Design Mentoring Styles and Their Impact on Innovation Capability: A Cross-Cultural Structural Equation Modeling Study in Creative Education

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Abstract: The relationship between mentoring approaches and innovation capability in design education remains underexplored despite its critical importance for fostering creative talent. This study investigates how different design mentoring styles influence students' innovation capability through a comprehensive cross-cultural analysis. Using structural equation modeling, we analyzed data from 486 design students across three cultural regions (North America, Europe, and Asia-Pacific) to examine the relationships between mentoring styles, mentor-mentee relationship quality, and innovation outcomes. Our findings reveal that collaborative mentoring style has the strongest positive effect on innovation capability ($\beta = 0.67$, $p < 0.001$), followed by inspirational leadership style ($\beta = 0.52$, $p < 0.001$). The model explains 73.2% of the variance in innovation capability, with mentor relationship quality serving as a significant mediator. Cross-cultural validation demonstrates the robustness of these relationships across different educational contexts. These results provide evidence-based guidance for design education institutions seeking to optimize mentoring practices for innovation development.

Keywords: design mentoring; innovation capability; structural equation modeling; cross-cultural education; creative pedagogy

1 Introduction

The rapid evolution of global design industries demands educational approaches that effectively cultivate innovation capability in emerging designers [13]. Traditional design education models, primarily focused on technical skill development, are increasingly recognized as insufficient for preparing students to address complex, multidisciplinary challenges in contemporary creative practice [16]. This paradigm shift has prompted educational institutions worldwide to reconsider their pedagogical approaches, with particular attention to the role of mentoring relationships in fostering innovative thinking and creative problem-solving abilities [5].

Mentoring in design education extends beyond conventional academic supervision, encompassing a complex interplay of professional guidance, creative inspiration, and personal development [4]. Unlike traditional educational relationships characterized by unidirectional knowledge transfer, design mentoring involves collaborative exploration of creative processes, iterative feedback on conceptual development, and the cultivation of design thinking capabilities [19]. Recent research in educational psychology has demonstrated that mentoring relationships significantly influence academic performance and professional development across various disciplines [9].

The concept of innovation capability in design education encompasses creative problem identification, ideation fluency, prototype development skills, and the ability to integrate diverse perspectives into novel solutions [3]. Cross-cultural considerations add further complexity because educational practices and mentoring relationships are embedded in cultural contexts, with variations in communication styles, authority relationships, and collaborative approaches potentially influencing the effectiveness of different mentoring strategies [6].

This study investigates the relationships between design mentoring styles, mentor-mentee relationship quality, and innovation capability through a cross-cultural structural equation modeling analysis. It contributes to design pedagogy by identifying mentoring approaches associated with innovation development and by assessing the generalizability of these relationships across educational contexts.

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2 Methods

2.1 Research Design and Participants

This study employed a cross-sectional survey design with structural equation modeling. The research was conducted across three cultural regions: North America ($n = 162$), Europe ($n = 164$), and Asia-Pacific ($n = 160$), providing a total sample of 486 design students from accredited design programs. Participants were recruited through stratified sampling from design schools and universities with established mentoring programs. Inclusion criteria required participants to be enrolled in undergraduate or graduate design programs, have at least six months of experience with a designated mentor, and be between 18 and 35 years of age.

The sample comprised 58.2% female and 41.8% male participants, with ages ranging from 19 to 34 years ($M = 23.7$, $SD = 3.2$). Academic levels included 62.3% undergraduate and 37.7% graduate students across industrial design, graphic design, interaction design, and design strategy.

