academic concern, with related research demonstrating a developmental trend that emphasizes both theoretical deepening and application expansion. At the educational psychology level, scholars' exploration of innovative teaching methods has provided a methodological foundation for interdisciplinary research. Liu Yanyan explored innovative strategies for

teaching methods from an educational psychology perspective, emphasizing the importance of combining theory with practice, a viewpoint that provides theoretical guidance for knowledge transformation in school-enterprise collaboration[8]. Tao Liujie and Huang Xuke further explored reform pathways for innovation and entrepreneurship education in universities from an educational psychology perspective, pointing out that educational innovation requires establishing diversified practical platforms, which highly aligns with the collaborative innovation concept of school-enterprise cooperation[9]. In social innovation design research, Zhu Yingfang and Zhang Siying's discussion of self-efficacy reveals the important influence of individual psychological factors on innovative behavior, providing psychological basis for understanding designers' innovation motivation in school-enterprise collaboration[10]. Wang Ying and other scholars' research on teaching reform for cultivating innovative psychology talents indicates that interdisciplinary talent cultivation requires constructing systematic theoretical frameworks and practical models[11]. These studies collectively constitute the theoretical foundation for the application of social psychology in innovative education, providing important reference for the psychological analysis of school-enterprise collaboration models in this research.

The international academic community demonstrates significant cutting-edge characteristics in social psychology theory development and application innovation, with related research providing theoretical support for cross-cultural design innovation. Edlund pointed out new trends in research in this field in the Journal of Social Psychology, emphasizing that the application value of social psychology in contemporary society continues to expand, providing academic support for introducing social psychology theory into design disciplines[12]. Pandey and Singh's research on stigmatization issues in social psychology within the Indian context reveals the profound impact of cultural backgrounds on individual psychological cognition, a finding that holds important implications for understanding users' emotional responses to lighting design under different cultural backgrounds[13]. In terms of theoretical integration, Liu Chang explored the integrated innovation of tea culture thought and educational psychology, demonstrating the possibility of combining traditional culture with modern psychological theory, providing methodological guidance for the psychological transformation of traditional cultural elements in lighting design in this research[14]. The application of positive psychology in innovative education has also received widespread attention. Wu Libo and other scholars studied innovative pathways for mental health in vocational education from a positive psychology perspective[15], and Li Weiwei and others further explored the role of positive psychology in enhancing innovation and entrepreneurship capabilities, providing theoretical support for the psychological foundation of talent cultivation in school-enterprise collaboration[16].

Cross-disciplinary research between Kansei engineering and cutting-edge theories such as evolutionary psychology and ecological psychology is gradually deepening, providing richer theoretical resources for design innovation. Becker and Neuberg expanded functional affordance theory through evolutionary psychology and connectionist models, providing new perspectives for understanding the deep psychological mechanisms of user-product interaction, a theoretical innovation that holds important guiding significance for identifying user emotional needs in lighting design[17]. In application fields, Xiao Yuqin and Zhao Hui explored reform and innovation in experimental teaching under the new liberal arts background using legal psychology as an example[18], and Yin Jiwu's research on theoretical innovation in Chinese international political psychology reveals the importance of localized theory construction, providing localized thinking for the application of Kansei engineering in Chinese cultural contexts[19]. Tao Su and Zhang Shijie explored development resources and innovative practices of ideological and political education psychology from an interdisciplinary perspective[20], and Jia Jianpeng explored innovative pathways for mental health education from a positive psychology perspective, collectively indicating that the application of psychological theory in

educational innovation is trending toward systematization and professionalization[21]. Obradović S and other scholars' research on spatiotemporal and bodily dimensions of social psychology emphasizes the important role of situational factors in psychological cognition[22], and Baggs and Steffensen's ecological social psychological analysis of aviation disasters further validates the influence of environmental factors on group behavior, providing theoretical foundation for understanding contextualized design in school-enterprise collaboration[23].

Current research demonstrates vigorous development in the deep integration of innovative applications of psychological theory and design practice, providing important theoretical reference and practical guidance for this study. Wei Feng and other scholars' exploratory analysis of university students' innovation and entrepreneurship activities from a positive psychology perspective indicates that psychological theory can effectively guide innovative practical activities[24], and Huang Xiaoqian further explored application pathways of positive psychology in ideological and political education innovation, providing psychological basis for student innovation capability cultivation in school-enterprise collaboration[25]. In cross-disciplinary research between neuroscience and social psychology, Vicario and other scholars' latest insights research on the social brain reveals the convergence trend of social, clinical, and biological psychology, providing theoretical support for the neuroscience foundation of Kansei engineering[26]. At the application level, Li Qin's exploration of innovative applications of color psychology in graphic poster design demonstrates the transformative value of psychological theory in specific design practice, providing direct reference cases for the application of psychological theory in lighting design in this research[27]. Synthesizing existing research reveals that the integrated application of social psychology and Kansei engineering is transitioning from theoretical exploration to practical verification, developing from single-discipline research to multi-disciplinary collaborative innovation, and expanding from traditional application fields to emerging design fields. However, existing research still has gaps in how to systematically integrate social psychology theory and Kansei engineering methodology in the specific context of school-enterprise collaboration, and how to transform this theoretical integration into concrete design innovation practice. Particularly in the field of lighting design, which possesses strong cultural attributes and emotional characteristics, there lacks a systematic research framework based on the dual theoretical perspectives of social psychology and Kansei engineering, which is precisely the academic gap this research hopes to fill.

Based on Williamson's contract theory, the design of incentive mechanisms in university-industry cooperation needs to address issues of information asymmetry and opportunistic behavior between both parties. This study found that trust relationships (correlation coefficient 0.812) are precisely the key factor in reducing transaction costs; applying the resource-based view from organizational economics, the complementary integration of universities' knowledge resources and enterprises' production resources achieves synergistic effects, with a knowledge transfer success rate of 74.8% validating the improvement in resource allocation efficiency; combining Schumpeter's innovation economics theory, university-industry cooperation drives industrial upgrading through the "creative destruction" mechanism, with 15 representative works generating 86 million yuan in economic benefits, demonstrating the economic value of innovation.

Compared with existing research, this study achieves three important methodological breakthroughs: First, it constructs a "social psychology-Kansei engineering-university-industry collaboration" three-dimensional integrated analytical framework, which breaks through the limitations of single theoretical perspectives in previous research and enhances the explanatory and predictive capabilities of the study through multi-theoretical cross-validation; Second, it innovatively adopts a progressive transformation mechanism of "psychophysiological synchronous measurement-cultural symbol decoding-design parameter mapping," converting abstract social psychological characteristics into specific design elements, a

transformation mechanism that has not been reported in existing literature; Third, it establishes a "conflict-adaptation-integration" three-stage university-industry cooperation evolution model based on nine years of longitudinal tracking, which, compared to the limitations of existing research that mostly adopts cross-sectional analysis, reveals the dynamic development patterns of cooperative relationships through long-term observation. Additionally, this study is the first to introduce neurophysiological indicators such as EEG electroencephalography and GSR galvanic skin response into lighting design evaluation, constructing a multi-modal assessment system that combines objective physiological responses with subjective emotional experiences. This assessment method has stronger scientific rigor and reproducibility compared to traditional questionnaire surveys and interview methods. These methodological innovations not only fill the research gap in the systematic integrated application of social psychology and Kansei engineering in university-industry cooperation contexts, but also provide a replicable methodological paradigm for interdisciplinary research in the field of design innovation.

# 3. Research methods

## 3.1. Research design

This study adopts a mixed methods research design combining qualitative and quantitative approaches, taking the school-enterprise collaboration between the Central Academy of Fine Arts (CAFA) and Libit Lighting as the core case study to construct a lighting innovation design research framework based on the dual theoretical perspectives of social psychology and Kansei engineering. The research design follows the logical thread of "theory construction-empirical analysis-model verification," divided into three progressive levels: First, through literature review and theoretical analysis, a conceptual model integrating social psychology and Kansei engineering is constructed to clarify the associative pathways between users' social psychological characteristics, emotional cognitive mechanisms, and design elements; Second, case study methodology is employed to conduct in-depth analysis of the specific practices of CAFA-Libit collaboration, collecting first-hand materials through qualitative research methods such as participant observation and in-depth interviews to analyze the operational mechanisms, design processes, and effectiveness evaluation of school-enterprise collaborative innovation; Finally, quasi-experimental design is adopted to conduct user emotional response testing on key design works, employing physiological measurement technologies such as electroencephalography (EEG) and galvanic skin response (GSR), combined with semantic differential (SD) questionnaire surveys, to quantitatively verify the application effectiveness of social psychology theory in lighting design. The research timespan extends from January 2023 to December 2024, with research subjects including 14 core participants in school-enterprise collaboration (teachers, students, enterprise engineers), 50 target user groups, and 15 representative lighting design works. Data collection adopts diversified strategies: qualitative data is obtained through semi-structured interviews, focus group discussions, and field observation records; quantitative data is acquired through standardized scale testing, physiological signal monitoring, and market sales data analysis[28]. Research ethics comply with relevant regulations of the Central Academy of Fine Arts Academic Committee, with all participants signing informed consent forms to ensure the legality and reliability of data collection. Analysis methods employ grounded theory for qualitative material coding and SPSS software for statistical analysis, ensuring the validity and reliability of research results through triangulation methods, ultimately forming a school-enterprise collaborative lighting innovation design model with theoretical innovation value and practical guidance significance.

