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

Methods

A questionnaire with 11 items and 63 topics was designed in this study. The detailed content is as follows.

Item 1: Gender

Item 2: Education level

Item 3: Aesthetic education (AE)

AE1: I can keenly perceive the formal beauty and regular beauty contained in nature

AE2: I can appreciate the beauty of simplicity, symmetry, and harmony presented in scientific theories, mathematical formulas, and experimental data

AE3: I am adept at discovering and appreciating the beauty in different artistic disciplines, such as painting and music

AE4: In my daily study and life, I can often notice the beauty of details that others overlook

AE5: I possess at least one artistic skill (such as playing a musical instrument, painting, calligraphy, photography, dancing, etc.) and am capable of creative expression

AE6: I am willing to try incorporating artistic elements into my academic presentations (such as PPTs, posters, and illustrations in papers)

AE7: I have made attempts or had experiences in cross-disciplinary integration of different art forms

AE8: I understand some basic aesthetic concepts and theories (such as gracefulness, sublimity, artistic conception, gestalt psychology, etc.)

AE9: I am able to apply aesthetic knowledge to conduct in-depth analysis and evaluation of a work of art or a design

AE10: I am accustomed to examining the design of everyday products and technological products from an aesthetic perspective

AE11: I believe there is an intrinsic connection between aesthetic standards and

the standards of truth in science

AE12: I often ponder the potential connections between my research field and the fields of art and humanities

AE13: I consciously seek inspiration for scientific research from artistic works

AE14: I believe that solving complex scientific problems requires the integration of scientific and artistic ways of thinking

AE15: I am happy to participate in lectures or exhibitions in the interdisciplinary field of art and science

Item 4: Aesthetic education environment (AEE)

AEE1: My college provides rich and high-quality art general courses for students to choose from

AEE2: I can easily access (offline or online) various art exhibitions, concerts, theatrical performances and other activities in school

AEE3: the school has a good atmosphere and platform to encourage and support students' spontaneous artistic creation and display

AEE4: The school's campus environment and architectural design reflect the importance of aesthetic and humanistic care

AEE5: I can often see art related information and activity publicity on campus (such as posters, public accounts, lectures)

AEE6: The school will invite famous artists or scholars to hold high-level lectures in the cross fields of art and science

Item 5: Supervisor's support (SS)

SS1: My supervisor encourages me to participate in academic or cultural activities that are not directly related to my major to broaden my horizons

SS2: When I put forward some innovative ideas that seem to be "unprofessional" or interdisciplinary, my supervisor will discuss the possibility with me

SS3: My supervisor believes that good humanistic and artistic literacy is very important for the long-term development of a scientist

SS4: In the group meeting or daily communication, the supervisor will share or appreciate the scientific work with aesthetic value

SS5: When I failed to achieve results in a short time due to my interest in exploration, the supervisor can express understanding and give me some tolerance

SS6: My supervisor supports me to explore some risky topics according to my academic interest and curiosity

Item 6: Analogical transfer ability (ATA)

ATA1: I am good at finding common ground between two seemingly unrelated disciplines (such as biology and architectural design)

ATA2: When solving a scientific problem, I often look for inspiration or solutions from the arts or humanities

ATA3: I can try to use the model or theory of one field to explain the phenomenon in another field

ATA4: In learning and research, I can understand complex new concepts through metaphor or analogy

ATA5: My research ideas are often the result of interdisciplinary knowledge fusion

ATA6: When I see a certain structure or pattern in my artistic works, I will think about whether it can be applied to my scientific research

Item 7: Aesthetic value recognition (AVR)

AVR1: In my opinion, an excellent scientific theory or model should also be concise and beautiful in form

AVR2: In my scientific research work, the pursuit of “elegance” of solutions is as important as the pursuit of “correctness”

AVR3: Scientists’ pursuit of truth and artists’ pursuit of beauty are essentially interlinked

AVR4: I will try to optimize an experimental design or theoretical framework because it is "not beautiful enough"

AVR5: Aesthetic feeling is an important implicit standard for me to judge the

merits of others' scientific research achievements

AVR6: I believe that scientific research truth must be beautiful

Item 8: Exploratory research motivation (ERM)

ERM1: I am engaged in scientific research mainly out of strong curiosity about unknown fields

ERM2: When solving a scientific puzzle, the happiness I feel comes more from the process itself than from the result

ERM3: Even if there is no external reward, I am willing to take time to explore the problems that I am interested in but may not have direct output

ERM4: In scientific research, the process of learning and understanding new knowledge can bring me great satisfaction

ERM5: In order to satisfy my thirst for knowledge, I often delve into knowledge that is not directly related to the current topic

ERM6: It is the research content itself that attracts me, not the pressure to graduate or publish my thesis that drives me

Item 9: Art immersive experience (AIE)

AIE1: When I devote myself to appreciating or creating works of art, I often forget the passage of time

AIE2: Artistic activities (such as listening to music, watching art exhibitions, writing, etc.) can let me completely relax and recover from the fatigue and pressure of scientific research

AIE3: In my artistic experience, I feel a deep sense of pleasure and spiritual fulfillment

AIE4: Art provides me with a "spiritual shelter" that can temporarily escape from the troubles of scientific research

AIE5: I can concentrate on the current artistic activities without thinking about other things

AIE6: Artistic experience makes me feel that I have established a deeper

connection with the world and regained my inner peace

Item 10: Research resilience (RR)

RR1: I believe that I have the ability to overcome most of the difficulties and challenges on the road of scientific research

RR2: Even in the face of repeated experimental failures, I can still remain optimistic and actively look for new solutions

RR3: The negation and doubt from the outside will not easily shake my determination to pursue my research objectives

RR4: I can accept the uncertainty in the scientific research process (such as negative results, unpredictable difficulties)

