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Research on Messaging Applications as Mediators to Enhance Design Creativity in Industrial Design Students in China

Qian Zhao[1] and LeeHsing Lu[2]
[1] Ph.D. Candidate, Graduate School of Business and Advanced Technology Management, Assumption University, Thailand
[2] Ph.D., Graduate School of Business and Advanced Technology Management, Assumption University, Thailand
[1]E-mail: catherinezhaoq@outlook.com, ORCID ID: https://orcid.org/0009-0006-5722-6459
[2]E-mail: leelu@mail.com, ORCID ID: https://orcid.org/0000-0002-4818-1440

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Abstract

Background and Aim: In globalization, creativity emerges as a pivotal factor in bolstering the competitiveness of nations and individuals. Therefore, fostering students' creativity becomes a crucial goal of education and a key driver for societal development and innovation. This study, with its potential to determine the factors that affect the design creativity of industrial design students through messaging applications, holds significant promise. The research framework includes variables such as design creativity (DC), knowledge sharing (KS), cooperative learning (CL), inspiration (IN), creative self-efficacy (CS), and the use of messaging applications (UMA). By exploring the influence of educational methods on creativity development through the analysis of students' creative generation process in messaging applications, we aim to provide new perspectives and tools that could profoundly impact creativity and educational research.

Materials and Methods: In this research, we meticulously collected 467 valid questionnaires from colleges and universities in Sichuan Province, China, employing rigorous quantitative methods and questionnaire surveys. To ensure the utmost accuracy of the questionnaire data, we conducted a confirmatory factor analysis (CFA) to test the relationship between the observed variables and the potential variables. Subsequently, we employed the structural equation model (SEM) to test the research hypothesis comprehensively. Applying these two analytical techniques underscores the scientific rigor of our research methods and the robustness of our results.

Result: The results of data analysis show that the use of message application, knowledge sharing, cooperative learning, inspiration, and creative self-efficacy significantly affect design creativity. Using message application as an intermediary variable improves industrial design students' knowledge-sharing and creative self-efficacy, thus enhancing their design creativity. However, the intermediary role of message application between inspiration, collaborative learning, and design creativity is not significant. This finding contrasts with the results of pilot tests, reflecting the differences in educational strategies implemented by different educators in influencing students' interaction and inspiration in collaborative learning.

Conclusion: Studying the use of message applications to enhance creativity can promote educational equity and social interaction and stimulate interdisciplinary learning and collective wisdom. At the same time, cultivate students' innovative skills and lifelong learning and innovation ability. The research results provide educators with insights into how industrial design students can use new applications more effectively to improve their design creativity and confirm the effectiveness of students' creativity self-assessment. Therefore, in educational practice, the design creativity self-assessment scale can be used to evaluate students' design works. In addition, this study can be used as a reference for teaching and creativity research in other art disciplines.

Keywords: Design creativity; Mediator; Messaging applications; Knowledge sharing; Creative self-efficacy

Introduction

Creativity is the most basic skill in the 21st century (Millon-spectator & Beenen, 2015), which has different definitions in different disciplines. This study focuses on design creativity (DC), the ability to produce innovative and fresh designs (Dumas et al., 2016). It is also described in detail as the art of creating completely novel and fascinating ideas, artifacts, processes, and solutions (Zhou & George, 2001). With the progress of science and technology and the acceleration of globalization, creativity has evolved from a competitive advantage to a necessity for survival (Csikszentmihalyi & Sawyer, 2014). Therefore, improving creativity in education can promote individual innovation ability and change. Support all industries in moving towards sustainable development. Stine-Morrow et al. (2014) showed through research that creativity is a continuous and dynamic self-expression process, which can be enhanced at any age. Creating an environment that allows students to share knowledge and information, cooperate with others, and participate in the actual creative process is essential to improving students' creative ability (Eid & Al-Jabri,

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2016) put forward three dimensions to evaluate students' creativity: creative process, creator and creation itself. This study emphasizes students' self-evaluation of design creativity, which is crucial for understanding the individual cognitive process in design innovation.

With the popularity of smartphones, digital communication has diversified in education, and it is no longer limited to email and messages. The wide application of social media, including social networking sites and messaging applications, has significantly impacted students' communication behavior. Research shows that social media can promote students' participation and positively impact their creativity (Rasheed et al., 2020). Liu et al. (2022) confirmed the effectiveness of multimedia technology in education through meta-analysis, which can significantly enhance students' creativity. Gulzar et al. (2021) further emphasized that social media can enhance students' participation and creativity by providing rich information and interactive opportunities. However, Xiao Lixin et al. (2014) pointed out that most college students' online learning behavior is limited to simply storing information resources, lacking in-depth analysis and creative utilization. This shows that although network resources provide conditions for cultivating creativity, many students have not mastered effective methods to enhance creativity in this environment. Therefore, teachers are responsible for guiding students in mastering the methods of digital tools to promote professional learning and creativity.