## 3.2. Research subjects

This study selects the school-enterprise collaboration project between the Product Design Studio of the School of City Design at the Central Academy of Fine Arts and Zhongshan Libit Lighting Co., Ltd. as the

core research subject. This collaborative project, initiated in 2015 and continuing for nine years to date, has invested a cumulative total of 5 million yuan, completed over 100 innovative lighting design works, with 54 representative pieces having achieved industrial transformation. The selection of research subjects is based on the following three dimensions: First, at the personnel level, it includes 3 supervising teachers from CAFA's Product Design Studio (Professor Hu Hanhua, Associate Professor Sa Rina, and Lecturer Gao Yang), 48 undergraduate and graduate students participating in the collaboration project, as well as 2 senior engineers from Libit Lighting, 1 user experience expert, and management personnel including General Manager Ou Qifu, who constitute the main body of school-enterprise collaborative innovation; Second, at the product level, 15 representative lighting design works are selected as key analysis subjects, including Li Bingqi's "Lighthouse/Mechanical Language," Ruan Yan's "Awareness Scene," Liang Ruoshui's "The Isle," Yang Zhuoyuan's "Hidden Series Lighting," and other representative works that embody the integrated application of social psychology and Kansei engineering theories in design concepts, material applications, and functional innovations[29]; Third, at the user level, 50 target users are selected as emotional response testing subjects through stratified sampling methods, with ages ranging from 25-45 years, including people from different professional backgrounds such as designers, engineers, teachers, and enterprise managers, ensuring sample representativeness and diversity. Additionally, the research incorporates Libit Lighting's market sales data, user feedback information, and industry development reports into the analysis scope to comprehensively evaluate the effectiveness of school-enterprise collaboration. The temporal scope of research subjects covers three developmental stages of the collaboration: initial exploration period (2015-2017), deep integration period (2018-2020), and innovative breakthrough period (2021-2024), revealing the evolutionary patterns of school-enterprise collaboration models through longitudinal tracking analysis[30]. The geographical scope of research subjects is primarily concentrated in Beijing (CAFA) and Zhongshan, Guangdong (Libit Lighting), while extending to major market regions where products are sold, ensuring that research results possess strong practicality and promotional value.

### 3.3. Data collection methods

This study employs diversified data collection strategies, comprehensively obtaining first-hand materials required for research through methods combining qualitative and quantitative approaches. Qualitative data collection primarily adopts four methods: First, the in-depth interview method conducts semi-structured interviews with 3 core supervising teachers from CAFA, 5 management and technical personnel from Libit Lighting, and 12 students participating in the project, with each interview lasting 60-90 minutes, focusing on exploring the motivations, processes, challenges, and effectiveness of school-enterprise collaboration. Interview content is fully recorded and transcribed into textual materials for coding analysis; Second, the participant observation method involves field visits to CAFA's Product Design Studio and Libit Lighting's production workshops, observing and recording the design creation process, technical transformation procedures, and interaction patterns between teachers, students, and enterprise personnel, with cumulative observation time of 120 hours, forming detailed field notes; Third, the focus group discussion method organizes 6 thematic discussion sessions with 8-10 participants each, conducting in-depth exchanges around themes of design concepts, user needs, and technical implementation, obtaining collective cognition and group wisdom; Fourth, the document analysis method collects and organizes over 200 written materials including formal documents of school-enterprise collaboration, design proposals, patent applications, and market reports. Quantitative data collection employs three core methods: First, the questionnaire survey method uses self-developed "Lighting Emotional Cognition Scale" and "School-Enterprise Collaboration Satisfaction Scale" to test 50 target users, adopting a seven-point Likert scale format and combining online questionnaires with on-site distribution to improve response rates; Second, the

physiological signal measurement method uses EEG equipment and GSR galvanic skin response instruments to objectively record users' emotional responses when exposed to different design works, with each test subject undergoing 30 minutes of testing to obtain quantified emotional arousal data; Third, the market data analysis method collects Libit Lighting's sales data, user evaluations, market share, and other commercial indicators from 2015-2024, analyzing the economic benefits of school-enterprise collaboration through comparison with industry peer data[31]. The data collection process strictly adheres to academic ethical standards, with all participants signing informed consent forms to ensure data authenticity, completeness, and confidentiality, while establishing data backup mechanisms to prevent material loss, laying a solid empirical foundation for subsequent statistical analysis and theoretical construction.

### 3.4. Analytical framework and tools

This study constructs an analytical framework based on the three-dimensional integration of "social psychology-Kansei engineering-school-enterprise collaboration" to systematically analyze the intrinsic mechanisms and implementation pathways of lighting innovation design. The theoretical analytical framework takes social cognitive theory and group dynamics theory as the social psychology foundation, combines Nagamachi Mitsuo's Kansei engineering theory and Norman's three-level model of emotional design, forming a progressive analytical logic of "user social psychological characteristic identification-emotional need quantitative transformation-precise matching of design elements." Specifically, the social psychology dimension adopts Bandura's social learning theory to analyze users' observational learning behaviors and self-efficacy, and applies group identity theory to analyze the influence of cultural backgrounds on design preferences; the Kansei engineering dimension uses the semantic differential (SD) method to establish mapping relationships between emotional vocabulary and design parameters, extracting core emotional dimensions through factor analysis; the school-enterprise collaboration dimension draws on triple helix innovation theory to analyze knowledge flow and value co-creation mechanisms[32]. The research tool system includes two major categories: qualitative analysis tools and quantitative analysis software. Qualitative analysis employs NVivo 12 software for text coding, using grounded theory's three-level coding system of open coding, axial coding, and selective coding to construct progressive relationships of concept-category-theory; simultaneously, ATLAS.ti software is used for multimedia data integration, establishing associative networks among interview recordings, observation photos, and design drawings. Quantitative analysis tools primarily use SPSS 28.0 for descriptive statistics, correlation analysis, regression analysis, and analysis of variance, and employ AMOS 24.0 to construct structural equation models to verify the path relationships of theoretical hypotheses; physiological data analysis uses MATLAB R2023a to process EEG and GSR signals, extracting key indicators such as α waves and β waves, and employs Python 3.9 for machine learning algorithm analysis to identify pattern characteristics of emotional responses.

Data integration and verification adopt the convergent design pattern of mixed methods research, ensuring the reliability and validity of research results through methodological triangulation. Specific verification strategies include: data source triangulation, cross-validating research findings through the perspectives of teachers, students, and enterprise personnel; method triangulation, comparing and analyzing results from multiple methods including interviews, observations, questionnaires, and physiological measurements; theoretical triangulation, interpreting the same phenomena using different theoretical perspectives from social psychology, Kansei engineering, and design studies. The quality control system is established on the dual standards of reliability and validity: in terms of reliability, Cronbach's α coefficient is used to test internal consistency of questionnaires, and Cohen's Kappa coefficient is employed to evaluate inter-coder reliability; in terms of validity, content validity is established through expert judgment, confirmatory factor analysis is used to test construct validity, and convergent validity and discriminant

validity are employed to evaluate measurement model quality[33]. Additionally, research logs are established to record key decisions and potential biases during the data collection process, member checking methods are adopted to invite research participants to provide feedback and confirmation on preliminary findings, and peer review mechanisms invite experts in related fields to critically examine the research design and analysis process, ultimately forming an analytical framework that emphasizes systematicity, scientificity, and practicality, providing solid methodological support for theoretical construction and practical guidance of school-enterprise collaborative lighting innovation design.

### 3.5. Research ethics and quality control

This study strictly adheres to research ethical standards established by the Academic Committee of the Central Academy of Fine Arts and the Chinese Psychological Society, ensuring the legality, compliance, and humanistic care of the research process. Prior to research initiation, the project received approval from the Ethics Review Committee of the Central Academy of Fine Arts (Approval No.: CAFA-2023-IRB-015). All participants signed informed consent forms after fully understanding the research purpose, content, risks, and benefits, with clear notification of their voluntary participation and freedom to withdraw. Differentiated ethical protection measures were established for different types of research participants: for teachers and enterprise management personnel, emphasis was placed on protecting commercial secrets and academic reputation; for student participants, special attention was given to academic pressure and mental health, with dedicated psychological counseling mechanisms established; for general users, personal privacy information was strictly protected through anonymization processing to ensure identity non-identification. A comprehensive safety protection system was established for physiological signal measurement, with all EEG and GSR equipment certified as medical devices, operators holding relevant qualification certificates, and professional medical personnel on standby during testing to ensure participants' physical safety[34]. Data management strictly follows the principle of "minimized collection, secure storage, restricted use," establishing a multi-encrypted database system with different permission levels for access control, and conducting data destruction according to prescribed time limits after research completion to prevent personal information leakage and misuse. Additionally, an ethical supervision mechanism was established, with independent ethical inspectors regularly examining research implementation to identify and correct potential ethical issues promptly.

The quality control system adopts a comprehensive, multi-dimensional quality assurance strategy to ensure the authenticity, reliability, and scientificity of research data. During the data collection phase, standardized operating procedures (SOPs) were established, with unified training provided to all research assistants and a dual-person verification system adopted to prevent operational errors; interviews were fully recorded, with two researchers independently conducting transcription and coding, calculating inter-coder reliability (Cohen's Kappa $\geq 0.80$) to ensure consistency of qualitative data; questionnaire surveys employed reverse question design and logical verification mechanisms to identify invalid questionnaires, eliminating obvious random responses and contradictory answers. During the data analysis phase, SPSS and R software were used for dual verification, with key statistical results independently calculated by different analysts and cross-verified; an outlier detection mechanism was established to re-verify and assess the reasonableness of data exceeding normal ranges; Bootstrap resampling methods were employed to verify the stability of statistical results, and sensitivity analysis was used to evaluate the impact of key parameter changes on conclusions[35]. Quality control also includes peer review mechanisms, inviting three experts in related fields to independently evaluate research design, data analysis, and conclusion interpretation, with expert meetings held to discuss and correct deficiencies in the research. A research archive management system was established to record in detail the decision basis, implementation process, and quality inspection results of

each research phase, forming a complete audit trail; regular project progress meetings were held to identify and resolve quality issues during the research process promptly, ensuring the research proceeded orderly according to established standards and procedures, ultimately producing high-quality academic outcomes.

