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The Influence of Aesthetic Education on Graduates' Research Innovation Ability Based on the Multiple Intermediary Model of Cognition, Emotion, and Motivation

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Abstract

Aesthetic education is a crucial component of the integrated development of moral, intellectual, physical, aesthetic, and labour education. It holds a significant position in Chinese higher education in the new era. Drawing on constructivist learning theory, cognitive psychology, positive psychology, and self-determination theory, this study developed an integrated cognition–emotion–motivation model to examine how aesthetic education is associated with graduate students' research innovation ability. Survey data were collected from 1208 graduate students, and the proposed model was tested using structural equation modelling and mediation analysis. The results showed that aesthetic education was positively associated with research innovation ability. Three mediating pathways were supported: analogical transfer ability served as a cognitive pathway; art immersive experience and research resilience formed an emotional pathway; and aesthetic value recognition and exploratory research motivation constituted a motivational pathway. In addition, an aesthetic education environment strengthened the relationship between aesthetic education and analogical transfer ability, while supervisor support strengthened the relationship between art immersive experience and research resilience. These findings clarify the mechanisms through which aesthetic education is related to graduate students' innovation-related capacities and highlight the importance of integrating aesthetic education, supportive environments, and supervisory guidance into research-oriented graduate training.

Keywords: aesthetic education; research innovation ability; graduates; multi-mediation

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1. Introduction

Aesthetic education in higher education refers to the process of cultivating aesthetic perception and shaping aesthetic behaviour based on aesthetic principles through aesthetic practice (Lee & Chao, 2023). Aesthetic education aims to develop students' capacities for critical judgement, reflective thinking, and open-ended inquiry beyond merely transmitting knowledge about art or beauty. In the context of Chinese graduate education, aesthetic education has become an increasingly significant component of holistic educational development. It designed not only to enhance artistic and cultural literacy but also to foster broader cognitive, emotional, and motivational competencies that underpin research innovation (J. Wang, 2025). By engaging with diverse aesthetic experiences, students are encouraged to actively construct knowledge, critically analyse complex information, and integrate multiple perspectives into problem-solving.

However, universities often implement aesthetic education in a manner that prioritises form over substance, constrained by the traditional mindset that prioritises "knowledge-focused education over aesthetic education" (Zheng, 2024). Students may participate in aesthetic activities without achieving meaningful insight and thus reducing the potential benefits for creativity or research capacity. In contrast, this study conceptualises aesthetic education as a multi-dimensional process that fosters critical reflection, cognitive flexibility, and intrinsic motivation. Students can internalise principles of pattern recognition, structural analysis, and expressive communication through sustained engagement with aesthetic experiences (M. Wang & Zhang, 2022). It is transferable to scientific and technical problem-solving contexts.

Developing innovative talent is a central goal of modern higher education, particularly in the context of national strategies to strengthen scientific and technological capabilities (Lenhart et al., 2023; L. Zhang & Reyes, 2024; X. Zhang et al., 2012). Despite this, a persistent gap exists between specialised scientific training and broader humanities and arts education. Research innovation is often constrained to conventional and narrowly defined problem-solving approaches (McManus & Furnham, 2006). Historical evidence highlights that significant scientific breakthroughs often arise at the intersection of artistic and scientific inquiry. From Leonardo da Vinci's integration of anatomical knowledge with the art of painting, to Einstein's imaginative proposal of relativity through "thought experiments". These examples underscore the potential for aesthetic education to cultivate the cognitive, emotional, and motivational capacities necessary for innovative research.

Therefore, this study is grounded in constructivist learning theory and integrates principles from cognitive psychology, positive psychology, and self-determination theory to form a comprehensive framework for understanding the mechanisms through which aesthetic education may be associated with graduate students' research innovation ability. Specifically, the study examines three mediating pathways: (1) analogical transfer ability, which represents the cognitive application of patterns and structures learned through aesthetic experiences to novel problems; (2) art immersive experience leading to research resilience, capturing the emotional and psychological benefits derived from deep engagement with art; and (3) aesthetic value recognition influencing exploratory research motivation, reflecting how the internalisation of aesthetic principles can inspire curiosity and intrinsic motivation in scientific research. Additionally, the study evaluates the potential moderating effects of the aesthetic education environment, including access to rich resources and interdisciplinary activities, and supervisor support, which may enhance the effectiveness of these pathways.

The study offers a systematic explanation of how aesthetic education is associated with research innovation, moving beyond prior research that considered these factors in isolation. It emphasises the interaction of cognitive, emotional, and motivational processes, providing insight into the complex and synergistic mechanisms by which aesthetic education may contribute to graduate students' innovative capacities. This comprehensive framework highlights the importance of creating educational environments that not only provide aesthetic experiences but also support reflection, critical dialogue, and the application of learned insights to scientific inquiry. This study offers practical guidance for designing and implementing graduate aesthetic education programmes by articulating the relationships among aesthetic education, cognitive flexibility, emotional resilience, and intrinsic motivation. Institutions can leverage these findings to foster interdisciplinary thinking, enhance critical reflection, and cultivate innovative, resilient, and self-motivated researchers.

