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Research Article

Cultivating Innovative Literacy in Middle School Art Education: From Design Thinking to Curriculum Practice

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Abstract

Middle school art education has long been confronted with the contradiction between the innovation-oriented policy objectives and the technique replication model. This study aims to develop the middle school art curriculum based on the five-phase design thinking model, including the phases of empathize, define, ideate, prototype, and test, with the school governance conditions incorporated in the design of the curriculum implementation. A quasi-experimental design was adopted with the intact Grade 7 students from a Chinese urban public middle school as the participants. One class was assigned as the experimental group (n=38) receiving the design thinking curriculum for 12 weeks, and one class was assigned as the control group (n=36) receiving the conventional curriculum with the same teacher. A mixed-methods approach was employed for the curriculum evaluation with the use of the Innovative Literacy Scale (ILS), artwork assessment rubrics, student reflective journals, and teacher interviews. ANCOVA results showed that the adjusted total score of the experimental group was significantly higher than that of the control group ($F(1,71)=18.67$, $p<0.001$, partial $\eta^2=0.21$), with the highest effect size for the cognitive dimension (Cohen's $d=0.68$), followed by the behavioral ($d=0.53$) and affective dimensions ($d=0.38$). The experimental group outperformed the control group significantly in originality, process quality, and iteration evidence, but no significant difference was found for the dimension of presentation. These results indicate that the distinctive value of the design thinking curriculum lies in fostering innovation process competencies, defined as the integrated cognitive, behavioral, and affective capacities for systematic creative problem-solving, rather than technical skills alone. The design thinking structure reduced creative anxiety and ensured inclusive participation for students of different abilities. Flexible timetabling, process-oriented assessment, and peer-based teacher training were identified as critical school governance conditions.

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Keywords

Design Thinking, Innovative literacy, Middle school art education, Curriculum practice, School governance

1. Introduction

In the global arena of education reform, innovative literacy has become a focal point in 21st-century learning. The Organisation for Economic Co-operation and Development identifies creative thinking and complex problem-solving as important components in the talent pool in Education and Skills 2030 (OECD, 2019). Similarly, the United Nations Educational, Scientific and Cultural Organization underscores the need to develop innovation capacity in the process of systematic innovation in the education sector (UNESCO, 2021). In this context, art education is widely regarded as one of the most natural sites to cultivate innovative literacy with its inherent creative characteristics. However, in the empirical study of visual arts education in the world over time, it has been found that in most middle school art classrooms in China, the dominant form of art instruction was still "teacher demonstration-student imitation-product grading," structurally compressing students' time and space for divergent thinking and independent creation (Hetland et al., 2013). In China's compulsory education sector, the 2022 revised Art Curriculum Standards formally incorporate "innovation consciousness" into the literacy framework (Ministry of Education of China, 2022; Yin, 2022). At the instructional level, however, an operational pathway to translate this policy into practice has yet to be developed. Such translation has been found to extend beyond instruction alone, also involving coordinated governance decisions at the school level in relation to timetabling, grading schemes, and teacher professional development.

To bridge this gap, design thinking has emerged in educational research as a specific methodology for fostering innovation. It has been derived from the practice of design professionals and has been further refined in its application in the d.school at Stanford University, culminating in a specific model of design thinking that is divided into the phases of empathize, define, ideate, prototype, and test (Brown, 2008). Over the past decade, this model has been extensively introduced in K-12 educational settings, confirming its effectiveness in enhancing students' creativity, problem-solving skills, and iterative thinking (Li & Zhan, 2022). Subsequent research has further proven the theoretical potential of design thinking as a bridging model between the domain of creative cognition and its practical application in the domain of education (Henriksen et al., 2017). Existing applications of design thinking in education are limited to the STEM and STEAM domains, where art is typically treated as a component of interdisciplinary integration rather than as a distinct

disciplinary focus. The specific disciplinary uniqueness of art education is that its product is not merely functional, and its test is not merely a validation test, but rather a specific test that is based on aesthetic communication and self-reflexivity.

1.1. Theoretical Foundations of Innovative Literacy

The construct of innovative literacy in this study draws on three established theoretical traditions. The first is the Partnership for 21st Century Skills (P21) framework, which identifies creativity, critical thinking, communication, and collaboration as the four foundational competencies for contemporary learners (Trilling & Fadel, 2009). The P21 framework provides the macro-level justification for positioning innovative literacy as a core educational outcome rather than a peripheral enrichment activity.