Through a preliminary investigation among students majoring in industrial design at a university in Sichuan, China, the author confirmed that MA is the central hub of many learning-related activities, from exchanging information with classmates and teachers to completing courses and design competitions. In addition, MA serves as a repository of text and visual resources, displays individual creative works, and promotes design research through information retrieval. By carefully reading other people's works as a source of creative inspiration, MA has been fully integrated into the life of industrial design students, promoting the acquisition of information and knowledge, strengthening collaborative learning, and cultivating and stimulating their creativity. Industrial design includes the intersection of many disciplines, including engineering, ergonomics, business, aesthetics, and social, environmental, and cultural issues (Tovey, 1997). In industrial design, not only should the product's functionality be considered, but its aesthetic appeal, innovation, and emotional value should be considered (Gotzsch, 1999). The design process includes problem identification, critical thinking, planning, creation, and continuous improvement, and finally, forms design proposals and final products. The design aims to solve problems and produce various alternative solutions, thus leading to innovative results in art design education, cultivation, and improvement. In recent years, many scholars have explored how to improve creativity through educational technology. Zaman et al. (2010) found that the "flowing" experience immersed in instant messaging activities can promote creativity. The study also discussed how the use of IM affects users' cognitive and emotional states, thus affecting their creativity. Mage (2024) discussed that educational applications can stimulate students' creativity and critical thinking through personalized learning environments, gamification education, and interactive simulation. Tang et al. (2022) pointed out that the application of information and communication technology (ICT), artificial intelligence (AI), and cloud computing technology in the field of education provides new possibilities for improving students' creativity. However, no matter in China or other countries, there is a lack of research on the influence of MA on students' creativity, especially for art majors with high requirements for innovation ability, which shows that there is a gap worth exploring in the field of educational technology research on the potential role of MA in art education and creativity cultivation.

Objectives of Research

1. To clarify the relationship between the use of messaging applications and design creativity.
2. To identify the factors that influence the design creativity of industrial design students by using messaging applications.

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Literature review

Creative component model

In individual creativity research, Amabile (1997) put forward a creative component model with three key elements: professional skills, creative thinking, and task motivation. The interaction of these elements and the appropriate external environment determines the realization of individual creativity. Further, the research by Greenhow and Lewin (2015) reveals the influence of diverse learning environments on learning methods, time, and content. It emphasizes the promotion of creativity by integrating formal and informal learning activities. The flexibility of the online environment facilitates the implementation of this blended learning mode and helps to form a learning practice community. Gruzd et al. (2016) pointed out that these communities can personalize the learning experience according to learners' interests, goals, and styles. The research of Ahmed et al. (2019) further emphasizes the role of Internet technology in promoting knowledge sharing, which is essential to improving the individual's knowledge-processing ability and creativity. Amabile (1997) emphasized the importance of the synergy among the processes, fields, and task motivation processes related to creativity to the innovation output. Educators and researchers like Stine-Morrow et al. (2014) and Tsai (2013) actively develop theories and methods to cultivate this essential trait. Based on these studies, we can find that the stimulation of creativity depends not only on the individual's inherent potential and motivation but also on the learning environment, technical tools, and educational strategies. Integrating diversified learning resources and modern educational technology can promote individual creativity more effectively. Based on the Amabile model, this study aims to explore the potential and role of educational technology in stimulating individual creativity and how to optimize this process through effective educational strategies.

Social constructivism learning theory

Vygotsky's 1978 social constructivism theory provides a foundation for understanding the importance of knowledge sharing in social interactions, emphasizing the construction of knowledge through collaborative negotiation. Students actively share ideas and interact with educators, which aids cognitive development—a concept furthered by Hakkarainen et al. (2013). Saleem et al. (2021) explored the theory's impact on teaching methods, student motivation, and learning. Varma et al. (2023) found positive correlations between experience, communication, and understanding in learning, highlighting their significance. The rise of the internet and smartphones has made online learning more dynamic and collaborative, facilitating the development of advanced learning skills. Hakkarainen et al. (2013) noted that collaborative learning introduces diverse perspectives and enhances critical thinking. Stacey (1999) added that digital interactions enable learners to engage with experts, contributing to knowledge co-creation and expanding online learning's potential. Supported by modern technology, social constructivist learning theory highlights the core role of interactive consultation in building knowledge. Through online collaborative learning, learners can be exposed to multiple perspectives, enriching their thinking and enhancing their critical thinking and advanced cognitive ability through interaction with experts and peers. This environment of communication and cooperation has effectively promoted the co-creation and sharing of knowledge.