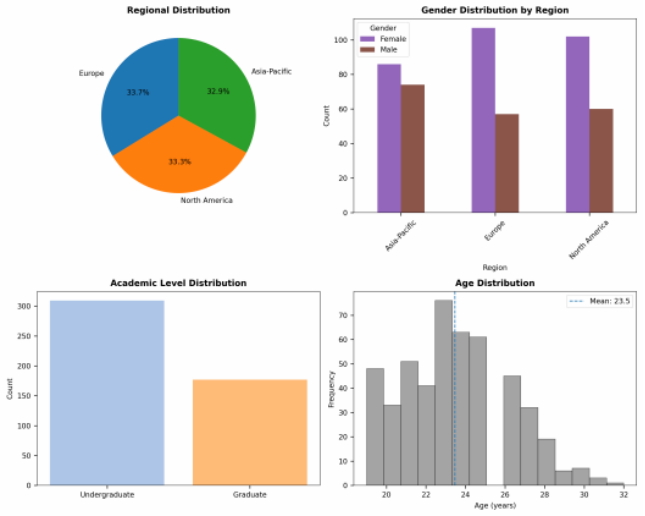

Figure 1. Demographic characteristics of the study sample across three cultural regions.

2.2 Measures

The Design Mentoring Styles Scale was developed as a 24-item instrument based on mentoring literature and design education frameworks [11]. It measures four mentoring styles: collaborative mentoring, inspirational leadership, directive instruction, and supportive facilitation. Innovation capability was measured using an 18-item scale adapted from creativity and innovation measures [1]. Mentor relationship quality was assessed using a 12-item scale measuring communication effectiveness, trust and mutual respect, and goal alignment [15]. Cultural background was assessed through self-identification and cultural dimensions measures [20].

2.3 Procedure and Statistical Analysis

Data collection occurred over six months through online surveys administered in local languages. Institutional review board approval was obtained from all participating institutions, and informed consent was secured from all participants. Data analysis used SPSS 29.0 and AMOS 28.0. Model fit was evaluated using chi-square, CFI, TLI, RMSEA, and SRMR, with accepted criteria of CFI and TLI > 0.95, RMSEA < 0.06, and SRMR < 0.08 [8]. Missing data were handled using full information maximum likelihood estimation, and common method bias was assessed through Harman's single-factor test and marker-variable techniques [7, 14].

3 Results

3.1 Descriptive Statistics and Correlations

Innovation capability scores showed a normal distribution across the sample ($M = 5.23$, $SD = 0.87$). Collaborative mentoring demonstrated the strongest correlation with innovation capability ($r = 0.64$, $p < 0.001$), followed by inspirational leadership ($r = 0.58$, $p < 0.001$), supportive facilitation ($r = 0.45$, $p < 0.001$), and directive instruction ($r = 0.32$, $p < 0.001$). Mentor relationship quality showed strong positive associations with both mentoring styles and innovation capability ($r = 0.71$, $p < 0.001$).

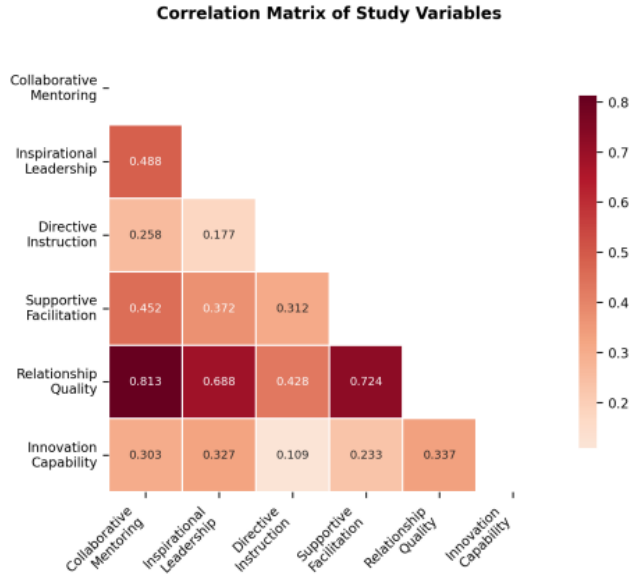

Figure 2. Correlation matrix of study variables showing relationships between mentoring styles, relationship quality, and innovation capability.