2. Literature Review

2.1. Aesthetic Education (AE)

Aesthetics originates from the Greek words "aisthetikos" and "aesthetics" (meaning "I feel") (D'Olimpio, 2022; Xenakis & Arnellos, 2014). Traditionally, it encompasses the appreciation and study of taste, beauty, and sensory and emotional responses generated through values, nature, art, and aesthetic experiences. The modern concept of aesthetic education, significantly shaped by Schiller in the 18th century, arose from the conviction that engagement with beauty and art elevates both the individual and society (Zheng, 2024). Schiller's vision was not one of indoctrination but of liberation and harmonisation of human faculties. Aesthetic education is an approach that promotes appreciation, critical reflection, cultural understanding, and participatory engagement with art and creative works (Greene, 2001). Its significance far exceeds the narrow confines of technical art instruction. It communicates human thought, culture, and emotion by stimulating the senses and inviting learners into a dialogue with various artistic media and the aesthetic dimensions of the environment itself (D. Hu, 2024; Xia et al., 2024).

In this study, aesthetic education is positioned as a constructivist pedagogical practice. It fosters graduates' active construction of understanding in form, structure, and meaning through open artistic experiences, critical dialogue, and reflective spaces, thereby influencing their research and innovation capabilities rather than instilling fixed aesthetic standards. From a constructivist perspective, the primary characteristic of graduate aesthetic education is problem-driven, deep inquiry. It advocates integrating diverse disciplinary thinking paradigms and expressive approaches within the problem domain of the real world (Karavakou et al., 2023). Aesthetic education cultivates students' critical reflective capacity, enabling them to analyse, interpret, and evaluate artistic works and the aesthetic qualities of their surroundings not merely based on preference, but through reasoned discourse (Carr, 2023). As (Greene, 2001) powerfully argues, aesthetic education is vital for cognitive, perceptual, emotional, and creative development. It plays a crucial role in fostering the comprehensive growth of students by empowering them to challenge assumptions, imagine alternatives, and construct personal and intellectual meanings through encounters with aesthetic forms (M. Han & Lu, 2024). It aligns with the university's core mission of fostering open inquiry and critique. The aesthetic education serves not as a transmitter of canonical beauty, but as a provocation to deeper seeing, thinking, and feeling, which is a foundation upon which innovative and resilient thought can be built (L. Wang et al., 2022).

2.2. Research Innovation Ability (RIA)

Innovation ability refers to the ability of individuals or teams to apply creative thinking and skills to propose novel and practical solutions when facing problems or challenges (L. Zhang & Reyes, 2024). Innovation capability can be regarded as a set of abilities composed of various competencies or skills, which include but are not limited to the ability to identify problems, critical thinking, resistance to interference, adaptability, and adjustment skills. Innovation is regarded as a crucial component of individual competence (Pérez Peñalver et al., 2018). Research innovation ability, as a key indicator of graduate education quality, is far more than just rigorous logical thinking and profound professional knowledge. Its essence stems deeper from unconventional imagination, profound insight, unwavering resilience in the face of challenges, and an aesthetic pursuit that elevates problem-solving into artistic creation (L. Zhang & Reyes, 2024).

A series of systematic strategies has been proposed in existing studies to enhance the research and innovation capabilities of graduate students. Optimising the graduate curriculum system (L. Wang et al., 2017), strengthening mentor guidance and teamwork (J. Y. Han et al., 2022), and fostering a positive academic environment (X. Han et al., 2023)

are effective strategies for enhancing academic success. The Chinese government has proposed the "Fivefold Integration" development theory in recent years. It requires the comprehensive development of moral, intellectual, physical, aesthetic, and labour education to enhance the research and innovation capabilities of graduate students. The importance of aesthetic education has garnered increasing attention. Aesthetic education cultivates students' pursuit of scientific phenomena and theories, stimulating their curiosity, imagination, and innovative consciousness (M. Liu, 2021). It encourages interdisciplinary thinking and practice, which is crucial for addressing today's complex scientific challenges. Moreover, aesthetic education plays a significant role in improving students' humanistic literacy and shaping sound personalities (Gao et al., 2023). This holistic development helps researchers cultivate a positive research attitude, resilient willpower, and professional ethics—essential internal drivers for innovation activities. Therefore, this study hypothesises the following: H1: Aesthetic education has a significant positive impact on the research innovation ability of graduate students.

2.3. Analogical Transfer Ability (ATA)

Analogy serves as the foundation for creative problem-solving in science and technological innovation (Kittur et al., 2019). From the perspective of combining constructivism and cognitive psychology, aesthetic education expands the cognitive schema of graduates, provides diverse knowledge structures and representation methods, and promotes cognitive flexibility. It accelerates the process of scientific discovery by transferring solutions or principles from known domains to novel problems. It can foster interdisciplinary knowledge integration as a cognitive tool. Analogical transfer ability enables students to apply patterns, structures, or principles acquired in aesthetic education fields such as art, literature, and philosophy to non-artistic domains like science and engineering (J. Zhang, 2014). Recent research suggests that analogical transfer facilitates the application of experiential knowledge from one domain (the source domain) to novel problem-solving in another distinct domain (the target domain), thereby promoting innovative design and scientific discovery (Guo et al., 2025; Kalogerakis et al., 2010).

Analogical transfer is one of the core mechanisms in cognitive processes, as viewed from the perspective of cognitive psychology (Reeves & Weisberg, 1994). It is not merely a simple superficial match but involves the mapping and application of deep structural features. This integrative ability is crucial for solving complex problems, as many innovations often stem from the cross-fertilisation of different disciplines. Moreover, analogical transfer ability enables researchers to break free from existing mental frameworks and draw inspiration from seemingly unrelated source domains, thereby uncovering breakthrough solutions. Therefore, this study hypothesises the following: H2: Analogical transfer ability plays a mediating role between aesthetic education and research innovation ability.