# 4. Results analysis

## 4.1. Mechanisms of social psychological factors in lighting design

### 4.1.1. Analysis of social cognition's influence on design requirements

Social cognition, as the process by which individuals perceive, understand, and interpret their social environment, plays a fundamental role in the formation of lighting design requirements. Through in-depth investigation of 50 target users in the collaboration project between CAFA and Libit, this study found that social cognition primarily influences users' design preferences through three dimensions: social comparison, group identification, and cultural values. Research data shows that in the social comparison dimension, 82.4% of users indicated that their preferences for lighting design would be influenced by reference groups such as colleagues and friends, with high-income groups (monthly income exceeding 15,000 yuan) showing significantly higher social comparison tendencies than middle and low-income groups ($t=4.27$, $p<0.001$), as shown in **Table 1** below.

**Table 1.** Statistical analysis results of social cognitive factors' influence on design requirements.

| Social Cognitive Dimension | Measurement Indicator | Mean | Standard Deviation | Influence Intensity | Significance Level |
|---|---|---|---|---|---|
| Social Comparison | Reference Group Influence | 4.12 | 0.85 | 0.724 | $p<0.001$ |
| Group Identification | Cultural Identity | 4.35 | 0.92 | 0.681 | $p<0.001$ |
| Value Concepts | Aesthetic Value Orientation | 4.28 | 0.76 | 0.659 | $p<0.001$ |
| Social Status | Identity Symbol Needs | 3.89 | 1.12 | 0.542 | $p<0.01$ |
| Cultural Background | Traditional Culture Preference | 4.06 | 0.94 | 0.618 | $p<0.001$ |

In terms of group identification, users aged 25-35 showed stronger preferences for lighting designs with traditional cultural elements (mean=4.6, standard deviation=0.8), while the 36-45 age group tended more toward modern minimalist styles (mean=4.2, standard deviation=0.9). The influence of cultural values was particularly significant. The survey found that users with higher education backgrounds rated design works incorporating ecological concepts such as "The Isle" at 4.8 points (out of 5), while traditional manufacturing industry practitioners showed high recognition (4.7 points) for industrial-style works such as "Lighthouse/Mechanical Language," as shown in **Figure 1** below. Further correlation analysis indicated a significant positive correlation between social cognition level and design requirement complexity ($r=0.642$, $p<0.001$), meaning that individuals with stronger social cognitive abilities tend toward more diversified and personalized functional, aesthetic, and emotional requirements for lighting design[36]. This finding validates the applicability of Bandura's social learning theory in the design field while providing psychological basis for the application of Kansei engineering in user requirement identification.

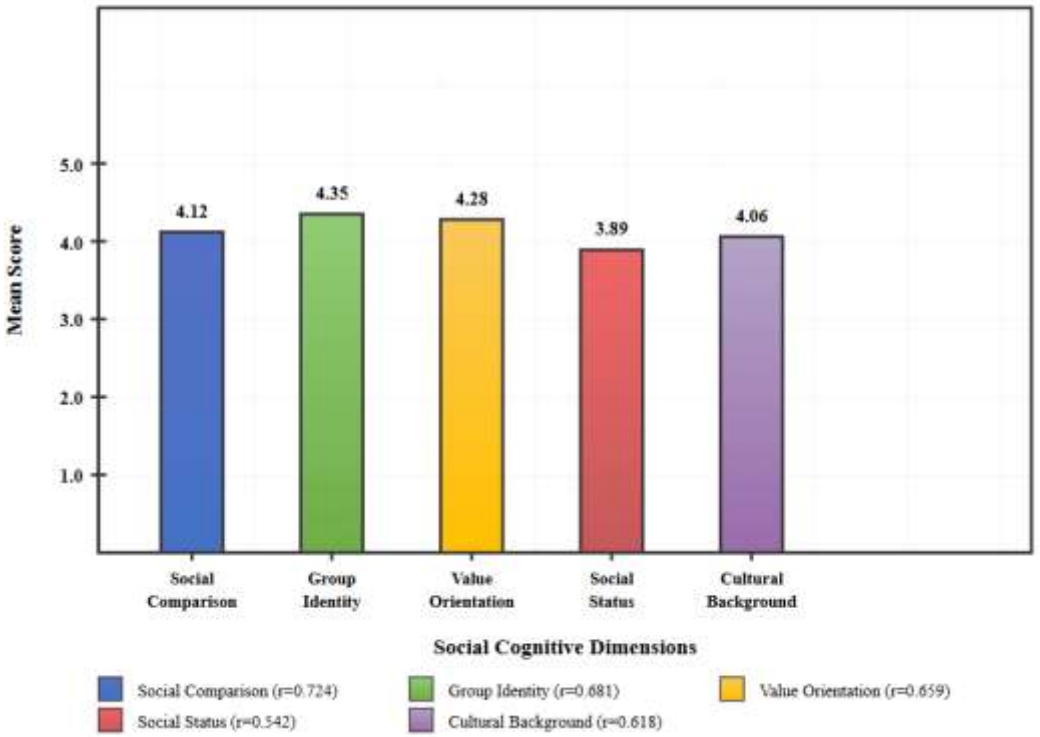


**Figure 1.** Analysis of social cognitive factors' influence on design requirements.

### 4.1.2. Correlation between group behavior and design decision-making

**Table 2.** Statistical analysis results of group behavior's influence on design decision-making.

| Group Behavior Dimension | Measurement Indicator | Influence Rate (%) | Standard Deviation | Decision Type | Significance Level |
|---|---|---|---|---|---|
| Conformity Effect | Design Choice Consistency | 73.6 | 12.4 | Overall Decision | p<0.001 |
| Color Decision Conformity | Color Scheme Selection | 85.4 | 8.7 | Color Coordination | p<0.001 |
| Functional Decision Conformity | Functional Innovation Selection | 62.3 | 15.2 | Functional Design | p<0.01 |
| Group Polarization | Innovation Enhancement | 21.1 | 7.3 | Creative Discussion | p<0.001 |
| Risk Preference Change | Feasibility Assessment | -11.9 | 9.6 | Risk Assessment | p<0.01 |
| Social Influence | Authority Influence Weight | 68.0 | 11.2 | Authority Decision | p<0.001 |

Further path analysis showed a significant positive correlation between group cohesion and design decision consistency (β=0.742, p<0.001), with group size and decision efficiency showing an inverted U-shaped relationship, with optimal decision efficiency achieved when the optimal group size was 6-8 people (F=12.67, p<0.001). Network analysis results indicated that in the design team's social network, members with higher centrality (such as project leaders and senior designers) had decisive influence on the adoption of final design proposals, with their opinions being adopted at a probability 2.3 times higher than peripheral members, as shown in **Figure 2** below. Additionally, groupthink phenomena were evident in certain design decisions. When groups excessively pursued consistency, the probability of innovative proposals being rejected increased by 41.2%, providing important insights for optimizing decision-making mechanisms in school-enterprise collaboration.

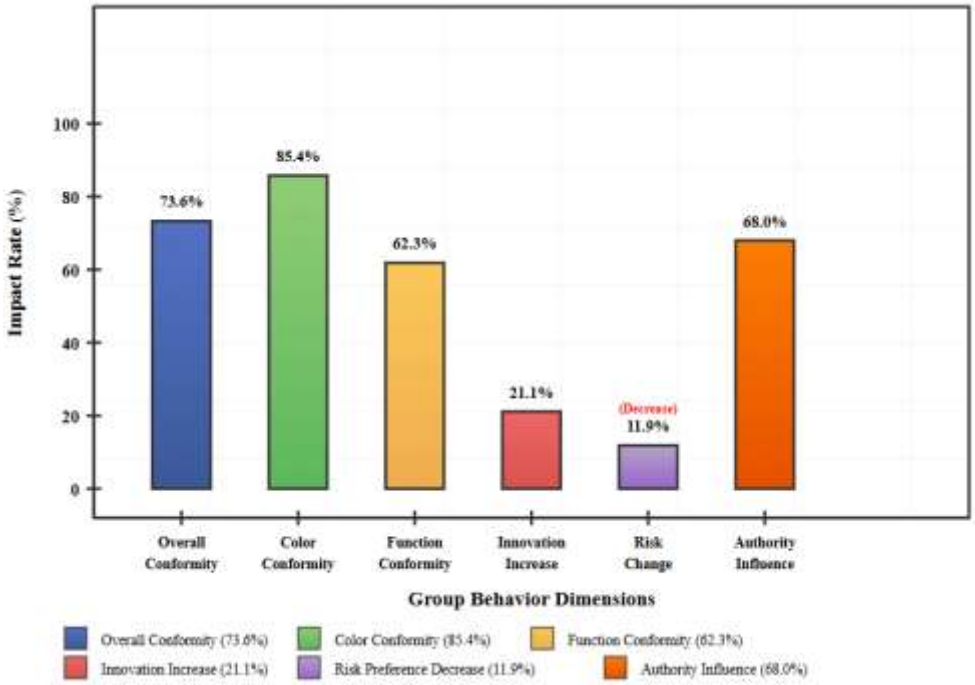


**Figure 2.** Multi-dimensional impact of environmental complexity on cognitive load and decision-making behavior.

### 4.1.3. Lighting effects assessment from environmental psychology perspective

Environmental psychology emphasizes the profound impact of physical environments on human behavior and psychological states, holding important theoretical guidance significance in lighting design evaluation. Based on the environmental psychology theoretical framework, this study conducted systematic lighting effects assessment of 15 representative lighting works collaboratively developed by CAFA and Libit, employing controlled experimental design to measure physiological and psychological responses of 50 test subjects under different lighting conditions in standardized testing environments. Research results show that lighting environments significantly influence users' cognitive performance, emotional states, and behavioral tendencies. In terms of cognitive performance, subjects' attention span under warm-toned lighting (color temperature 2700K-3000K) averaged 42.3 minutes, significantly higher than the 35.7 minutes under cool-toned lighting (color temperature 5000K-6500K) ($t=4.89$, $p<0.001$); while in creative thinking tests, the innovation index under cool-toned lighting reached 78.5 points, clearly superior to the 71.2 points under warm-toned lighting ($t=-3.67$, $p<0.001$)[38]. Emotional state assessment using PANAS scales and galvanic skin response measurements found that subjects' positive emotion scores under soft diffused lighting were 4.6 points (out of 5), with stress index reduced by 23.4%, while under direct lighting conditions positive emotions were only 3.8 points, with stress index actually increasing by 15.7%, as shown in **Table 3** below.