Knowledge sharing (KS)

Knowledge is a multi-faceted concept involving personal cognition and shared intelligence, from personal awareness to teamwork, knowledge infrastructure, process supervision, strategy formulation, and digital databases (Allawi & Redna, 2001). This study defines knowledge as accumulated experience, professional knowledge, and various documents created by students, such as reports, papers, and notes. Knowledge sharing refers to the personal exchange of knowledge (Van den Hooff et al., 2003), which is the key to teamwork, problem-solving, and innovation and requires extensive dissemination of information and professional knowledge (Cummings, 2004). The team needs to cultivate creativity and new ideas (Bell & Berry, 2007). Trust, reciprocal expectation, and willingness to share are the key factors in predicting individual knowledge-sharing behavior (Hassandoust et al., 2011). The ability to share knowledge and the perception of reciprocity are essential to promoting knowledge sharing among students, which is closely

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related to cultivating creativity (Arif et al., 2022). In addition, research shows that students' creativity can be effectively enhanced by learning online resources and participating in online knowledge-sharing and interactive activities (Ardaiz et al .,2011). This further emphasizes the importance of educators in guiding students to use online resources to enhance their creativity. Therefore, the following hypotheses are put forward:

H1: Knowledge sharing can enhance the design creativity of industrial design students.

H2: Using messaging applications as a mediating variable can enhance the impact of knowledge sharing on the design creativity of industrial design students.

Cooperative Learning (CL)

In collaborative learning, as a teaching method under the constructivist learning concept, multiple individuals form groups to work together to achieve shared learning goals (Johnson & Johnson, 1999). This method allows students to participate in teaching activities by grouping and mastering the learning content (Slavin, 1996), which has shown its importance in university education, especially in stimulating innovative thinking (López et al., 2023). Recent studies have evaluated the application of collaborative learning in education. The particular attention to teachers' participation in collaborative learning emphasized the importance of social skills and team management. Atxurra et al. (2015) discussed the application of cooperative learning in higher education and investigated the influence of positive interdependence and interaction on the learning effect. Yampinij et al. (2012) developed a social network-centric framework to promote collaborative learning and enhance knowledge construction. These studies show that collaborative learning is not only an effective way of knowledge transfer but can also significantly improve learning effectiveness and innovation ability by promoting student interaction and teamwork. Based on these early literature reviews and research results, the following hypotheses are put forward:

H3: Collaborative learning can enhance the design creativity of industrial design students.

H4: Using messaging applications as a mediating variable can enhance the impact of collaborative learning on the design creativity of industrial design students.

Inspiration (IN)

In the research of psychology and creativity, inspiration is generally regarded as the core psychological process of innovative thinking, which stimulates individuals' desire to engage in or experience something, especially in creative activities (Oleynick VC et al., 2014). Inspiration is a crucial driving force in the creative process. Its importance is also emphasized in the four-stage creative model proposed by Wallas (1926), highlighting the subconscious's role in forming inspiration. Paivio (n.d.) further elaborated on the role of internal inspiration in realizing ideas and experiences and pointed out that inspiration can come from the transformation from concept to phenomenon and affect the generation of creativity. Designers seek inspiration by comparing designs, images, and objects, which is very important for creative output (Wolf et al., 2017). The study of inspiration in the field of education is also quite in-depth. The EISI scale developed by Jones et al. (2014) explicitly evaluates the motivational elements of educators' inspiration, which include motivational leadership, empathy, flexibility, and enthusiasm. They also discussed various motivation factors, such as self-motivation, others' motivation, achievement, prosocial behavior, and external motivation. Eckert and Stacy (2003) emphasized the importance of drawing inspiration from the previous creation and design process, pointing out that this is an essential and universal nature. Inspiration can span different fields and experiences and provide rich thinking resources for individuals. Based on these studies, the following hypotheses are put forward:

H5: Inspiration can enhance the design creativity of industrial design students.

H6: Using messaging applications as a mediating variable can enhance the influence of inspiration on the design creativity of industrial design students.

Creative self-efficacy (CS)

Self-efficacy, originally put forward by Bandura and Cervone (1986b), is a psychological concept that refers to an individual's confidence in his ability to complete a specific task. This concept has become critical in understanding how individuals face challenges and maintain motivation. Especially in the

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creative field, creative self-efficacy refers to individuals' confidence in their innovative achievements (Tierney & Farmer, 2002). Jang and Choi (2004) found that creative self-efficacy can significantly enhance individual self-confidence and play a vital role in cultivating creativity in education and research (Bandura et al., 1999b). Further research considers the influence of self-esteem and emotional intelligence on creative self-efficacy (Karwowski et al., 2018). In addition, Kukul and Karatas (2019) developed a scale to measure the self-efficacy of computational thinking, including conceptual knowledge, algorithmic thinking, and self-evaluation, to evaluate individuals' self-awareness in different skill fields. Abdullah et al. (2017), from the perspective of organizational behavior, this paper analyzes how corporate social responsibility (CSR) can improve employees' performance and innovation ability by strengthening organizational identity, in which creative self-efficacy plays a moderating role. These results show that creative self-efficacy promotes innovation and performance at the individual level and can be used as an essential intermediary factor for organizational behavior and strategies to affect employee behavior. Based on the findings of these theoretical and empirical studies, the following hypotheses are put forward:

H7: Creative self-efficacy can enhance the design creativity of industrial design students.

H8: Using messaging applications as a mediating variable can enhance the influence of creative self-efficacy on the design creativity of industrial design students.