2.4. Art Immersive Experience (AIE) and Research Resilience (RR)

Positive psychology points out that immersive experiences provide emotional investment and pleasure, while psychological resilience is an individual's ability to actively adapt and persevere in the face of setbacks (Mao et al., 2024). From a constructivist perspective, aesthetic education provides opportunities for deep artistic immersion, helping graduate students experience conflicts, transformations, and narratives emotionally, thereby constructing psychological resources to cope with research setbacks and enhancing resilience to persist in exploration.

Art immersive experience refers to an individual's complete engagement in art activities, resulting in a state of self-forgetfulness that leads to profound emotional and cognitive experiences (N. Zhang & Shen, 2023). Crucially, this immersion is not a passive reception

but an active, dialogical process of encounter (Du et al., 2026). It can challenge preconceptions, disrupt habitual thinking, and open pathways to novel understandings. The connection between art and science is often found at this level of deep engagement. Art immersion facilitates interdisciplinary and analogical thinking by encouraging researchers to adopt perspectives, frameworks, and sensibilities from outside their immediate disciplinary confines (Mun, 2021). Furthermore, AIE cultivates a heightened state of aesthetic awareness and perceptual acuity. This refined sensitivity allows individuals to detect nuances, patterns, problems, and opportunities in their environment—whether in a laboratory or a dataset—with greater sharpness. This enhanced perception is not merely about appreciating beauty superficially. It involves discerning underlying structures, tensions, and potential harmonies, a skill directly transferable to identifying research questions and conceptual models.

Research resilience refers to the ability of researchers to maintain a positive attitude, persistently overcome difficulties, and ultimately achieve research goals when facing research challenges and pressures (Hong et al., 2026). Researchers with strong research resilience can quickly find solutions to scientific problems, thereby improving innovation efficiency (Ojo & Volkova, 2023; X. Zhang & Wei, 2025). They will not give up easily, but actively seek new ideas and methods, ultimately overcoming difficulties and achieving innovation. In the process of innovation, one can strive for excellence and continuously improve one's research results, thereby enhancing the quality of innovation (J. Y. Han et al., 2022). They will not be satisfied with initial results, but will continue to improve and optimise, striving to reach a higher level.

Scientific research often comes with immense pressure and anxiety, and immersive experiences in art can help researchers relax and alleviate stress and anxiety. Meanwhile, art immersive experiences can enhance the psychological regulation ability of researchers, enabling them to better cope with setbacks and failures in scientific research (Swiatek et al., 2024). In the world of art, researchers can experience a range of emotions and perspectives, gain a deeper understanding of human nature and life, and enhance their psychological adaptability and regulatory abilities. Therefore, this study hypothesises the following: H3: aesthetic education positively influences research innovation ability through the sequential mediating effect of "art immersion experience → research resilience".

2.5. Aesthetic Value Recognition (AVR) and Exploratory Research Motivation (ERM)

The self-determination theory suggests that intrinsic motivation is driven by autonomy, ability, and belongingness needs, while value identification is the process of critically internalising external values into personal values (Bandhu et al., 2024). Combining constructivism, aesthetic education guides graduate students to form personalised value judgments in critical aesthetic dialogue, thereby internalising the "pursuit of beauty" as an internal driving force for scientific research exploration, making scientific research a conscious pursuit of meaning.

Aesthetic value recognition refers to an individual's affirmation and internalisation of the value of beauty, which can stimulate students' internal motivation and encourage them to actively explore and discover beauty (Xiao, 2024). AVR in this study refers not to the passive acceptance or internalisation of externally defined standards of beauty, but to an active, reflective process through which individuals critically engage with aesthetic phenomena, discern value within them, and gradually develop a personal, reasoned stance toward what they find meaningful, coherent, or beautiful. This process of recognition holds significant potential for fostering scientific innovation. The pursuit of aesthetic value and the quest for scientific truth share foundational roots in human curiosity, the desire for understanding, and an appreciation for order, pattern, and elegance. When researchers

develop a deep, critically informed appreciation for aesthetic qualities—such as symmetry, simplicity, narrative cohesion, or expressive power—they often begin to seek these same qualities in their scientific work. Aesthetic value recognition can thereby reframe research as a form of meaning-making and creative synthesis, prompting closer attention to the elegance of a hypothesis, the coherence of a model, or the expressive clarity of a finding.

Exploratory research motivation refers to an individual's curiosity and thirst for knowledge in unknown fields, as well as the intrinsic driving force for pursuing discoveries and creations in scientific research activities (Huang et al., 2023). Exploratory research motivation is an essential prerequisite for scientific innovation activities. It can help researchers maintain a high level of interest and enthusiasm in scientific research activities. Researchers will become more focused and engaged, enhancing the sustainability and efficiency of scientific research activities.

The pursuit of beauty is a natural part of human nature (Mendelson et al., 2025). Aesthetic education can awaken students' deep desire for beauty, stimulate their curiosity, and spark their thirst for knowledge about the unknown world. This curiosity and thirst for knowledge are crucial sources of motivation for exploratory research. Aesthetic education can enhance students' aesthetic appreciation ability, enabling them to appreciate the beauty of science and discover the artistic value in scientific research. The aesthetic appreciation ability will enhance students' interest and enthusiasm for scientific research activities, thereby stimulating their exploratory research motivation. Therefore, this study hypothesises the following: H4: Aesthetic education positively influences research innovation ability through the sequential mediating effect of "aesthetic value recognition → exploratory research motivation".