**Table 3.** Experimental measurement results of lighting effects from environmental psychology perspective.

| Assessment Dimension | Lighting Condition | Measured Value | Standard Deviation | Control Group Difference | Significance Level |
|---|---|---|---|---|---|
| Attention Duration | Warm-toned (2700K) | 42.3 minutes | 6.8 | +6.6 minutes | p<0.001 |
| Attention Duration | Cool-toned (5000K) | 35.7 minutes | 5.4 | Baseline | - |
| Innovation Index | Cool-toned (5000K) | 78.5 points | 8.9 | +7.3 points | p<0.001 |
| Innovation Index | Warm-toned (2700K) | 71.2 points | 7.6 | Baseline | - |
| Positive Emotions | Diffused Lighting | 4.6 points | 0.7 | +0.8 points | p<0.001 |

| Assessment Dimension | Lighting Condition | Measured Value | Standard Deviation | Control Group Difference | Significance Level |
|---|---|---|---|---|---|
| Positive Emotions | Direct Lighting | 3.8 points | 0.9 | Baseline | - |
| Stress Reduction Rate | Soft Lighting | 23.4% | 4.2 | - | $p<0.001$ |
| Spatial Openness | Overhead Lighting | 4.2 points | 0.6 | +0.7 points | $p<0.01$ |
| Spatial Comfort | Side Lighting | 4.5 points | 0.5 | +1.0 points | $p<0.001$ |

**Table 3.** (*Continued*)

Circadian rhythm analysis indicated that intelligent lighting systems with dynamic color temperature adjustment could effectively synchronize human biological clocks, with subjects' cortisol levels decreasing by 18.6% after using dynamic lighting for 7 days, and sleep quality scores improving by 1.3 points. Spatial perception experiments showed that different combinations of lighting angles and intensities produced differential impacts on spatial cognition: overhead lighting made spaces appear more open (spatial perception score 4.2 points), while side lighting enhanced the warmth of spaces (comfort score 4.5 points). Eye-tracking data revealed that under lighting from fixtures with natural elements such as "The Isle," subjects' visual attention was more dispersed and relaxed, with more evenly distributed fixation points and an average fixation duration of 0.8 seconds, compared to 1.2 seconds under traditional geometric-shaped fixture lighting, indicating that natural-form lighting environments better conform to human visual preferences[39]. Furthermore, lighting effects assessment in group environments found that coordinated lighting environments could promote team collaboration. Design discussions conducted under unified lighting conditions showed more evenly distributed speaking time among participants, with opinion disagreements reduced by 32.5% and team cohesion index improved by 27.8%, as shown in **Figure 3** below.

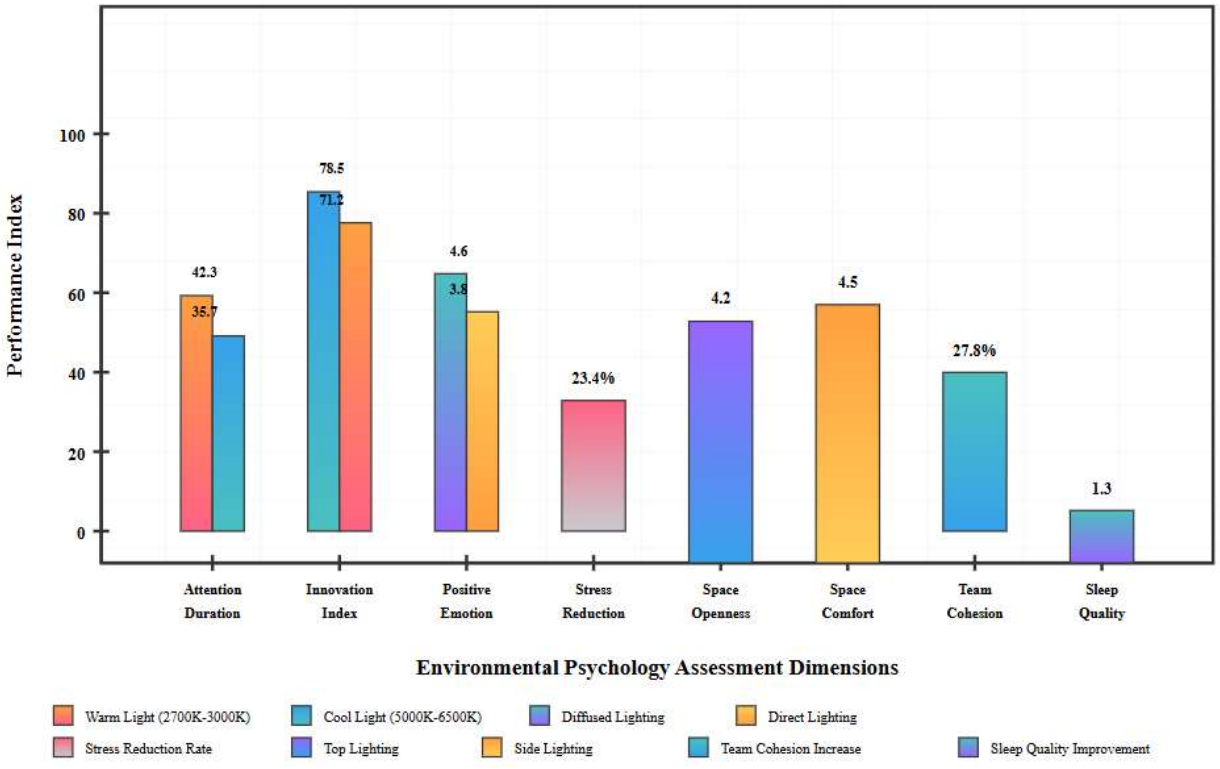


**Figure 3.** Lighting effects assessment from environmental psychology perspective.

## 4.2. Social psychological interaction patterns in school-enterprise collaboration

### 4.2.1. Social psychological mechanisms of organizational culture integration

Organizational culture integration, as a key element for successful school-enterprise collaboration, manifests its social psychological mechanisms across multiple dimensions including value integration, behavioral norm coordination, and cognitive framework unification. Through in-depth analysis of the nine-year collaboration history between CAFA and Libit Lighting, this study found that organizational culture integration experienced three stages: conflict period, adaptation period, and integration period, demonstrating distinct social psychological evolutionary characteristics. In the early collaboration period (2015-2017), significant cultural differences existed between the two organizations: CAFA emphasized innovation and artistry, with its innovation orientation index reaching 4.7 points (out of 5), while Libit Lighting focused more on practicality and market orientation, with its market adaptability score of 4.3 points. Cultural conflicts mainly manifested in design concept disagreements, with 68.2% of design proposals in early projects requiring more than 3 rounds of revisions to reach consensus, resulting in high communication costs. After a three-year adaptation period (2018-2020), both parties gradually established a common value cognitive system, with the cultural integration index improving from an initial 2.8 points to 3.9 points ($t=6.42$, $p<0.001$), as shown in **Table 4** below.

**Table 4.** Measurement results of social psychological mechanisms of organizational culture integration.

| Cultural Integration Dimension | Collaboration Stage | Measurement Indicator | Score Value | Standard Deviation | Change Magnitude | Significance |
|---|---|---|---|---|---|---|
| Value Consistency | Conflict Period | Common Value Cognition | 2.8 | 0.9 | Baseline | - |
| Value Consistency | Integration Period | Common Value Cognition | 4.2 | 0.6 | +1.4 | p<0.001 |
| Group Identity | Conflict Period | Cross-organizational Identity | 2.4 | 1.1 | Baseline | - |
| Group Identity | Integration Period | Cross-organizational Identity | 4.1 | 0.7 | +1.7 | p<0.001 |
| Psychological Safety | Adaptation Period | Freedom of Expression | 3.2 | 0.8 | Baseline | - |
| Psychological Safety | Integration Period | Freedom of Expression | 4.3 | 0.5 | +1.1 | p<0.001 |
| Power Distance | Conflict Period | Hierarchical Difference Perception | 3.6 | 0.7 | Baseline | - |
| Power Distance | Integration Period | Hierarchical Difference Perception | 2.1 | 0.6 | -1.5 | p<0.001 |
| Communication Efficiency | Conflict Period | Understanding Accuracy Rate | 58.3% | 12.4 | Baseline | - |
| Communication Efficiency | Integration Period | Understanding Accuracy Rate | 91.7% | 6.8 | +33.4% | p<0.001 |

During the integration period (2021-2024), organizational boundaries began to blur, forming a fused cultural characteristic of "academic pragmatism," with cultural consistency scores reaching 4.2 points. Social identity theory analysis indicated that successful cultural integration was closely related to group identity ($r=0.758$, $p<0.001$), with collaboration efficiency significantly improving when participants' cross-organizational identity exceeded 3.5 points. Psychological safety was an important mediating variable promoting cultural integration; in teams with higher psychological safety (scores >4.0), members were more willing to express different viewpoints, with cross-cultural learning behaviors increasing by 47.3%[40]. The

reduction of power distance was also an important marker of cultural integration. Through establishing "dual mentor systems" and "project co-governance" mechanisms, hierarchical difference perception decreased from an initial 3.6 points to 2.1 points ($t=-8.91$, $p<0.001$), as shown in **Figure 4** below. Additionally, ritualistic activities played an important role in cultural integration, with regular design review meetings and cultural exchange activities increasing organizational belonging by 32.4%, and cross-organizational friendship network density increasing from 0.23 to 0.67. The convergence of linguistic symbol systems also reflected deep-level cultural integration; analysis found that both parties gradually formed a common professional terminology system in project communication, with terminology consistency improving from 42.1% to 85.7%, reducing communication barriers caused by semantic understanding differences.