Using messaging applications (UMA)

In China, QQ and WeChat are the main messaging applications that college students widely use. WeChat, developed by Tencent, is a multifunctional instant messaging and social media application. Since its first release in 2011, it has quickly become a "super application" with a vast global user base. Its functions include instant messaging, multimedia messaging, and QR code scanning to contact new friends and find nearby friends. Ho & Ho (2022) says its monthly active users have reached 1.2 billion. WeChat is called a "super application" because it provides essential communication services and integrates various functions and features of other digital platforms. At the same time, Tencent QQ (QQ for short) is a popular instant messaging software platform supporting online messages, video and voice calls, and document sharing. Compared with similar applications in other countries, China's messaging application is richer and more comprehensive in function. Gulzar et al. (2021) found that using social media positively correlates with students' participation and creativity. Students who frequently use social media perform better in creativity. Because messaging applications belong to the social media category, it can be reasonably speculated that the frequent communication and interaction of college students through these applications may positively impact their creativity. Based on the above research and findings put forward the following hypotheses:

H9: Using messaging applications, industrial design students can enhance their design creativity.

Conceptual Framework

This research is based on the creative component model and social constructivist learning theory and also draws lessons from five early research theoretical frameworks. Arif et al. (2022) found that the ability to share knowledge and the perception of reciprocity are the key factors in promoting knowledge sharing among students, positively impacting their creativity. Yampinij et al. (2012) emphasized the role of social networks in collaborative learning. The importance of social constructivism is highlighted. Eckert and Stacy (2003) analyzed the relationship between design inspiration and commercial knitwear design and emphasized the importance of inspiration in design. Abdullah et al. (2017) discussed the mediating role of organizational identity and creative self-efficacy in improving employee performance through corporate social responsibility. Gulzar et al. (2021b) found that using social media positively relates to students' participation and creativity, among which intrinsic motivation plays the most crucial role.

The variables included in this study were: The independent variables are knowledge sharing(KS), cooperative learning(CL), inspiration(IN), and creative self-efficacy(CS). The intermediary variable is the usage of messaging applications(UMA), and the dependent variable is design creativity(DC).

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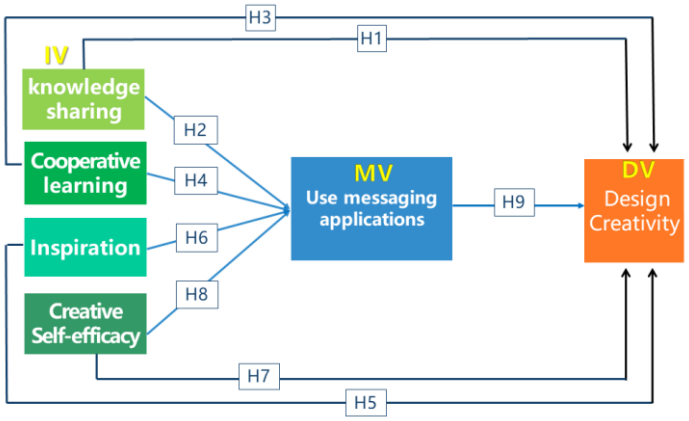

Figure1 Conceptual Framework

Methodology

Research Instrument

The researchers used a quantitative method to distribute an online survey to the target population. The research tool is a questionnaire composed of demographic information and observation variables. The demographic items include the gender and grade of students and the names of messaging applications used by students. In addition, 20 scale items adapted from previous studies are used to evaluate potential variables, including two for messaging applications (UMA) and three for knowledge sharing (KS). Five items are used for collaborative learning (CL), two items are used for inspiration (IN), four items are used for creating self-efficacy (CS), and four items are used for designing creativity (DC). All questions are answered with the five-point Likert scale (1 indicates strong disagreement, 2 indicates disagreement, 3 indicates neutrality, 4 indicates agreement, and 5 indicates strong agreement) (Salkind,2017).

To verify the questionnaire's validity, three associate professors engaged in industrial design education and research in Chinese universities were invited. They have rich teaching experience and have achieved many research results. According to the project-goal consistency (IOC) index, five projects scored 0.67, while the rest scored 1, and all projects were considered valid.

To test the reliability of the questionnaire, 30 undergraduates majoring in industrial design at a university in Sichuan were pre-tested, and the data were collected in September 2023. To ensure that the number of valid questionnaires collected reached the requirement of 30, a total of 35 questionnaires were distributed. Finally, 35 helpful answers were collected from the students (the response rate was 100%). Among the 35 participants, 20.34% were male, and 79.66 were female. George & Mallery (2010) pointed out that if the value exceeds 0.90, it is excellent; If the value is between 0.80 and 0.89, the result is good. The pre-test results of this study show that all the values are over 0.8, proving that the questionnaire's reliability meets the requirements.