2.6. Aesthetic Education Environment (AEE) and Supervisor Support (SS)

A well-designed aesthetic education environment typically features an abundance of artistic resources, including libraries, art galleries, and music halls. These resources provide students with exposure to different types of artworks, thereby enhancing their aesthetic vision and knowledge reserves. Students are encouraged to participate in artistic and cultural activities, thereby increasing their aesthetic interest and participation in such an environment. In addition, a good aesthetic education environment promotes interdisciplinary communication and cooperation, such as combining art with science, technology, and other fields, which helps students understand problems from different perspectives and facilitates the transfer and application of knowledge. Therefore, this study hypothesises the following: H5: The aesthetic education environment plays a positive regulatory role in the relationship between aesthetic education and analogical transfer. The better the aesthetic education environment in universities, the stronger the positive predictive effect of aesthetic education level on analogical transfer.

The supervisor's support is crucial in graduate education, as it can significantly influence the research abilities and innovative behaviours of graduate students. A supervisor's support can take various forms, such as providing timely guidance, offering positive feedback, and offering emotional encouragement. Research has shown that advice and support from mentors are key to improving the quality of graduate education (Ren & Li, 2024). A graduate is more likely to actively participate in research, overcome challenges, and ultimately enhance their research skills in a supportive academic environment. A supervisor's support can improve the emotional satisfaction and happiness that graduates experience in artistic activities (Adarlo et al., 2025). Graduates are more likely to actively participate in creative activities and gain greater emotional benefits from them when they feel cared for and supported by their supervisors (Cai et al., 2026). A supervisor can help a graduate connect art experiences with scientific research work, thereby promoting cognitive integration.

Additionally, supervisors can offer opportunities and resources for graduates to engage in art activities and provide guidance on how to apply art experiences to their scientific research. Therefore, this study proposes the following hypothesis: H6: Supervisor's support plays a positive moderating role in the relationship between art immersive experience and research resilience. The higher the super's support, the stronger the positive predictive effect of an art immersive experience on research resilience.

2.7. Research Model

The model presented in this study is illustrated in Figure 1, based on the previous analysis and hypothesis testing.

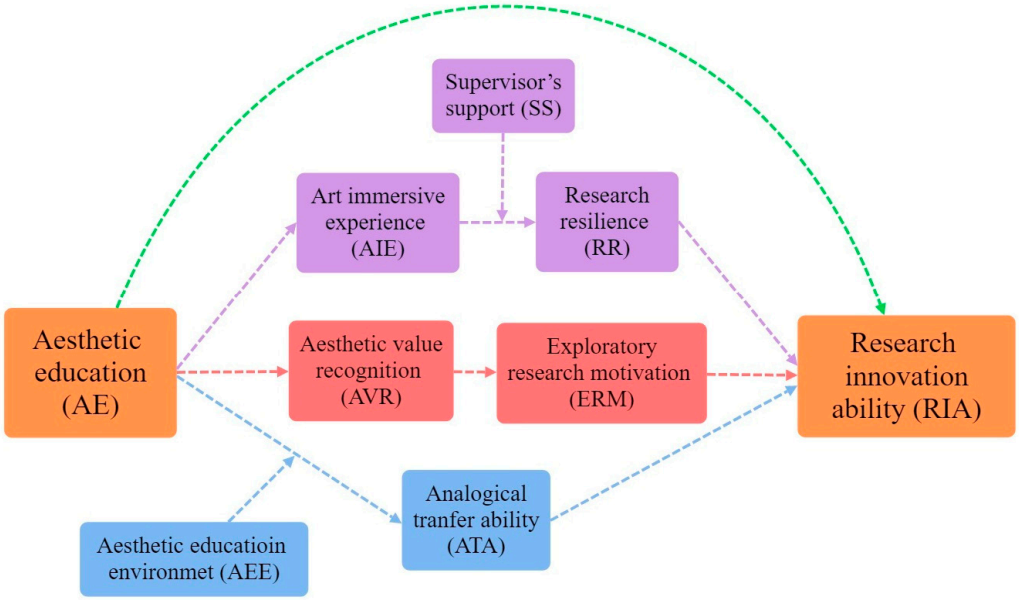

Figure 1. The schematic diagram of the assumed model.

3. Methods

3.1. Study Design and Participants

This study employed a cross-sectional survey design to examine the associations between aesthetic education and graduate students' research innovation ability. A questionnaire with 11 items and 63 topics was designed. The program determines the sample size and power through G*power 3.1 analysis. The results show that a model with an α level of 0.05 and a power level of 0.95 needs at least 153 samples. Therefore, 300 samples were used for questionnaire verification in this study. The Cronbach's α of the scale and the structural validity of the CFA analysis are shown in Table S1 in the Supplementary Material, which align with expectations after verification. Data were collected from a total of 1208 graduate students (610 males and 598 females) enrolled at Chinese Universities, spanning multiple disciplines including science, engineering, and humanities. Participants are master's and doctoral students.

3.2. Procedure

The questionnaire was administered online through the Sojump platform (https://www.wjx.cn), and participants were recruited using random sampling. Participation was voluntary, and respondents were informed about the purpose of the study, the confidentiality of their responses, and their right to withdraw at any time. No personal identifying information was collected to ensure anonymity.