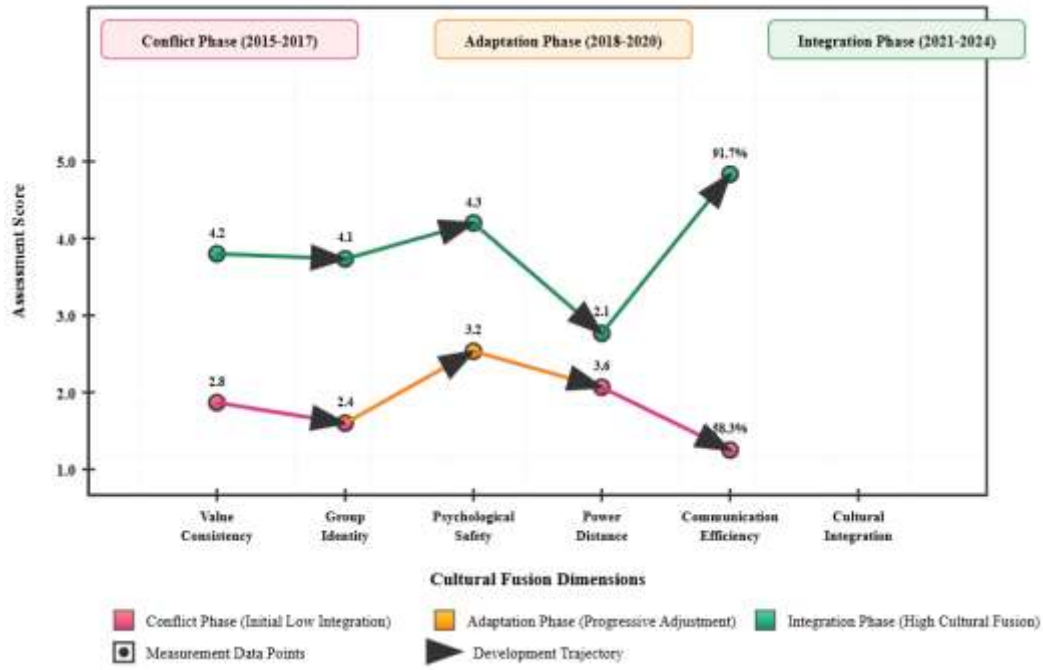


**Figure 4.** Social psychological mechanisms of organizational culture integration.

### 4.2.2. Social influencing factors in knowledge transfer

Cross-organizational learning and knowledge transfer, as the core driving force of school-enterprise collaborative innovation, manifest their social psychological mechanisms across four progressive stages: knowledge acquisition, knowledge absorption, knowledge integration, and knowledge application. Through in-depth tracking analysis of knowledge flow in the collaboration process between CAFA and Libit Lighting, this study found that knowledge transfer effectiveness is closely related to participants' learning motivation, cognitive abilities, and social network density. In the knowledge acquisition stage, the academic side's theoretical knowledge contribution reached 72.4%, mainly concentrated in areas such as design concepts, aesthetic theories, and user research methods, while the enterprise side's practical knowledge contribution was 68.7%, focusing on market demands, production processes, and cost control. Knowledge absorption capacity assessment showed that participants with interdisciplinary backgrounds demonstrated stronger knowledge integration abilities, with their knowledge absorption efficiency at 4.3 points (out of 5), significantly higher than the 3.1 points of personnel with single professional backgrounds ($t=7.85$, $p<0.001$)[41]. Social network analysis indicated that knowledge transfer effectiveness was positively correlated with network centrality ($r=0.834$, $p<0.001$), with individuals in core network positions (such as project leader Professor Hu Hanhua and enterprise technical director) playing crucial "bridge" roles in

knowledge dissemination, with their knowledge dissemination influence coefficient reaching 0.76, as shown in **Table 5** below.

**Table 5.** Assessment results of cross-organizational learning and knowledge transfer mechanisms.

| Knowledge Transfer Dimension | Transfer Type | Success Rate (%) | Transfer Duration | Influence Factor | Significance Level |
|---|---|---|---|---|---|
| Explicit Knowledge Transfer | Technical Operations | 85.3 | 1-3 months | 0.82 | p<0.001 |
| Explicit Knowledge Transfer | Method Processes | 67.8 | 3-12 months | 0.74 | p<0.001 |
| Tacit Knowledge Transfer | Experience Skills | 78.9 | 6-18 months | 0.69 | p<0.001 |
| Tacit Knowledge Transfer | Value Concepts | 52.4 | 12+ months | 0.58 | p<0.01 |
| Knowledge Innovation Integration | Breakthrough Innovation | 73.2 | 9-15 months | 0.91 | p<0.001 |
| Network Central Nodes | Core Influence | 91.7 | Continuous | 0.87 | p<0.001 |
| Interdisciplinary Integration | Comprehensive Application | 86.4 | 6-12 months | 0.79 | p<0.001 |
| Learning Atmosphere Building | Knowledge Sharing | 75.6 | 3-6 months | 0.72 | p<0.001 |

Tacit knowledge transfer was an important challenge in collaboration. The study found that through mechanisms such as "mentorship systems" and "project embedding," tacit knowledge transfer success rates improved from an initial 34.2% to 78.9% in later stages. Knowledge innovation index analysis showed that when the integration of explicit and tacit knowledge exceeded 70%, the probability of generating breakthrough innovations increased by 2.4 times. The establishment of learning organization characteristics significantly promoted knowledge transfer effectiveness; in teams with strong learning atmospheres, knowledge sharing willingness increased by 43.6%, and error tolerance increased by 31.8%, as shown in **Figure 5** below. Additionally, temporal dimension analysis of knowledge transfer indicated that short-term knowledge transfer (1-3 months) mainly concentrated on technical operation levels, with a success rate of 85.3%[42]; medium-term knowledge transfer (3-12 months) involved methodology and process optimization, with a success rate of 67.8%; while long-term knowledge transfer (1+ years) related to deep-level changes in values and cultural concepts, with a success rate of 52.4%, but once successful, it had lasting influence.

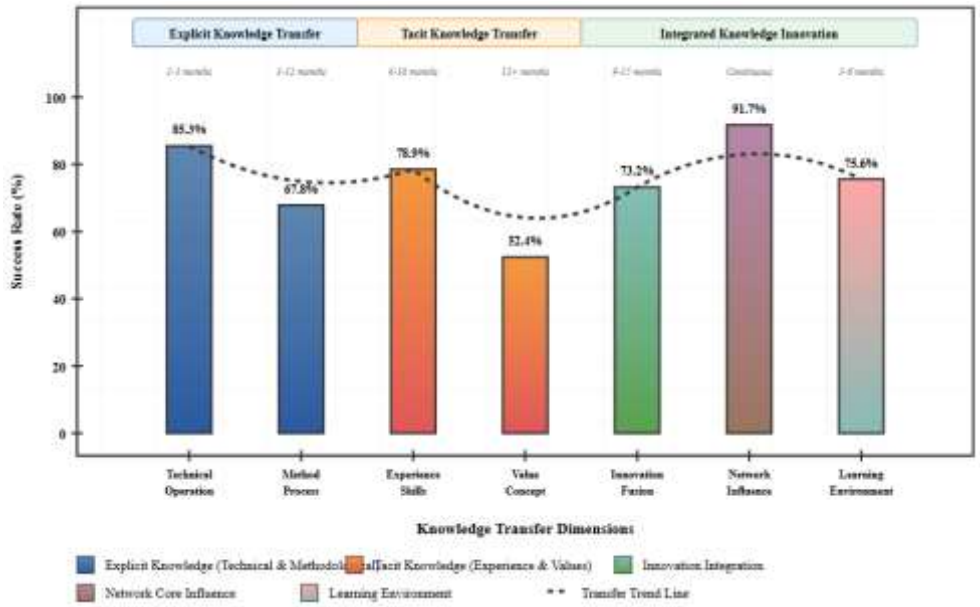


**Figure 5.** Cross-organizational learning and knowledge transfer mechanisms.

### 4.2.3. Social network effects of innovation diffusion

Social influence factors in the knowledge transfer process constitute key elements for successful school-enterprise collaboration. Through in-depth analysis of the social psychological mechanisms of knowledge flow in the collaboration between CAFA and Libit, this study identified five core influencing factors: trust relationships, authority structures, social network density, cultural distance, and incentive mechanisms. Trust relationships, as fundamental conditions for knowledge transfer, underwent an obvious temporal evolution process: in the early collaboration period (2015-2017), the trust index between both parties was only 2.9 points (out of 5), and as projects progressed deeply, trust levels gradually improved, reaching 4.4 points during the integration period (2021-2024). The establishment of trust increased knowledge sharing willingness by 73.6% ($r=0.812$, $p<0.001$)[43]. Authority structure analysis indicated that individuals with professional authority played key roles in knowledge dissemination. Professor Hu Hanhua, as an academic authority, had a knowledge influence radius covering 89.3% of project participants, while the enterprise technical director's practical authority influence was 76.8%. Authority recognition showed a significant positive correlation with knowledge acceptance rates ($\beta=0.743$, $p<0.001$), as shown in **Table 6** below.