Population and Sample

In 1993, the word "industrial design" officially appeared in China's professional catalog of higher education. Although there is no specific statistical data on the professional classification of college students in China, according to the available data, it is estimated that 298 universities in China offer industrial design courses, and about 71,520 undergraduates study this major every year. As it is not feasible to collect nationwide samples quickly, Sichuan Province, which has the most significant number of universities in southwest China, was chosen to conduct research given the characteristics of close population and cultural background and no clear stratification. It covered all educational stages from primary to core to elective courses, reflecting the course difficulty, knowledge, and skill level of students of different grades. The minimum sample size required is calculated to effectively test the research hypothesis using the structural equation model (SEM). Assuming that the expected effect size is 0.2, involving six potential variables and

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20 observed variables, the significance level (P value) is 0.05, the statistical power is 0.8, and the minimum sample size required is determined to be 403.

In this study, simple random sampling and snowball sampling techniques are adopted. First, some samples are determined by random sampling to ensure the initial samples' representativeness. Then, the snowball sampling method is used to increase the sample size. In the snowball sampling process, because the questionnaire is passed through the teachers of this major, there is a clear target group, which ensures that all the diffused members meet the research standards.

Data Collection and Analysis

The formal questionnaire survey began in October 2023 and lasted for one month. Data collection is divided into two parts: one is to distribute questionnaires to students majoring in industrial design at Xihua University, Sichuan; The second is to distribute questionnaires to industrial design teachers at other universities in Sichuan, and they will forward them to students. The distribution amount is at least 15% more than the calculated minimum sample size to ensure the number of valid questionnaires. After collection, the incomplete or invalid questionnaires are eliminated, and only the remaining questionnaires are considered valid.

The whole process and research method ensure that researchers ethically conduct research and attach importance to voluntary participation and confidentiality. Questionnaires are distributed online through quiz stars, and students are promised to keep their answers confidential. You cannot modify or resubmit the questionnaire after completing it. The questionnaire is anonymous, but the IP address will be recorded when collected, which will be kept confidential in the study. To protect data, password protection is set for related files. In the end, 487 students voluntarily participated in and submitted questionnaires online. Then, 467 valid questionnaires were screened using Jamovi software, and the data were calculated and analyzed. Jamovi is an efficient and easy-to-use statistical analysis tool that simplifies the statistical test from basic to advanced with its intuitive interface and automation function. As an open-source software, it ensures the transparency and continuous improvement of the code through community support. In addition, Jamovi's data visualization and model fitting indicators further enhance the accuracy and reliability of the analysis.

Based on CFA and SEM's ability in theoretical verification, measurement evaluation, multivariate analysis, fitting test, robustness test, and data interpretation. It can help researchers confirm theoretical assumptions, ensure measurement validity, analyze the relationship between variables, evaluate the model's fitness, and verify the robustness of the model through various estimation methods. At the same time, the statistical results enhanced the understanding of the data and improved the research's accuracy and credibility. Therefore, in the data analysis part, the discriminant validity, average variance (AVE), comprehensive reliability (CR), and factor load of the questionnaire are evaluated by confirmatory factor analysis (CFA). Subsequently, the structural equation model (SEM) is used to analyze the hypothetical relationship between variables and their influence.

Results

Demographic Information

The students who participated in this study were all from industrial design majors, aged between 18 and 24. There are 96 boys and 371 girls, accounting for 20.6% and 79.4%, respectively. The big difference between male and female is mainly because the number of female students majoring in art at China University is generally higher than that of male students. Among them were 91 freshmen (19.5%), 48 sophomores (10.3%), 242 juniors (51.8%), and 86 seniors (18.4%). Three hundred sixty-five people use QQ and WeChat simultaneously (78.2%),21 people only use QQ (4.5%), and 81 people only use WeChat.The data shows that all the students involved in the study use message applications, which meet the sample requirements.

Descriptive Statistics of Variables

Table 1 shows students' positive comments on using message applications to assist professional learning and improve creativity. The average score of UMA is 4.4, which is significantly higher than the

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average, indicating that UMA has become a vital tool for students to communicate. The average score of KS is 4.34, which shows that students tend to exchange information and share knowledge through UMA. The CL score is 4.25, which reflects that students generally believe that UMA contributes to teamwork and collective learning. The IN score is 4.09, which shows that students think UMA helps capture and generate design inspiration. The average score of CS is 4.03, which shows that students generally have the confidence to complete creative tasks and highlights the value of UMA in improving self-confidence and creativity. The average score of DC is 4.02, which shows that students have a recognition attitude towards their creativity.

Table 1 Descriptive Statistics of Relative Advantage

Item Statement	Mean	SD	Interpretation
UMA	4.41	0.63	Strongly Agree
KS	4.34	0.62	Strongly Agree
CL	4.25	0.64	Strongly Agree
IN	4.09	0.85	Agree
CS	4.03	0.78	Agree
DC	4.02	0.72	Agree

Confirmatory Factor Analysis (CFA)

Before structural equation model (SEM) analysis, confirmatory factor analysis (CFA) is used to evaluate the correlation between potential variables and test the fitting degree of the model. CFA reveals how data conform to a specific structure and identifies potential structural problems (Mueller & Hancock, 2001). The calculated GFI index is 0.978, which exceeds the acceptable standard of 0.85 (Sica & Ghisi, 2007). In addition, the AGFI index is 0.971, which exceeds the benchmark of 0.80. The results prove the global adaptability of the model.