3.3. Measures

This study designed nine scales for AE, RIA, ATA, AIE, RR, AVR, ERM, AEE, and SS. The contents of the scale are shown in Supporting Information. The scales were all 5-point Likert scales (1 = strongly disagree, 5 = strongly agree). The Cronbach's α of the final scale and the structural validity of the CFA analysis are shown in Table 1.

Table 1. The reliability and construct validity of the scale.

	Cronbach's α	*χ2/df*	TLI	CFI	RMSEA	RMR	GFI	PNFI
AE	0.858	1.666	0.990	0.992	0.023	0.024	0.984	0.784
AEE	0.886	1.210	0.999	0.999	0.013	0.011	0.997	0.598
SS	0.883	4.424	0.985	0.990	0.053	0.021	0.990	0528
ATA	0.902	0.977	1.000	1.000	0.000	0.010	0.998	0.599
AVR	0.902	3.586	0.990	0.994	0.046	0.019	0.991	0.595
ERM	0.900	3.985	0.989	0.994	0.032	0.019	0.991	0.529
AIE	0.892	3.331	0.990	0.995	0.026	0.018	0.993	0.529
RR	0.876	3.904	0.990	0.995	0.027	0.018	0.994	0.497
RIA	0.891	2.064	0.996	0.998	0.007	0.014	0.995	0.531

3.4. Statistical Processing

Data analyses were conducted using SPSS 26.0 and AMOS 29. Descriptive statistics, Pearson correlation analyses, and reliability assessments were performed in SPSS. SEM was used in AMOS to test the hypothesised relationships among constructs. Mediation effects were examined using the Process macro (version 4.1) for SPSS. To assess potential common method variance (CMV), Harman's single-factor test was conducted.

4. Results

4.1. Descriptive Statistics and Correlation Analysis

The mean value, standard deviations, and Pearson correlation matrix are presented in Table 2. Correlation analysis revealed that educational level and gender were not significantly correlated with AE, RIA, ATA, AIE, RR, AVR, and ERM. By contrast, AE was significantly and positively correlated with RIA, ATA, AIE, RR, AVR, and ERM. RIA was also significantly and positively correlated with AE, ATA, AIE, RR, AVR, and ERM. These results provide preliminary support for the proposed associations among aesthetic education, the three mediating mechanisms, and graduate students' research innovation ability.

Table 2. Descriptive statistics and correlation analysis of variables.

	M ± SD	EL	GE	AE	ATA	AVR	ERM	AIE	RR	RIA
EL	1.266 ± 0.442	1								
GE	1.495 ± 0.500	0.004	1							
AE	3.759 ± 0.646	0.026	−0.052	1						
ATA	3.679 ± 0.960	−0.000	−0.011	0.471 *	1					
AVR	3.674 ± 0.959	0.023	−0.035	0.459 *	0.473 *	1				
ERM	3.644 ± 0.971	−0.014	−0.037	0.441 **	0.424 *	0.456 *	1			
AIE	3.686 ± 0.937	−0.023	−0.027	0.430 *	0.446 *	0.435 *	0.443 *	1		
RR	3.667 ± 0.944	−0.036	0.004	0.466 **	0.477 *	0.441 **	0.414 **	0.454 *	1	
RIA	3.709 ± 0.922	0.008	−0.016	0.494 *	0.533 **	0.517 *	0.491 **	0.479 **	0.482 *	1

EL: Education Level, Master = 1, Doctor = 2; GE: Gender, Male = 1, Female = 2. * $p < 0.05$, ** $p < 0.01$.

Harman's single-factor test was conducted to assess the potential risk of common method variance because all variables were measured using self-reported questionnaires at a single time point. The results of the unrotated exploratory factor analysis showed that 12 factors had eigenvalues greater than 1, and these factors jointly explained 67.4% of

the total variance. The first factor accounted for 24.9% of the variance, which was below the commonly used threshold of 40%. Therefore, no single dominant factor emerged, suggesting that common method variance was unlikely to seriously affect the interpretation of the results.

4.2. Structural Equation Model (SEM)

The model established in this study is complex, comprising three mediation paths, with two of them exhibiting moderated effects. In this study, Amos 29 software was used to establish the SEM, excluding the moderate effect, as shown in Figure S1 in the Supplementary Material.

The model fitness test results are presented in Table S2 in the Supplementary Material after calculation. The $\chi 2/df$ is less than 3, and the RMSEA is less than 0.08. Additionally, the GFI, CFI, IFI, and TLI results are all greater than 0.9. RMR is 0.095, which is higher than 0.08. It may be due to the large number of variables and paths in the model, which makes the model more complex and leads to a higher RMR (Kline, 2015). The model is considered to be able to reasonably reflect the data situation, given that all other fitting indicators have reached their respective benchmark values (L. T. Hu & Bentler, 1999).

This study uses SEM to test the theoretical hypothesis model. The path coefficient and significance level are shown in Table 3. The results showed that the standardised coefficients of all paths were greater than 0, indicating statistical significance, and the model fitted well. AE was significantly and positively associated with RIA (β = 0.473, $p < 0.05$), which verifies the establishment of H1. In the cognitive path, AE was significantly associated with ATA (β = 0.706, $p < 0.01$), and ATA was significantly associated with RIA (β = 0.124, $p < 0.05$). The indirect effect of AE on RIA through ATA was 0.088, supporting H2. The coefficient of the ATA → RIA path remained statistically significant, though it was relatively small. It suggests that ATA may represent a meaningful cognitive mechanism linking aesthetic education and RIA.