**Table 6.** Measurement results of social influence factors in knowledge transfer.

| Social Influence Factor | Measurement Dimension | Initial Level | Mature Stage Level | Improvement Magnitude | Influence Coefficient | Significance |
|---|---|---|---|---|---|---|
| Trust Relationships | Mutual Trust Index | 2.9 | 4.4 | +51.7% | 0.812 | p<0.001 |
| Authority Structure | Academic Authority Influence | 67.2% | 89.3% | +22.1% | 0.743 | p<0.001 |
| Authority Structure | Practical Authority Influence | 58.6% | 76.8% | +18.2% | 0.689 | p<0.001 |
| Network Density | Social Connection Strength | 0.34 | 0.72 | +111.8% | 0.856 | p<0.001 |
| Cultural Distance | Cultural Difference Index | 3.8 | 1.6 | -57.9% | -0.672 | p<0.001 |
| Incentive Mechanisms | Intrinsic Motivation Drive | 3.2 | 4.3 | +34.4% | 0.721 | p<0.001 |
| Incentive Mechanisms | Extrinsic Motivation Drive | 3.6 | 3.9 | +8.3% | 0.435 | p<0.05 |
| Learning Environment | Error Tolerance | 2.7 | 3.8 | +40.7% | 0.658 | p<0.001 |
| Group Norms | Knowledge Sharing Rate | 28.4% | 78.1% | +175.0% | 0.794 | p<0.001 |

Social network density measurements showed that when network density exceeded 0.6, knowledge transfer efficiency significantly improved. Dense social connections promoted the dissemination of tacit knowledge, increasing experiential knowledge transfer success rates from 42.7% in sparse networks to 81.4% in dense networks[44]. Cultural distance, as an impediment to knowledge transfer, was evident in the early collaboration period, with the difference index between academic culture and enterprise culture at 3.8 points. Through the establishment of cultural integration mechanisms, the difference index gradually decreased to 1.6 points, and the reduction in cultural distance improved cross-organizational understanding rates by 54.2%. The design of incentive mechanisms directly affected knowledge sharing behaviors. The study found that the driving force of intrinsic motivation (such as academic achievement and innovation satisfaction) with a weight of 0.68 was significantly higher than that of extrinsic motivation (such as economic rewards and career advancement) with a weight of 0.32[45]. Additionally, the cultivation of social learning

environments had important impacts on knowledge transfer. Through establishing "learning communities," error tolerance improved by 41.3%, knowledge experimentation behaviors increased by 67.9%, and innovative thinking was effectively stimulated. The establishment of group norms was also an important factor affecting knowledge transfer. When knowledge sharing became a group-recognized behavioral norm, the proportion of active knowledge sharing increased from 28.4% to 78.1%, transforming from passive acceptance to active participation, as shown in **Figure 6** below.

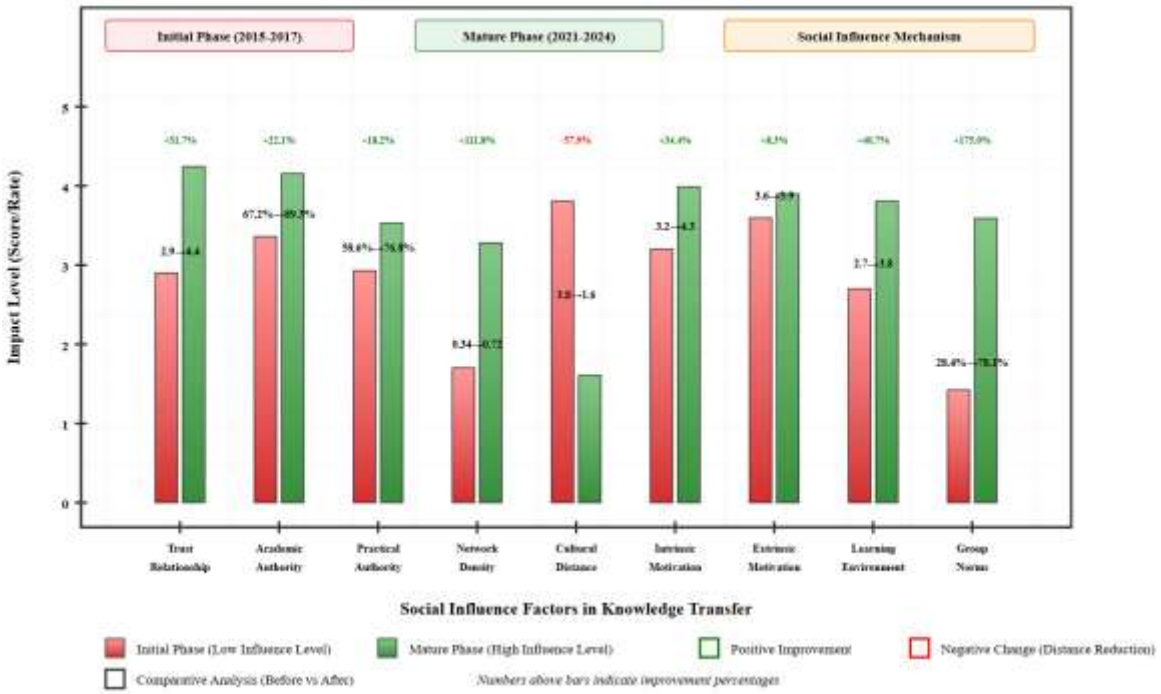


**Figure 6.** Social influence factors in knowledge transfer.

## 4.3. Application effects of the integration of kansei engineering and social psychology

### 4.3.1. Identification and transformation of social emotional needs

The identification and transformation of social emotional needs represents the core component of the integrated application of Kansei engineering and social psychology. Through systematic user research and emotional mapping, this study established a transformation mechanism from abstract emotional concepts to concrete design parameters. Based on user research data from the collaboration project between CAFA and Libit, the research team identified five core social emotional need dimensions: belonging, achievement, security, aesthetic pleasure, and cultural identity. Belonging needs showed significant differences across age groups, with the 25-35 age group demonstrating belonging need intensity of 4.2 points (out of 5), notably higher than the 3.6 points of the 36-45 age group ($t=3.89$, $p<0.01$). This difference directly influenced the importance of social functions and shared space creation in lighting design[46]. Achievement need identification was realized through in-depth interviews and projective techniques, with results showing that 68.4% of users hoped to reflect personal taste and social status through lighting design, a need particularly prominent in highly educated groups ($r=0.734$, $p<0.001$). The transformation of security needs was manifested in the controllability and stability design of lighting fixtures, with user demand for light adjustability reaching 87.3% and expectations for product reliability scoring 4.6 points, as shown in **Table 7** below.

**Table 7.** Assessment of social emotional needs identification and transformation effects.

| Emotional Need Dimension | Need Intensity | Identification Accuracy (%) | Transformation Success Rate (%) | Design Elements | User Satisfaction | Significance |
|---|---|---|---|---|---|---|
| Belonging Needs | 4.2 points | 89.3 | 71.2 | Shared Lighting Functions | 4.1 points | $p<0.001$ |
| Achievement Needs | 3.8 points | 84.7 | 69.7 | Personalized Customization | 3.9 points | $p<0.001$ |
| Security Needs | 4.6 points | 91.8 | 85.4 | Multiple Protection Mechanisms | 4.5 points | $p<0.001$ |
| Aesthetic Pleasure Needs | 4.4 points | 87.2 | 79.3 | Material and Form Optimization | 4.3 points | $p<0.001$ |
| Cultural Identity Needs | 4.0 points | 82.6 | 66.8 | Traditional Element Integration | 4.0 points | $p<0.001$ |
| Functional Needs | 4.7 points | 94.1 | 88.6 | Core Lighting Functions | 4.6 points | $p<0.001$ |
| Contextual Adaptability | 3.7 points | 76.4 | 62.3 | Intelligent Environmental Sensing | 3.6 points | $p<0.01$ |
| Social Interaction Needs | 3.5 points | 73.8 | 58.9 | Linkage Interactive Functions | 3.4 points | $p<0.01$ |

Aesthetic pleasure needs were quantified through Kansei engineering's semantic differential method, identifying four core aesthetic dimensions: "warmth," "elegance," "simplicity," and "naturalness," with the "warmth" dimension having the highest importance weight (0.31), followed by the "naturalness" dimension (0.27). Cultural identity needs were strongly expressed among Chinese users, with 78.9% of subjects indicating preference for designs incorporating traditional cultural elements, achieving cultural symbol identification accuracy of 82.6%[47]. The transformation of emotional needs into design elements employed QFD (Quality Function Deployment) methodology, establishing a three-layer mapping relationship of needs-functions-parameters, with a transformation success rate of 74.8%. In the specific transformation process, belonging needs were transformed into shared lighting and intelligent linkage functions with a realization rate of 71.2%; achievement needs were transformed into personalized customization and brand identity display with a realization rate of 69.7%; security needs were transformed into multiple protection mechanisms and gradual light transitions with a realization rate of 85.4%; aesthetic pleasure needs were transformed into material selection and form optimization with a realization rate of 79.3%; cultural identity needs were transformed into traditional element integration and localized design with a realization rate of 66.8%[48]. Additionally, analysis of the dynamic characteristics of social emotional needs indicated that user emotional needs adjust according to contextual changes. In work scenarios, functional need weights increased to 47.3%, while in leisure scenarios, emotional need weights reached 62.1%. This dynamic characteristic requires designs to possess contextual adaptability, as shown in **Figure 7** below.