The statistical summary in Table 2 shows that Cronbach's alpha value exceeds 0.80, the composite reliability (Cr) exceeds 0.60, and the extracted mean-variance (AVE) exceeds 0.50. Therefore, these results confirm CFA results' convergence and discriminant validity.

Table 2 Goodness of Fit for Confirmatory Factor Analysis

Latent Variables	Source of Questionnaire	Factors Loading	Cronbach's Alpha	AVE	CR
Using messaging applications(UMA)	(Hughes, 2012)	0.865 0.873	0.860	0.869	0.869
Knowledge Sharing(KS)	(Sharabati, 2017)	0.846 0.812 0.856	0.878	0.703	0.878
Cooperative learning(CL)	(So & Brush,2008)	0.844 0.735 0.879 0.820 0.858	0.913	0.687	0.913
Inspiration(IN)	(Thrash & Elliot, 2003)	0.808 0.853 0.841	0.873	0.696	0.872

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Latent Variables	Source of Questionnaire	Factors Loading	Cronbach's Alpha	AVE	CR
Creative self-efficacy(CS)	(Alshahrani & Pennington, 2019)	0.873 0.863 0.870 0.890	0.928	0.764	0.928
Design creativity(DC)	(Madjar et al., 2011)	0.835 0.884 0.867 0.780	0.906	0.710	0.909

Remark: CR = Composite Reliability, AVE = Average Variance Extracted

Voorhees et al. (2015) emphasized the importance of discriminant validity in analysis. Before the structural equation model (SEM) analysis, this study tested the discriminant validity of each structure. According to the criteria of Fornell and Larcker (1981), establishing discriminant validity requires that the square root of the AVE of each structure is greater than the correlation coefficient between this structure and other structures. After calculation and verification, the square root of AVE of the structure in this study meets this condition, thus successfully establishing the discriminant validity between structures and ensuring the accuracy and reliability of the measurement results.

Table 3 Discriminant Validity

	M_UMA	M_KS	M_CL	M_IN	M_CS	M_DC
M_UMA	**0.932**					
M_KS	0.778	**0.838**				
M_CL	0.693	0.824	**0.829**			
M_IN	0.46	0.561	0.724	**0.834**		
M_CS	0.471	0.562	0.706	0.826	**0.874**	
M_DC	0.495	0.546	0.617	0.673	0.728	**0.842**

Structural Equation Model (SEM)

A series of specific linear equations were estimated and tested using Confirmatory Factor Analysis (CFA) combined with Structural Equation Modeling (SEM). Erasmus et al.'s study (2015) examined the causal relationships between structures composed of independent and dependent variables. Therefore, each strong fit index in the SEM validation was sufficient to meet the research objectives.

Table 4 Goodness of Fit for Structural Equation Modeling

Index	Criterion	Source After	Statistical Values
GFI	≥ 0.85	Sica and Ghisi(2007)	0.978
AGFI	≥ 0.80	Sica and Ghisi(2007)	0.971
NFI	≥ 0.80	Sica and Ghisi(2007)	0.916
CFI	≥ 0.80	Bentler (1990)	0.934
TAG	≥ 0.80	Sharma et al. (2005)	0.922
RMSEA	< 0.08	Pedroso et.al. (2016)	0.045

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Research Hypothesis Testing Result

Table 5 details the calculated results of each structural path, revealing the influence of various factors on the design creativity of industrial design students. The standardized path coefficient (β) for knowledge sharing is 0.607, indicating a significant positive impact on design creativity (z-value = 12.2***). Similarly, collaborative learning significantly enhances design creativity, with a β value of 0.671 (z-value = 13.7***). Inspiration also significantly impacts design creativity, with a β value of 0.754 (z-value = 15.1***). Moreover, creative self-efficacy has an even more pronounced significant effect on design creativity, with a β value of 0.791 (z-value = 16.9***). The significant impact of messaging applications on design creativity is also noteworthy, with a β value of 0.797 (z-value = 14.35***). Further analysis shows that through the mediating variable of using messaging applications, the effects of knowledge sharing and creative self-efficacy on design creativity remain significant, with β values of 0.528 and 0.479 and z-values of 2.865* and 3.215***, respectively. However, the impacts of collaborative learning and inspiration on design creativity do not reach significant levels, with β values of -0.149 and 0.026 and z-values of -0.639 and 0.136, respectively.