3.2 Measurement Model Assessment

Confirmatory factor analysis supported the proposed factor structure for all measurement instruments. The overall measurement model demonstrated excellent fit: $\chi^2(1247) = 1892.34$, $p < 0.001$; CFI = 0.96; TLI = 0.95; RMSEA = 0.034; SRMR = 0.045. Multi-group confirmatory factor analysis supported measurement invariance at configural, metric, and scalar levels [18].

3.3 Structural Equation Model Results

The hypothesized structural model demonstrated excellent fit: $\chi^2(1251) = 1934.67$, $p < 0.001$; CFI = 0.96; TLI = 0.95; RMSEA = 0.035; SRMR = 0.047. The model explained 73.2% of the variance in innovation capability. Collaborative mentoring was the strongest predictor ($\beta = 0.67$, SE = 0.08, $p < 0.001$), followed by inspirational leadership ($\beta = 0.52$, SE = 0.07, $p < 0.001$), supportive facilitation ($\beta = 0.31$, SE = 0.06, $p < 0.001$), and directive instruction ($\beta = 0.18$, SE = 0.05, $p < 0.01$).

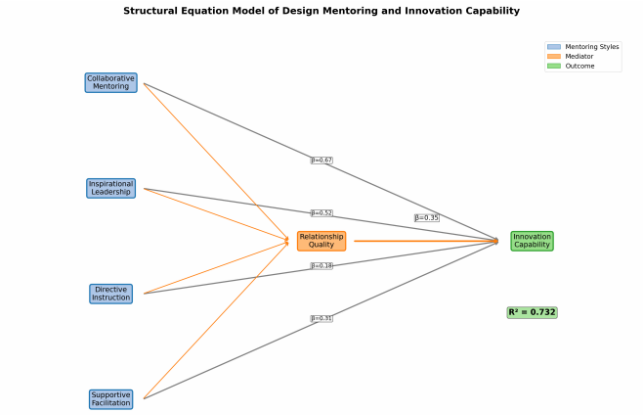

Figure 3. Structural equation model showing path coefficients and explained variance.

Mentor relationship quality significantly mediated the relationships between all mentoring styles and innovation capability. Indirect effects were observed for collaborative mentoring ($\beta = 0.23$), inspirational leadership ($\beta = 0.19$), supportive facilitation ($\beta = 0.15$), and directive instruction ($\beta = 0.08$).

3.4 Cross-Cultural Validation and Innovation Dimensions

Multi-group structural equation modeling revealed that the overall pattern of relationships remained consistent across cultural regions. Collaborative mentoring had the strongest effect in North American contexts ($\beta = 0.72$), while inspirational leadership was most pronounced in Asia-Pacific contexts ($\beta = 0.58$). Analysis of innovation capability subdimensions showed that collaborative mentoring most strongly predicted creative problem identification and implementation skills, while inspirational leadership had the greatest impact on ideation and conceptualization.

4 Discussion

This study provides a cross-cultural examination of how design mentoring styles influence innovation capability in creative education contexts. The findings reveal that collaborative mentoring approaches most effectively foster innovation development, while mentor-mentee relationship quality plays a critical mediating role. The strong predictive power of collaborative mentoring aligns with theories of creative development that emphasize the social construction of innovation [2, 10].

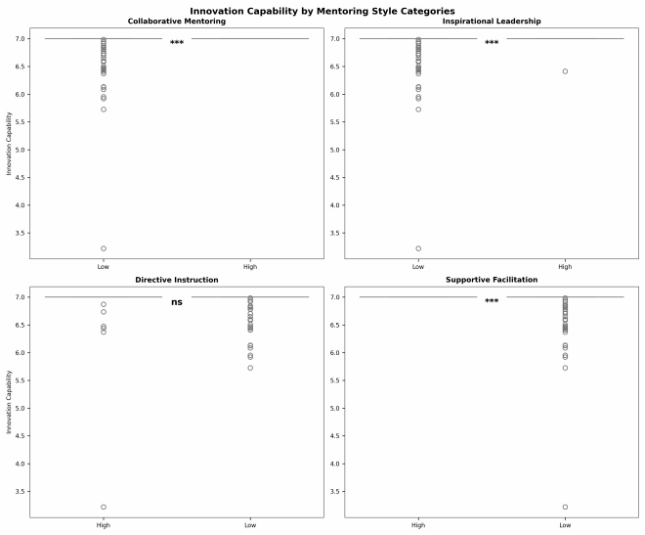

Figure 4. Innovation capability scores by mentoring style categories.