Table 3. Path coefficients of the SEM.

Path Relationship	β	R.W.	S.E.	t	p	
AE → RIA	0.473	0.8	0.099	8.103	*	H1: OK
AE → ATA	0.706	1.326	0.093	14.243	**	H2: OK
ATA → RIA	0.124	0.112	0.038	2.917	*	
AE → AIE	0.686	1.182	0.085	13.874	*	H3: OK
AIE → RR	0.548	0.541	0.034	15.927	***	
RR → RIA	0.144	0.143	0.028	5.059	**	
AE → AVR	0.722	1.282	0.09	14.267	*	H4: OK
AVR → ERM	0.535	0.562	0.035	16.282	**	
ERM → RIA	0.193	0.175	0.026	6.769	**	

β = standardised regression coefficient; R.W. = unstandardized regression weight; S.E. = standard error. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

In the cognitive path, AE was significantly associated with ATA (β = 0.706, $p < 0.01$), and ATA was significantly associated with RIA (β = 0.124, $p < 0.05$). The indirect effect of AE on RIA through ATA was 0.088, supporting H2. The coefficient of the ATA → RIA path remained statistically significant though it was relatively small. It suggests that ATA may represent a meaningful cognitive mechanism linking aesthetic education and RIA.

In the emotional path, AE was significantly associated with AIE (β = 0.686, $p < 0.05$), AIE was significantly associated with RR (β = 0.548, $p < 0.001$), and RR was significantly associated with RIA (β = 0.144, $p < 0.01$). The sequential indirect effect of AE on RIA through AIE and RR was 0.054, supporting H3. These results indicate that AIE and RR

may jointly explain part of the relationship between aesthetic education and research innovation ability.

In the motivation path, AE was significantly associated with AVR ($\beta = 0.722$, $p < 0.05$), AVR was significantly associated with ERM ($\beta = 0.535$, $p < 0.01$), and ERM was significantly associated with RIA ($\beta = 0.193$, $p < 0.01$). The sequential indirect effect of AE on RIA through AVR and ERM was 0.075, supporting H4. These findings suggest that AVR and ERM may constitute an important motivational mechanism through which aesthetic education is associated with research innovation ability.

Among the three mediation paths, the cognitive pathway showed the largest indirect effect, followed by the motivational pathway and the emotional pathway. However, the three pathways represent different theoretical dimensions and should be interpreted as complementary rather than competing mechanisms. The cognitive pathway reflects the role of cross-domain structural mapping, the emotional pathway reflects the role of psychological resilience developed through immersive experience, and the motivational pathway reflects the role of internalised aesthetic value and exploratory motivation.

4.3. Moderating Effect

The moderating effect of supervisor support (SS) on the relationship between AIE and RR was analysed and the results are presented in Table S3 in the Supplementary Material. The results show that the interaction term of AIE and SS has a significant and positive predicted RR ($\beta = 0.1044$), indicating that SS moderated the relationship between AIE and RR. Simple slope analysis further showed that the positive association between AIE and RR varied across different levels of SS, as illustrated in Figure 2A. When SS was low, the association between AIE and RR was relatively weak ($\beta = 0.2746$). At the mean level of SS, the association became stronger ($\beta = 0.3688$). When SS was high, the association was strongest ($\beta = 0.4630$). These findings indicate that supervisor support strengthens the positive relationship between art immersive experience and research resilience, supporting H5.

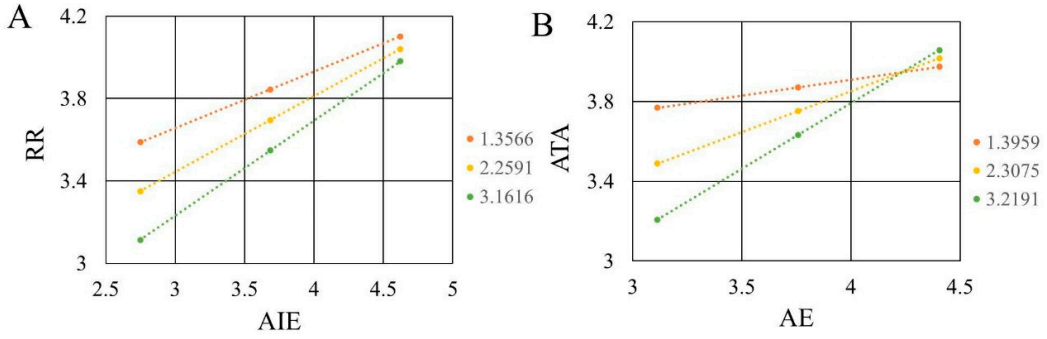

Figure 2. Simple slopes for the interaction of SS and AIE (**A**), AE and AEE (**B**).

The moderating effect of aesthetic education environment (AEE) on the relationship between AE and ATA was also examined. As shown in Table S4, the interaction term between AE and AEE significantly and positively predicted ATA ($\beta = 0.2738$), indicating that AEE moderated the relationship between AE and ATA. The overall model is significant ($R^2 = 0.2741$, $F(3, 1204) = 151.57$), indicating that the model explained 27.41% of the variance in ATA. Simple slope analysis showed that the positive association between AE and ATA increased as the level of AEE increased. When AEE was low, the association between AE and ATA was relatively weak ($\beta = 0.1586$). At the mean level of AEE, the association was stronger ($\beta = 0.4081$). When AEE was high, the association was strongest ($\beta = 0.6577$). These results suggest that a supportive aesthetic education environment enhances the positive relationship between aesthetic education and analogical transfer ability, supporting H6.