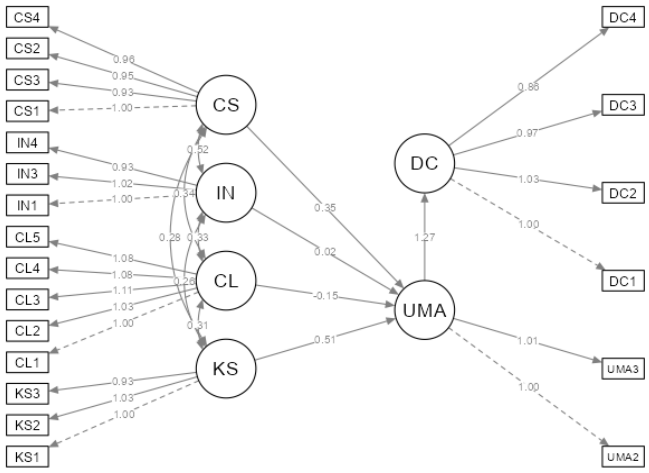

Figure 2 Structural Equation Model (SEM)

Table 5 Hypothesis Results

Hypothesis	Paths	Standardized Path Coefficient (β)	Z-value	Tests Result
H1	KS→DC	0.607	12.2***	Supported
H2	KS →UMA → DC	0.528	2.865*	Supported
H3	CL→DC	0.671	13.7***	Supported
H4	CL →UMA → DC	- 0.149	-0.639	Not Supported
H5	IN→DC	0.754	15.1***	Supported
H6	IN →UMA → DC	0.026	0.136	Not Supported
H7	CS→DC	0.791	16.9***	Supported
H8	CS →UMA → DC	0.479	3.215***	Supported
H9	UMA→DC	0.797	14.35***	Supported

*** = P<.001, * = P<.05

According to Table 5 and Figure 2, the β coefficient of H1 is 0.607, which indicates that KS significantly improves the DC of industrial design students. This is consistent with the research of Arif et al. (2022), who found that knowledge-sharing ability and reciprocal perception can promote creativity. The

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coefficient of H2 is 0.528, which supports the mediation of UMA between KS and DC. This echoes the view of Del Giudice and Della Peruta (2016), who believe that Internet information promotes KS, thus enhancing creativity. The coefficient of H3 is 0.671, which supports the role of CL in improving students' DC, which is consistent with the findings of Ugalde et al. (2021) on the academic impact of interactive learning. The coefficient of H4 is -0.149, which does not support UMA in regulating the influence of CL on DC. The coefficient of H5 of 0.754 proves that IN can promote DC, which is consistent with the research structure of Eckert and Stacy (2003) on the role of IN in DC. The coefficient of 0.026 of H6 does not support UMA adjusting the influence of IN on DC. The coefficient of H7 is 0.791, which indicates that CS significantly improves the DC of industrial design students and supports Bandura's (1997) theory that self-efficacy plays a crucial role in cultivating creativity. The coefficient for H8, at 0.479, indicates that User-Managed Adaptation (UMA) can amplify the beneficial effects of Collaborative Sharing (CS) on Design Cognition (DC). This finding aligns with Shang et al. (2011), who posited that Web 2.0 platforms can bolster CS and DC. The coefficient of H9 is 0.797, which indicates that UMA has a positive impact on the DC of industrial design students, consistent with the research of Zhang et al. (2024) on the benefits of social media to academic and creative performance.

These findings show that KS, CL, IN, and CS are the key factors to improve the DC of industrial design students. As a tool, messaging applications can enhance the influence of KS and CS on DC. Educators should consider adding more activities to promote knowledge sharing and collaborative learning in the curriculum and use news applications to enhance students' creative self-efficacy and inspiration through tools to promote teamwork and creative generation, thereby enhancing design creativity.

Some limitations may affect the results of this study, including social expectation deviation, which may lead to the participants' answers being influenced by social expectations or researchers' expectations rather than reflecting their true feelings or behaviors. At the same time, the study's limitation lies in the singleness of data collection methods, mainly relying on questionnaires, which may limit the depth and breadth of data.

Discussions

Based on the hypothesis test from H1 to H9, this study concludes that UMA, KS, CL, IN, and CS all directly influence DC. At the same time, it is concluded that UMA as the intermediary variable can enhance the influence of KS and CS on DC. The intermediary effects are (P=0.001)(P=0.004) respectively. The results support the hypothesis that messaging applications directly affect design creativity and indirectly enhance DC through KS and CS. Message application promotes formal and informal knowledge sharing (Solima et al., 2015) and helps cultivate and enhance individual creativity (Sawyer & Henriksen, 2023b). Lin and Hu (2015) further pointed out that the network environment combining learning with technology can improve creative self-efficacy and stimulate creativity. The results of this study are consistent with previous studies.