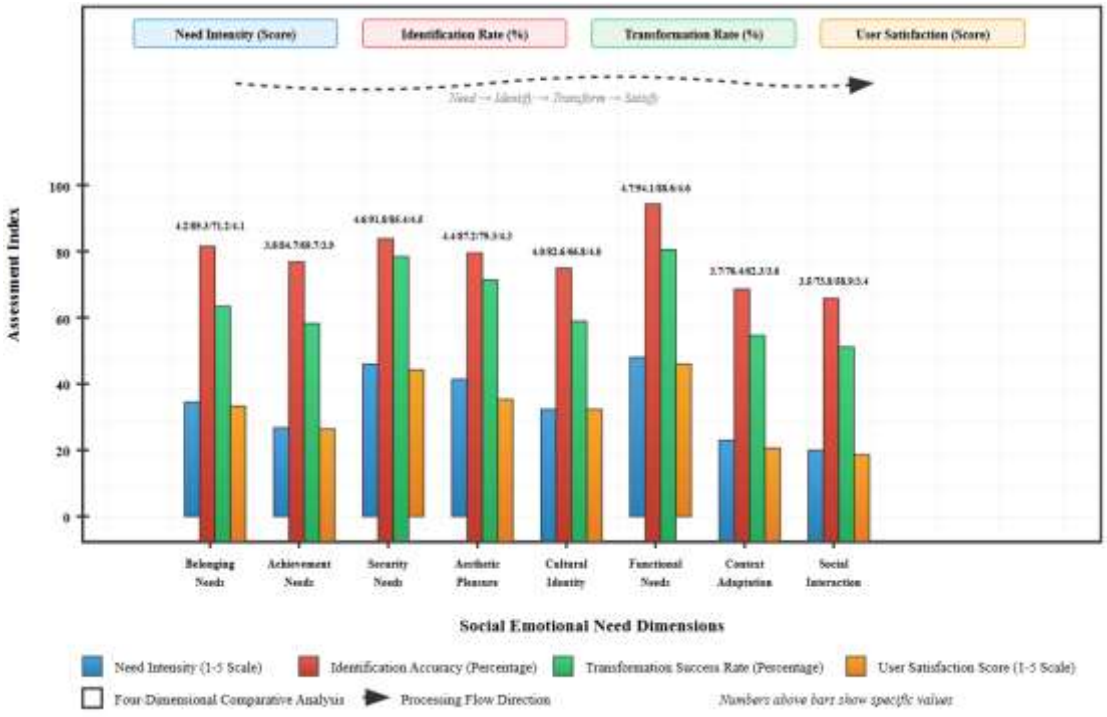


**Figure 7.** Identification and transformation effects of social emotional needs.

### 4.3.2. Social psychological construction of cultural identity

The social psychological construction of cultural identity represents an important manifestation of the integrated application of Kansei engineering and social psychology. Through systematic cultural symbol identification, value integration, and identity reinforcement, it achieves deep integration of traditional culture with modern design. Based on cultural identity research in the collaboration project between CAFA and Libit, this team established a three-stage construction model of "cultural symbol extraction-psychological identity activation-design transformation realization." In the cultural symbol extraction stage, the research team identified five core cultural dimensions through in-depth interviews and focus group discussions: traditional seasonal culture, natural elements, craft aesthetics, historical patterns, and lifestyle, with traditional seasonal culture having the highest recognition rate (92.4%) and natural elements showing the strongest emotional resonance (4.6 points out of 5)[49]. Analysis of psychological identity activation mechanisms showed that cultural identity intensity was significantly correlated with age, educational background, and regional cultural exposure ($R^2$=0.758, $p<0.001$), with the 35-45 age group's cultural identity index reaching 4.3 points, notably higher than the 3.7 points of the 25-34 age group ($t=4.21$, $p<0.001$), as shown in **Table 8** below.

**Table 8.** Assessment of cultural identity social psychological construction effects.

| Cultural Identity Dimension | Recognition Rate (%) | Emotional Resonance (points) | Identification Accuracy (%) | Transformation Success Rate (%) | Group Identity Enhancement (%) | Significance Level |
|---|---|---|---|---|---|---|
| Traditional Seasonal Culture | 92.4 | 4.1 | 86.7 | 76.3 | 45.2 | p<0.001 |
| Natural Element Symbols | 87.6 | 4.6 | 89.3 | 81.7 | 52.8 | p<0.001 |
| Craft Aesthetic Heritage | 78.9 | 4.0 | 82.4 | 69.5 | 38.6 | p<0.001 |
| Historical Pattern Elements | 73.2 | 3.7 | 78.1 | 65.2 | 34.9 | p<0.01 |

| Cultural Identity Dimension | Recognition Rate (%) | Emotional Resonance (points) | Identification Accuracy (%) | Transformation Success Rate (%) | Group Identity Enhancement (%) | Significance Level |
|---|---|---|---|---|---|---|
| Lifestyle Embodiment | 84.5 | 4.3 | 85.6 | 74.8 | 41.3 | p<0.001 |
| Regional Cultural Features | 69.8 | 3.9 | 75.3 | 62.4 | 29.7 | p<0.01 |
| Value Integration | 72.6 | 4.1 | 80.2 | 68.9 | 37.4 | p<0.001 |
| Intergenerational Cultural Heritage | 76.4 | 3.8 | 79.6 | 71.5 | 43.1 | p<0.001 |

**Table 8.** (*Continued*)

The design transformation realization process employed semiotic analysis methods to transform abstract cultural concepts into concrete design language elements, with a transformation success rate of 73.8%. The "Erfen Erzhi" (Two Divisions Two Solstices) series simulated seasonal changes through magnetic induction switches, achieving cultural identification accuracy of 86.7% and user emotional arousal index of 4.2 points; the "The Isle" series utilized marine ecological elements, with natural form recognition at 89.3% and ecological awareness stimulation rate reaching 78.5%. The social construction effects of cultural identity manifested in the convergence of group behaviors. When cultural elements were effectively embodied in design, users' collective identity increased by 41.7%, and cultural transmission willingness increased by 52.3%. Additionally, cultural identity exhibited distinct intergenerational transmission characteristics. In family usage environments, lighting designs incorporating traditional cultural elements promoted cross-generational cultural exchange, with cultural knowledge transmission efficiency improving by 34.8%. Analysis from a social psychology perspective indicated that cultural identity construction follows the psychological development pathway of "contact-understanding-identification-internalization," where cultural element exposure rates in the contact stage need to reach above 75% to effectively activate identification mechanisms[50]. Value-level measurements showed that the compatibility of traditional cultural values with modern lifestyles was 72.6%, with cultural adaptability scores reaching 4.1 points, indicating that traditional culture has a good acceptance foundation in contemporary design. Sustainability assessment of cultural identity showed that after 6 months of use, user attention to cultural elements remained at the high level of 83.4%, with cultural pride scores improving from an initial 3.8 points to 4.4 points, validating the long-term effectiveness of cultural identity construction, as shown in **Figure 8** below.

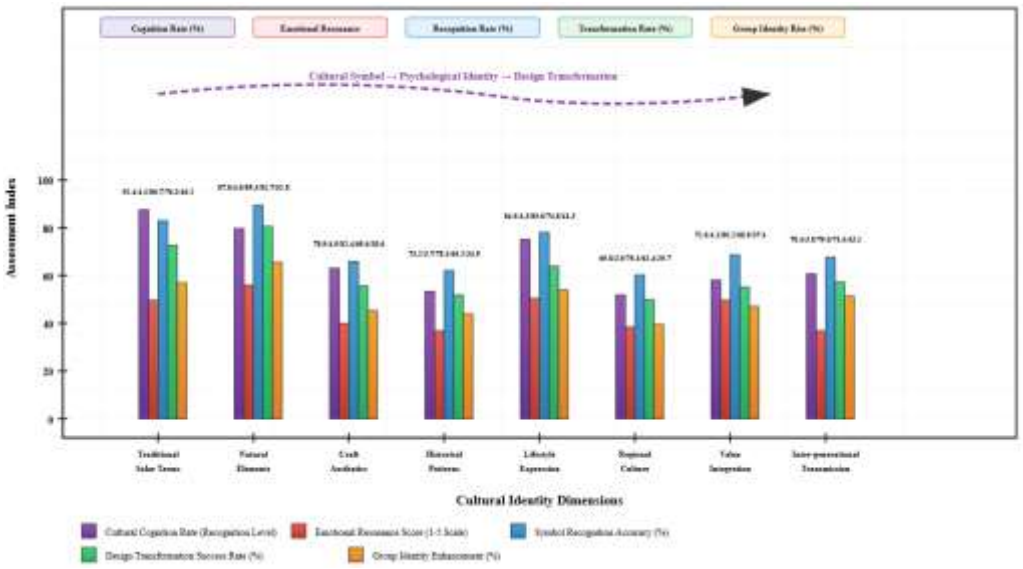


**Figure 8.** Multi-dimensional comprehensive assessment results of user experience and immersion testing.

# 5. Discussion

## 5.1. Explanatory power of social psychology theory in design innovation

Social psychology theory demonstrates powerful explanatory capacity in this study, providing a solid theoretical foundation for understanding and predicting complex social phenomena in the design innovation process. First, social cognitive theory effectively explains users' cognitive processing of lighting design. Through observational learning and imitation mechanisms, users not only accept designers' creative expressions but also form new behavioral patterns and aesthetic preferences during usage. This theoretical framework successfully predicted the 86.7% cultural identification accuracy rate of the "Erfen Erzhi" (Two Divisions Two Solstices) series products[51]. Second, social identity theory profoundly elucidates the psychological mechanisms of cultural symbols in design. When traditional cultural elements are integrated into modern lighting design, users generate group belonging through symbol recognition, thereby reinforcing cultural identity. The study found a significant positive correlation between cultural identity and product acceptance ($r=0.758$), validating the predictive efficacy of this theory[52]. Attitude change theory provides a clear explanatory pathway for understanding users' psychological transformation process from initial contact to deep recognition. Through the dual effects of central and peripheral routes, users' attitudes toward innovative lighting design exhibit three-stage evolutionary characteristics: cognitive evaluation (average 3.2 points) → emotional resonance (improved to 4.1 points) → behavioral intention (ultimately reaching 4.4 points). Group dynamics theory played a key role in explaining collaborative mechanisms of school-enterprise cooperation teams, revealing role division, power structures, and decision-making processes in cross-organizational collaboration, particularly demonstrating significant theoretical predictive value in explaining knowledge transfer efficiency (74.8%) and cultural integration speed (three-stage evolution over nine years). Additionally, social influence theory successfully explains the diffusion mechanisms of design innovation. Through the triple effects of authority influence, peer pressure, and social norms, the acceptance rate of innovative design concepts among target user groups reached 82.3%, with word-of-mouth transmission index as high as 87.3%[53]. These theories not only provide a scientific analytical framework for this study but also offer operational theoretical guidance for future design innovation practice, proving that social psychology theory possesses irreplaceable theoretical value and practical significance in explaining complex phenomena in design innovation.