RR5: I think the setbacks in scientific research are temporary and part of learning and growth

Item 11: Research innovation ability (RIA)

RIA1: I am good at raising novel and valuable research questions from a conventional phenomenon

RIA2: I can often generate new research ideas through cross domain association and analogy

RIA3: When the experiment fails or the idea is blocked, I can quickly change the angle and find an alternative

RIA4: I am able to accept and explore those complicated problems without clear answers or paths for the time being

RIA5: I am used to seeing the research object as a whole system and analyzing the complex correlation of its internal elements

RIA6: I can independently design a forward-looking and exploratory research plan

Table S1 The reliability and construct validity of the preliminary research scale

	Cronbach's α	*χ2/df*	TLI	CFI	RMSEA	RMR	GFI	PNFI
Aesthetic education	0.862	0.999	1.000	1.000	0.000	0.045	0.963	0.766
Aesthetic education environment	0.893	1.842	0.986	0.992	0.053	0.030	0.981	0.589
Supervisor's support	0.898	3.903	0.955	0.973	0.099	0.039	0.964	0.579
Analogical transfer ability	0.886	1.395	0.993	0.996	0.036	0.026	0.986	0.591
Aesthetic value recognition	0.888	4.100	0.948	0.959	0.102	0.046	0.959	0.575
Exploratory research motivation	0.879	2.865	0.968	0.983	0.079	0.034	0.976	0.520
Art immersive experience	0.892	0.717	1.005	1.003	0.000	0.016	0.993	0.596
Research resilience	0.868	2.687	0.974	0.987	0.075	0.033	0.983	0.490
Innovation ability	0.896	2.424	0.977	0.986	0.069	0.031	0.979	0.586

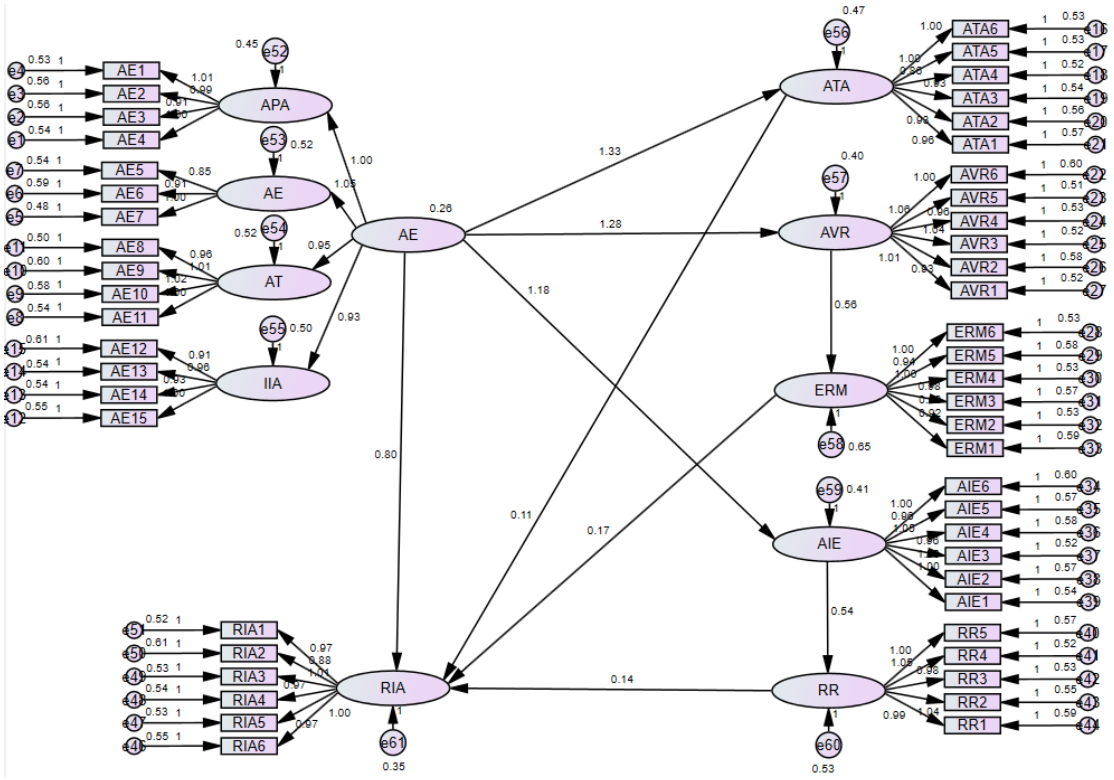


Fig. S1 Structural equation model

Table S2 The results of the goodness-of-fit test for the structural equation model

Indicators	*χ2/df*	RMSEA	RMR	GFI	CFI	IFI	TLI
Results	1.629	0.023	0.095	0.942	0.977	0.977	0.976

Table S3 Results of the moderation model

	B	*SE*	*t*	*p*	95% CI
Constant	3.5780	0.2674	13.3802	0.0000	(3.0533, 4.1026)
AIE	0.1329	0.0709	1.8734	0.0613	(-0.0063, 2.2720)
SS	-0.5494	0.0926	-5.9322	0.0000	(-0.7311, -0.3677)
Int_1	0.1044	0.0263	3.9765	0.0001	(0.0529, 0.1559)

Table S4 Results of the moderation model

	B	*SE*	*t*	*p*	95% CI
Constant	4.8945	0.4684	10.4502	0.0000	(3.9756, 5.8134)
AE	-0.2236	0.1213	-1.8422	0.0657	(-0.4616, 0.0145)
AEM	-1.1597	0.1418	-8.1788	0.0000	(-1.4379, -0.8815)
Int_1	0.2738	0.0386	7.0991	0.0000	(0.1981, 0.3494)