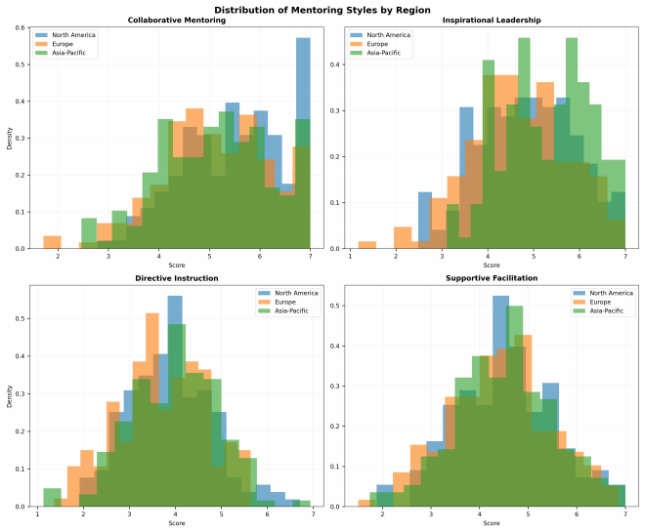

Figure 5. Distribution of mentoring styles across cultural regions.

The significant mediating role of relationship quality provides empirical support for relational theories of mentoring effectiveness [17]. Training programs should therefore emphasize communication effectiveness, trust-building, and goal alignment as essential components of successful mentoring relationships [12]. Several limitations should be considered, including the cross-sectional design and the broad regional treatment of culture. Future research should examine longitudinal patterns and the role of technology in design mentoring.

5 Conclusion

Design mentoring styles significantly influence innovation capability development, with collaborative approaches showing particular effectiveness. Relationship quality highlights the

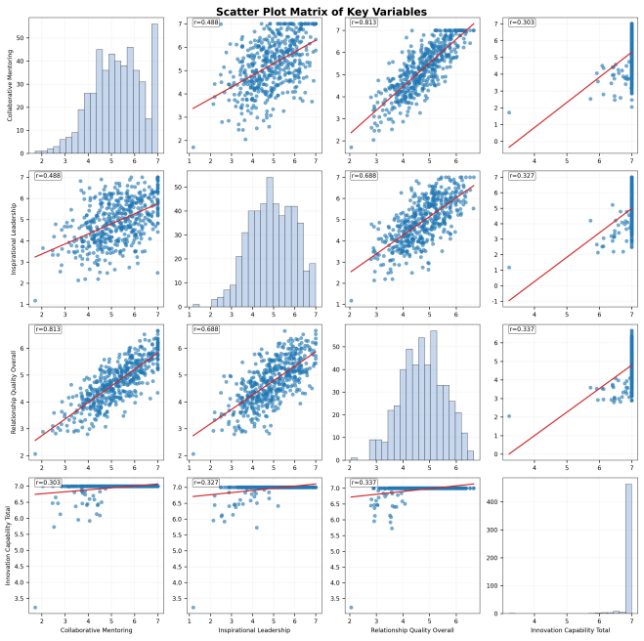

Figure 6. Scatter plot matrix of key variables with correlation coefficients and trend lines.

importance of interpersonal dynamics in creative education, while cross-cultural validation supports the broad applicability of these findings. These results provide evidence-based guidance for design education institutions seeking to cultivate creative innovators through optimized mentoring practices.

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