The second theoretical anchor is Creative Cognition Theory, which conceptualizes creativity not as a mysterious gift but as a set of cognitive operations that can be systematically studied and trained (Ward et al., 1999). This perspective underpins the cognitive dimension of innovative literacy by framing divergent thinking, problem identification, and creative ideation as trainable mental processes that benefit from structured pedagogical scaffolding such as the design thinking model.

The third theoretical anchor is Self-Determination Theory (SDT), which posits that intrinsic motivation is sustained when the basic psychological needs for autonomy, competence, and relatedness are met (Ryan & Deci, 2000). SDT provides an explanatory framework for the affective dimension of innovative literacy. The design thinking curriculum is hypothesized to foster creative self-efficacy and tolerance for ambiguity by providing students with autonomy in problem definition, a sense of competence through iterative prototyping, and relatedness through collaborative brainstorming and peer critique.

Building on these three frameworks, innovative literacy is operationalized as a three-dimensional construct. The cognitive dimension refers to divergent thinking, problem identification, and creative ideation. The affective dimension includes creative self-efficacy, tolerance for ambiguity, and intrinsic exploratory motivation. The behavioral dimension involves iterative prototyping, co-creative practices, and revisionary behaviors (Beghetto & Kaufman, 2014). This framework deliberately departs from the traditional Romantic view of “artistic talent” and emphasizes that innovative literacy is not a gift given to a few but a set of competencies that can be cultivated in all students through systematic instruction.

1.2. School Governance and Curriculum Innovation

Moreover, it is also critical to expand the analytical perspective to cover the school governance level. Curriculum innovation success is not only dependent on teachers’

instructional practices but, more critically, on how well the school governance structure can create an institutional space for innovative teaching practices. Flexible timetabling arrangements, modification of assessment policy from product-based grading to process-based portfolio evaluation, and teacher training on design thinking pedagogy collectively form the governance requirements for successful curriculum implementation. Incorporating the governance dimension advances the contribution of this study beyond a single pedagogical method to a comprehensive curriculum innovation scheme.

1.3. Research Objectives and Research Questions

From the above analytical framework, three research objectives can be formulated. The first objective is to design a design thinking-based art curriculum framework for middle school students, representing a systematic adaptation of the design thinking model to the art education.The corresponding research question is: RQ1: How can the five-phase design thinking model be systematically adapted to the disciplinary characteristics of middle school art education? The second objective is to evaluate the differential effects of a design thinking-based art curriculum and conventional teaching methods on middle school students' three-dimensional innovative literacy skills using a quasi-experiment design over a 12-week intervention period. The corresponding research question is: RQ2: To what extent does the design thinking-based art curriculum improve students' cognitive, affective, and behavioral dimensions of innovative literacy compared with conventional instruction?The third objective is to identify and analyze school governance factors that affect implementation fidelity and sustainability.The corresponding research question is: RQ3: What school governance factors enable or constrain the faithful and sustainable implementation of the design thinking curriculum?

2. Methodology

2.1. Curriculum Framework Architecture

The curriculum framework is structured based on the adaptation logic between the five-phase design thinking model and the disciplinary characteristics of art education. In each phase, specific art learning activities are targeted at particular dimensions within the three-dimensional innovative literacy structure, with corresponding methods of assessment for each phase's objectives. The 12-week curriculum design within this framework consists of five advancing phases, ranging from perception of the external world to problem definition and divergent solution generation, to substantive iterative creation, and then to peer feedback and self-reflection (Figure 1).