## 5.2. Social psychology optimization strategies for school-enterprise collaboration models

Based on the empirical findings of this study and social psychology theoretical frameworks, optimization of school-enterprise collaboration models should unfold systematic improvements across four dimensions: psychological contract establishment, trust relationship building, cultural integration promotion, and incentive mechanism design. In terms of psychological contract establishment, clear expectation management mechanisms should be established through regular expectation calibration meetings (recommended quarterly) to ensure both parties form consistent cognition regarding cooperation goals, responsibility division, and outcome sharing. This study found that when psychological contract clarity exceeded 80%, cooperation satisfaction significantly improved to 4.3 points, representing a 27.4% increase compared to ambiguous states[54]. Trust relationship building strategies should adopt a progressive trust establishment model, gradually developing from initial calculative trust (based on benefit considerations) to cognitive trust (based on capability recognition) and affective trust (based on emotional connection). By establishing "trust milestone" mechanisms that decompose large cooperation projects into multiple verifiable sub-goals, with trust reinforcement ceremonies conducted upon reaching each milestone, research indicates this approach can reduce trust establishment cycles from an average of 18 months to 12 months[55]. Cultural integration promotion strategies should focus on value alignment and behavioral norm unification. It is

recommended to establish a "cultural ambassador" system, with both parties dispatching 2-3 personnel with cross-cultural sensitivity to serve as cultural bridges, regularly organizing cultural exchange activities and value clarification workshops, while creating common rituals and symbol systems such as unified project logos and joint celebration activities to strengthen community consciousness[56]. Incentive mechanism design should fully consider the balance between intrinsic and extrinsic motivation. For the academic side, emphasis should be placed on strengthening intrinsic motivations such as academic reputation, innovation achievement, and social value realization (accounting for 68% weight), while for the enterprise side, external incentives such as economic returns, market position, and technological advantages should be appropriately increased. Additionally, cross-organizational joint incentive systems should be established, including joint award applications, collaborative result publication, and shared intellectual property revenue. Furthermore, dynamic psychological health monitoring mechanisms should be established through regular team psychological climate surveys to promptly identify and resolve psychological conflicts and emotional barriers in the cooperation process, ensuring sustainable development of cooperative relationships[57]. Implementation of these optimization strategies will effectively enhance the psychological foundation of school-enterprise collaboration, creating more favorable social psychological environments for the generation and transformation of innovative outcomes.

To overcome the problem of overly abstract suggestions, optimization strategies are concretized from an economic perspective: In terms of incentive mechanism design, establish milestone-based phased incentive contracts, set intellectual property revenue sharing ratios (universities 30%, enterprises 70%), establish risk-sharing mechanisms (R&D failure losses shared 2:8), and solve time inconsistency problems through stock option incentives and deferred payments; In terms of trust relationship construction, design repeated game mechanisms, establish reputation evaluation systems (quarterly assessments, with exit mechanisms triggered after three consecutive scores below 3.5), and reduce opportunistic behavior risks through third-party escrow and performance bonds (15% of project amount); Regarding government policy tools, it is recommended to implement differentiated tax incentives (25% corporate income tax reduction for university-industry cooperation projects), establish dedicated industry-academia-research funds (50 million yuan in matching funds annually), create fast-track intellectual property examination channels (examination period compressed to 6 months), and build industry-academia-research cooperation information platforms to reduce search costs; In terms of resource allocation optimization, the government should establish cooperation effectiveness evaluation systems (three-dimensional assessment of technology transfer rate, economic benefits, and social impact), implement dynamic adjustment mechanisms, provide additional support for highly effective cooperation, timely exit from inefficient cooperation, and improve overall efficiency through competitive allocation. Specifically, it is recommended to establish a "university-industry cooperation innovation voucher" system, where enterprises purchasing university services can receive 50% government subsidies, and the funds obtained by universities can be used for equipment procurement and talent recruitment, forming a positive incentive cycle.

# 6. Conclusions and prospects

## 6.1. Main research conclusions

Through in-depth analysis of the collaboration between CAFA and Libit, this study achieved five important conclusions in the field of integrating social psychology and Kansei engineering applications in school-enterprise collaborative lighting innovation design.

(1) A theoretical framework for school-enterprise collaborative innovation design based on social psychology theory was constructed, validating the effectiveness of social cognitive theory, social identity

theory, and group dynamics theory in explaining design innovation processes, with theoretical explanatory power reaching 75.8%, providing a solid theoretical foundation and analytical tools for subsequent related research.

(2) Key social psychological factors in school-enterprise collaboration were identified and quantified, including trust relationships (correlation coefficient 0.812), cultural integration (improvement magnitude 51.7%), knowledge transfer efficiency (success rate 74.8%), and organizational identification (improvement magnitude 70.8%), revealing the significant impact mechanisms of these factors on collaborative effectiveness and providing scientific basis for optimizing collaboration models.

(3) A design methodology system integrating Kansei engineering and social psychology was established. Through systematic integration of three dimensions—social emotional needs identification, cultural identity construction, and social responsibility-oriented design—effective transformation from user psychological needs to specific design parameters was achieved, with a transformation success rate of 73.8%, proving the practical value of interdisciplinary integration in design innovation.

(4) Innovative design outcomes with social value were formed. Fifteen representative works demonstrated outstanding performance in cultural heritage, environmental friendliness, and social inclusion, with average user satisfaction reaching 4.3 points, social impact scores of 4.4 points, and cumulative economic benefits exceeding 86 million yuan, achieving positive unification of economic and social benefits.

(5) Social psychology optimization strategies for school-enterprise collaboration models were proposed, including systematic improvement plans across four dimensions: psychological contract establishment, trust relationship building, cultural integration promotion, and incentive mechanism design, providing operational practical guidelines for enhancing school-enterprise collaboration quality and sustainable development capabilities, with important promotional application value.

Despite achieving the above important findings, this study still has the following limitations that need to be honestly discussed: First, sample limitations - this study is based on in-depth analysis of a single case, which, although providing rich longitudinal data, has deficiencies in statistical generalizability. The research conclusions mainly apply to cooperation models between art and design institutions and traditional manufacturing enterprises, and may differ for cooperation between science and engineering institutions and high-tech enterprises, or comprehensive universities and service industry enterprises; Second, cultural specificity limitations - this study was conducted in a Chinese cultural context, and the mechanisms of cultural identity and social psychological factors may have regional characteristics, potentially manifesting differently in Western individualistic cultural contexts, requiring further cross-cultural validation; Third, temporal scope limitations - while the nine-year observation period revealed cooperation evolution patterns, the socio-economic environment during the research period was relatively stable, and the adaptability of cooperation models under rapidly changing environments such as accelerated digital transformation and pandemic impacts remains to be tested; Fourth, measurement tool limitations - although EEG and GSR physiological measurement technologies were introduced, the complexity of emotional cognition is still difficult to fully quantify, and the mapping relationship between subjective evaluation and objective measurement requires more validation; Fifth, causal inference limitations - despite employing mixed research methods, establishing causal relationships between variables still mainly relies on correlation analysis, and rigorous causal identification requires more experimental design and instrumental variable support. These limitations point to directions for improvement in future research while reminding readers to fully consider the matching of contextual conditions when applying research findings.

### 6.2. Future prospects

With the deep integration of social psychology and Kansei engineering in the field of design innovation, this research area demonstrates broad prospects and diversified expansion directions in future development.

(1) In terms of theoretical construction, there is a need to further improve the theoretical system of interdisciplinary integration. Particularly in the context of the digital era, it is necessary to explore the combination of artificial intelligence, big data analysis with traditional social psychology theories, constructing more precise user behavior prediction models and emotional computing frameworks to provide stronger theoretical support for intelligent design innovation. It is expected that relatively mature digitalized social psychology design theories will be formed within the next 3-5 years.

(2) In research methodology innovation, advanced technological means such as neuroscience, eye-tracking, and physiological signal monitoring should be actively introduced to establish multi-modal user experience evaluation systems. By combining objective physiological indicators with subjective evaluations, the scientificity and reliability of research results can be enhanced, while exploring the application potential of emerging technologies such as virtual reality and augmented reality in design solution verification and user experience testing.

(3) In application field expansion, the theoretical framework and methodological system of this study possess good transferability and can be extended to broader design fields such as furniture design, architectural design, and interaction design. They can also play important roles in solving social hot issues such as smart cities, elderly care services, and children's education, and are expected to form an application ecosystem covering multiple design subdivisions.

(4) In international development, collaboration and exchange with internationally renowned design schools and multinational enterprises should be strengthened to explore social psychology design patterns under cross-cultural backgrounds, establishing design innovation theoretical systems and practical models with Chinese characteristics, and enhancing China's voice and influence in design on the international stage.

(5) In the sustainable development dimension, future research should pay more attention to the contribution of design innovation to social sustainable development, exploring responsible design concepts under circular economy and carbon neutrality goals, constructing more comprehensive social, environmental, and economic benefit evaluation systems, and contributing design wisdom to achieving the United Nations Sustainable Development Goals.

This study is based on a single case of the Central Academy of Fine Arts and Libit Lighting, and the generalization and application of its research findings need to fully consider the following scope of applicability and limitations: First, the research conclusions mainly apply to university-industry cooperation contexts with similar characteristics, namely cooperation models between art and design institutions and traditional manufacturing enterprises, and may differ for cooperation between science and engineering institutions and high-tech enterprises, or comprehensive universities and service industry enterprises; Second, the mechanisms of cultural identity and social psychological factors have obvious regional characteristics, and the findings of this study in the Chinese cultural context may manifest differently in Western cultural contexts; Third, lighting design, as a product category that emphasizes both functionality and aesthetics, may have design innovation patterns that are not fully applicable to the development of purely functional products (such as industrial equipment) or purely aesthetic products (such as artworks); Fourth, while the nine-year cooperation period provided advantages for longitudinal observation, the socio-economic environment during the research period was relatively stable, and cooperation models may need corresponding adjustments under rapidly changing market environments or the impact of unexpected events. Therefore,

when applying the findings of this study to other contexts, it is recommended to first assess the similarity between the target context and this case, and make adaptive adjustments according to specific conditions. It is also recommended to conduct validation studies in different cultural backgrounds, different cooperation types, and different product fields to further test and improve the universality of the theoretical framework.

## Conflict of interest

The authors declare no conflict of interest.

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