However, the mediating effect of UMA between CL and DC has not been confirmed (P = 0.523), and the mediating effect of UMA on the relationship between IN and DC is not significant (P=0.892). This result is inconsistent with the pre-research survey and the pre-test stage of the questionnaire. There may be several reasons for this result: First, in the pre-research and pre-test stage of the questionnaire, the students who participated in and provided feedback were all the author's students. Guidance on how to use tools to promote professional learning was obtained in teaching. However, the 467 students who participated in the research came from different schools and classes and may not get the same practical guidance, thus affecting their ability to use tools for professional learning. This is consistent with the research of Merelo et al. (2023), and the effect of educational technology depends on teaching design and strategies. If there is no effective integration or the goal is unclear, It may not be able to promote cooperative learning and creative stimulation. At the same time, educational technology can assist creative work and be used for social interaction and entertainment. The difference in this use may affect its effect on creative inspiration (Yalcinalp & Avci,2019). In addition, using educational technology may lead to information overload,

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distract attention, and affect students' investment in cooperative learning (Yu, 2019). In the future, we can consider combining controlled experiments.

Researchers have been trying to improve students' design creativity in recent years through various methods and tools. Taking Artificial Intelligence Generated Content (AIGC) as an example, the empirical study of Huang et al. (2024) shows that AIGC can effectively improve students' self-efficacy and design creativity. However, while rapidly producing design works, AIGC also has the potential risk of reducing students' active thinking and affecting the development of innovative thinking. The resource-intensive characteristics of AIGC may lead to unfair distribution of educational resources, contrary to the principle of educational equity. In contrast, messaging applications are essential in promoting user interaction, collaboration, and collective wisdom because of their ease of use. They are suitable for a broader range of user groups. Therefore, message applications are irreplaceable in promoting creative communication and user participation. Chun's (2021) research suggests that 3D printing technology can stimulate students' imagination and innovation and promote their ability to solve practical problems. The advantage of 3D printing lies in the production of solid models. At the same time, message applications have a unique advantage in promoting creative communication because of their ease of use, ability to communicate instantly, teamwork, and multimedia support. It surpasses 3D printing in stimulating creativity and social interaction, contributing to interdisciplinary innovation and development. Therefore, it is of significant influence to study how message applications can enhance design creativity in education. It promotes the modernization of teaching methods and realizes the deep integration of technology and education. Using news applications as a popular innovation tool, research promotes educational equity, strengthens the role of social interaction in creative development, and stimulates interdisciplinary learning and collective wisdom. At the same time, it cultivates students' practical skills and innovative thinking and provides critical data for educational policymakers to help them formulate more effective educational strategies. These achievements help students adapt to the rapidly changing world and future working environment and support the cultivation of lifelong learning and continuous innovation.

Implications for Practice

This study shows that message applications can improve students' innovative design ability by promoting knowledge sharing and creative self-efficacy. Educators can use the functions of message applications, such as group chat, search, and multimedia messages, to combine with educational goals and improve students' design creativity. The study also finds that the differences in teachers' teaching methods significantly impact student's performance in collaborative learning and inspiration, which affects creativity development. Educational institutions should adopt policies. Support the integration of message applications in teaching and provide guidance, technical support, and encouragement for innovative teaching. Teach educators how to use these applications effectively through professional development plans or seminars to enhance design creativity. In addition, the continuous teaching feedback mechanism is essential for evaluating the effect of message applications, which reveals the long-term benefits of message applications in improving students' participation, collaboration ability, and community awareness and helps educators understand the far-reaching value of these practices.

This research also discusses the evaluation of creativity, which is a challenge in creativity research and a critical link in teaching practice. The research results support the effectiveness of students' self-evaluation of creativity and provide solid theoretical support for applying the creativity self-evaluation scale. To further improve the accuracy and comprehensiveness of the evaluation, it is suggested that students' self-evaluation, peer evaluation, and teachers' professional ratings be combined to enhance the objectivity and reliability of the evaluation results.

At the same time, educators need to consider the possible challenges when using messaging applications, including promoting students' participation, managing online behavior, protecting data privacy, maintaining digital etiquette, and avoiding plagiarism.

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Recommendations for Future Research

This study focuses on the Sichuan Province, China, and future studies should be extended to various regions and international samples in China. Comparing different regions in China or China and international students will help to deeply understand the influence of cultural background on promoting creativity. In addition, the study can be extended from industrial design to other creative disciplines to comprehensively evaluate the effect of news applications in promoting creativity in various disciplines.

In terms of research methods, combining qualitative means such as interviews and focus groups can reveal students' experiences and perceptions in-depth and supplement the details that may be overlooked in quantitative research. This comprehensive method will help explore the factors that affect design creativity. In addition, longitudinal research can observe the long-term effect of news applications on students' creative process and reveal its evolution over time.

Based on this study, future research should deeply analyze the creative promotion functions of message applications, such as video calling, group chat, and multimedia sharing, and provide specific application suggestions for education. At the same time, the effects of message applications will be compared with other educational tools, and their advantages and limitations will be identified. It is also necessary to pay attention to the influence of emerging technologies on design creativity to ensure the timeliness and practicability of the research. Investigating how teachers integrate message application into teaching provides practical guidance for educators to enhance design creativity. In artistic creation, the importance of inspiration is widely recognized, but the research on it is minimal. This study attempts to analyze design inspiration with quantitative methods, and the results are different from expectations, but it provides a new perspective. Future research can use an interdisciplinary research perspective to explore the essence and influence of inspiration.

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