Therefore, the moderation analyses indicate that both individual learning contexts and supervisory support conditions shape the strength of the proposed mechanisms. Specifically, the aesthetic education environment appears to strengthen the cognitive pathway from AE to ATA, whereas supervisor support appears to strengthen the emotional pathway from AIE to RR.

5. Discussion

This study constructed and empirically tested an integrated model linking aesthetic education with graduate students' research innovation ability through cognitive, emotional, and motivational mechanisms. The research results not only confirm the direct promoting effect of aesthetic education but also systematically reveal the core issue of "how aesthetic education enables scientific research innovation" through three paths of cognition, emotion, and motivation. It clarifies the role of aesthetic education in university education as one of stimulating inquiry rather than indoctrinating norms. These findings provide empirical support for understanding aesthetic education not merely as a form of cultural or artistic enrichment, but as an educational practice that may contribute to the cultivation of innovative research capacities among graduate students.

5.1. Theoretical Significance of the Cognition–Emotion–Motivation Framework

A central contribution of this study is the development of a cognition–emotion–motivation framework for explaining the association between aesthetic education and research innovation ability. Previous studies have shown that aesthetic education may improve students' aesthetic literacy, humanistic quality, creativity, and artistic engagement (M. Han & Lu, 2024; Lee & Chao, 2023; M. Wang & Zhang, 2022). However, many studies have examined these outcomes separately and have not sufficiently explained the internal mechanisms through which aesthetic education relates to graduate students' research innovation ability. The present study addresses this limitation by integrating constructivist learning theory, cognitive psychology, positive psychology, and self-determination theory into a unified model.

The results suggest that the value of aesthetic education for graduate research innovation should not be understood through a single psychological process. It appears to involve the interaction of multiple mechanisms. Cognitively, aesthetic education may broaden students' representational systems and support analogical transfer. Emotionally, immersive aesthetic experiences may provide psychological resources that are associated with stronger research resilience. Motivationally, recognition of aesthetic value may stimulate exploratory research motivation by helping students perceive scientific inquiry as a meaningful and creative pursuit. This integrated explanation advances the literature by showing how aesthetic education may be linked with innovation through a coordinated system of thinking, feeling, and motivation.

5.2. Cognitive Pathway: Analogical Transfer as a Bridge

The cognitive pathway showed that AE was positively associated with ATA, and ATA was further associated with RIA. This finding is consistent with the view that analogy is a key mechanism in creative problem solving and scientific discovery (Kalogerakis et al., 2010; Kittur et al., 2019; Reeves & Weisberg, 1994). Aesthetic education exposes students to diverse forms, symbols, structures, and narratives, which may expand the cognitive resources available for solving research problems. When students encounter artistic forms, literary metaphors, or design principles, they may learn to identify deep structural similarities across apparently unrelated domains (Ibáñez & Cervel, 2023). Such

capacity is important for research innovation because innovative ideas often emerge when knowledge from one domain is transferred to another (Keshwani & Casakin, 2024).

The path from ATA to RIA remained statistically significant, though the path coefficient was relatively small. This result should be interpreted carefully. The modest effect may indicate that analogical transfer is only one component of research innovation ability and that its influence depends on other factors, such as disciplinary knowledge, methodological training, research environment, and academic experience. Nevertheless, even a small cognitive pathway may be meaningful in graduate education because research innovation is a complex outcome shaped by multiple interacting factors. The significance of ATA lies in its role as a bridge between aesthetic learning and scientific problem solving, rather than as a sole determinant of innovation.

The moderating role of AEE further supports this interpretation. The association between AE and ATA became stronger when students perceived a richer aesthetic education environment. This suggests that aesthetic education is more likely to support cognitive transfer when universities provide sufficient resources, interdisciplinary activities, artistic spaces, and opportunities for reflection (Zhou, 2024). Aesthetic education should therefore not be reduced to isolated courses or occasional cultural activities. Its cognitive benefits may depend on whether students are situated in an environment that encourages cross-domain observation, comparison, and application.

5.3. Emotional Pathway: Art Immersive Experience and the Development of Research Resilience

The emotional pathway indicated that AE was associated with AIE, which in turn was associated with RR, and RR was further associated with RIA. This finding is consistent with positive psychology research suggesting that immersive experiences and emotional engagement can contribute to psychological resilience and sustained effort (Mao et al., 2024). Scientific research often involves uncertainty, repeated failure, delayed rewards, and psychological pressure. Resilience becomes an important psychological resource that helps graduate students maintain motivation, adjust strategies, and persist in research tasks.

An art immersive experience may support research resilience by offering emotional regulation, psychological restoration, and tolerance for ambiguity (C. Liu et al., 2024). Deep engagement with art often involves conflict, transformation, uncertainty, and reconstruction. These experiences may help students develop the ability to interpret difficulties from multiple perspectives and respond more adaptively to setbacks. In this sense, art immersion is not merely an enjoyable aesthetic activity but may function as an emotional resource for research persistence.

The moderating role of SS shows that this emotional mechanism is shaped by the supervisory context. The relationship between AIE and RR was stronger when supervisor support was higher. This finding is consistent with studies showing that supervisor support is important for graduate students' research ability and innovative behaviour (J. Y. Han et al., 2022; Ren & Li, 2024). Supportive supervisors can provide emotional encouragement, tolerate exploratory attempts, and help students connect aesthetic experience with research practice. Thus, supervisor support may help transform aesthetic immersion into psychological resilience in the research process.

5.4. Motivational Pathway: Aesthetic Value Recognition and Exploratory Research Motivation

The motivational pathway showed that AE was associated with AVR, AVR was associated with ERM, and ERM was further associated with RIA. This pathway explains how aesthetic education may influence students' internal motivation for research. According to self-determination theory, individuals are more likely to engage persistently in an activity when they internalise its value and regard it as personally meaningful (Bandhu et al., 2024).

In this study, aesthetic value recognition refers not to the passive acceptance of externally defined beauty, but to an active process through which students develop personal understanding of order, coherence, elegance, and meaning.

When students recognise aesthetic value in scientific inquiry, research may be experienced not only as a task for graduation or publication, but also as a creative and meaningful process. They may begin to appreciate the elegance of theoretical models, the coherence of research design, the clarity of academic expression, and the beauty of discovering hidden patterns. This recognition can stimulate curiosity and exploratory motivation, which are important for sustained research engagement. This interpretation is consistent with the view that scientific creativity depends not only on technical competence, but also on imagination, intrinsic interest, and the pursuit of meaningful patterns (Bandhu et al., 2024; L. Zhang & Reyes, 2024).

5.5. Necessity of the Model Structure and Practical Implications

Although the model includes three mediating pathways and two moderating variables, its complexity is theoretically justified. Research innovation ability is multidimensional and cannot be fully explained by one mechanism. The cognitive pathway reflects the ability to transfer and reconstruct knowledge, the emotional pathway reflects the capacity to persist under uncertainty, and the motivational pathway reflects the internal drive to explore unknown problems. These three pathways are complementary rather than competing explanations.

The moderate explanatory power of the model is also reasonable. Innovation ability among graduate students is shaped by numerous individual, disciplinary, and institutional factors. The purpose of this study is not to exhaust all predictors of innovation, but to clarify meaningful mechanisms through which aesthetic education is associated with innovation-related capacities. The inclusion of AEE and SS further indicates that aesthetic education works within a broader educational ecology. A supportive environment strengthens cognitive transfer, while supervisor support strengthens the emotional transformation from art immersion to research resilience.

5.6. Practical Enlightenment

These findings have practical implications for graduate education. First, universities should regard aesthetic education as part of research talent cultivation rather than as an optional cultural supplement. Aesthetic courses and activities should encourage interpretation, reflection, analogy, and interdisciplinary application. Second, universities should strengthen aesthetic education environments by providing artistic resources, interdisciplinary workshops, public cultural spaces, and art–science activities. Third, supervisors should recognise their role not only as providers of technical guidance, but also as supporters of emotional resilience and exploratory thinking. By encouraging students to reflect on elegance, coherence, creativity, and meaning in research, supervisors can help connect aesthetic experience with scientific inquiry.

5.7. Limitations and Future Research

Several limitations should be noted. First, the causal conclusions of this study cannot be drawn because of the cross-sectional survey data. Although SEM can test theoretically hypothesised relationships, the findings should be interpreted as associations rather than evidence of causality. Future studies could use longitudinal designs, experimental interventions, or mixed-method approaches to further examine causal mechanisms.

Second, all variables were measured through self-reported questionnaires, which may introduce common method variance and social desirability bias. Harman's single-factor test showed that the first factor explained 24.9% of the variance, below the com-

monly used 40% threshold, suggesting that common method variance was unlikely to seriously bias the results. Nevertheless, future research should combine self-report data with supervisor evaluations, peer assessments, behavioural tasks, or objective indicators of research performance.

Third, although the scales showed acceptable reliability and construct validity, they were developed for this study. Future research should further examine their criterion validity by comparing them with established measures of flow, aesthetic experience, creativity, research self-efficacy, and innovation competence. Finally, the sample came from one university context, which may limit generalizability. Future studies should include students from different universities, disciplines, and cultural contexts to examine whether the proposed model remains stable across settings.

6. Conclusions

This study systematically reveals the impact mechanism of aesthetic education on graduates' research innovation ability by constructing and verifying an integrated model including three intermediary paths of cognition, emotion, and motivation. It not only provides a new framework for interdisciplinary research at the intersection of aesthetic education and scientific innovation but also offers a theoretical basis for universities to construct an aesthetic education system that supports critical dialogue, disciplinary integration, and open inquiry. Consequently, it aligns aesthetic education with the fundamental mission of higher education which is to cultivate questioning and innovative minds.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci16060902/s1, Figure S1: Structural equation model; Table S1: The reliability and construct validity of the preliminary research scale; Table S2: The results of the goodness-of-fit test for the structural equation model; Table S3: Results of the moderation model; Table S4: Results of the moderation model.

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Institutional Review Board Statement: This study was conducted in accordance with the ethical standards of the institutional and national research committee. According to Article 32 of the Ethical Review Measures for Life Sciences and Medical Research Involving Humans (National Health Commission of China, 2023), this study was exempt from institutional review board approval because it involved anonymous surveys and interviews that posed no more than minimal risk to participants. It did not involve sensitive personal information and had no potential for physical, psychological, or social harm. The need for ethical approval was waived by the Sichuan University Institutional Review Board. All procedures performed in this study were in compliance with the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from all individual participants included in the study. Participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time without penalty.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data that support the findings of this study are available upon request from the corresponding author.

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