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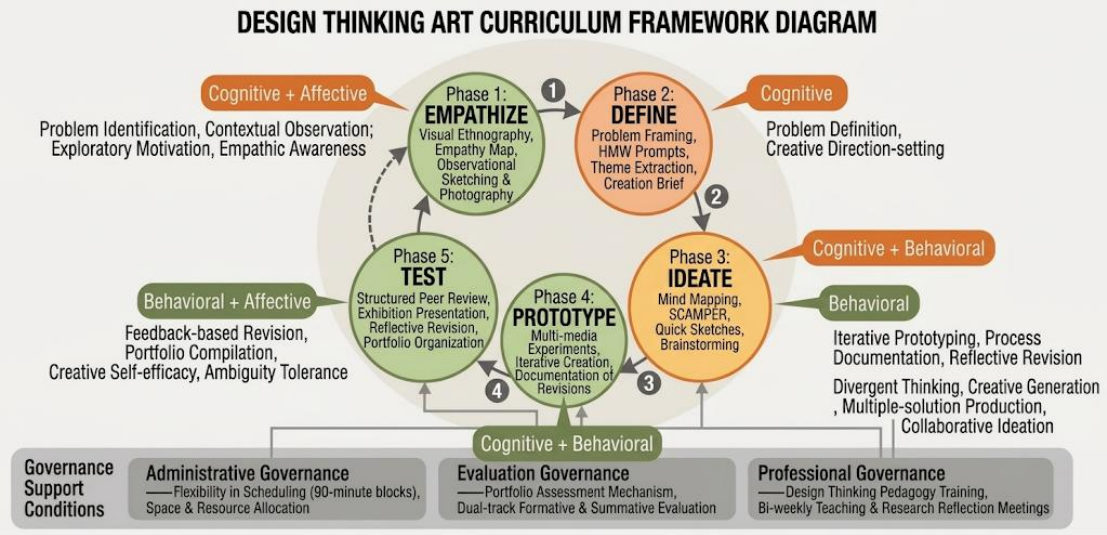
Figure 1

Design Thinking-Based Art Curriculum Framework Model



The curriculum process starts in Weeks 1–2, where Phase 1 (Empathize) is conducted. Students use the community and school campus as fields of observation to build a perceptual foundation using techniques of visual ethnography, Empathy Map creation, observation sketching, and photographing. This phase shifts away from the traditional notion of assigning predetermined themes, enabling students to generate creative ideas from their own observations. This process activates cognitive problem identification skills and stimulates affective exploratory motivation. The curriculum process then shifts to Phase 2 (Define) in Weeks 3–4, where students are challenged to transform their ambiguous observation-based findings into a set of structured creative directions using techniques of creating a ‘How Might We’ question for visual problem definition, deriving themes from observation data. This stage cultivates cognitive problem definition skills.

Phase 3 (Ideate), spanning Weeks 5–7, is the longest and most divergent phase. During this phase, the students will be engaged in brainstorming activities like mind mapping, SCAMPER, and rapid sketching, including divergent and convergent thinking in painting, collage, and digital media, and cognitive and behavioral aspects of multiple solution generation. Students then proceed to Phase 4 (Prototype) in Weeks 8–10, undertaking substantive creation through iterative development from low-fidelity drafts to high-fidelity artworks across varied media. They document their portfolios, recording not only visual iterations but also the reasoning behind each change, thereby internalizing iteration as a sustained practice.Phase 5 (Test), spanning Weeks 11–12, will complete the loop, including peer critique, classroom exhibition, and compilation of the portfolio, to extend the evaluative power from the teacher to the peers and the students. The five phases collectively form a

complete chain of literacy development from perception to expression, from divergence to convergence, and from individual creation to socialized feedback.

2.2. Governance-Embedded Implementation Design

The curriculum framework is pedagogically sound, but for the successful implementation of the above framework within real-life school settings, there is a need for support at the governance level. At the administrative level, the 45-minute single period format of the classroom has been converted into a 90-minute double period format to facilitate creative activities, while space has been provided for exhibition activities. At the assessment level, evaluation of portfolios has been incorporated, which records the outcomes of the innovation process for all the phases, such as observation journals, problem definition texts, sketch iterations, shifting the focus of evaluation from the completeness of the final product to the integrity of the innovation process itself. At the professional level, training for the teacher who implemented the innovation, such as training in design thinking pedagogy, including how to facilitate open-ended ideation, how to facilitate peer critique, has been provided, along with bi-weekly meetings during the implementation period itself. The relationship between the above three levels of governance and the above five phases of the curriculum is indicated in Table 1.

Table 1

Curriculum Implementation Matrix

Phase	Weeks	Art Activities	Target Literacy Dimension	Assessment Method	Governance Support
Phase 1: Empathize	1–2	Visual ethnography, empathy mapping, observational sketching	Cognitive + Affective	Observation journals	Approval for off-campus observation
Phase 2: Define	3–4	Problem framing, HMW prompts, theme extraction	Cognitive	Problem definition scoring	Cross-disciplinary coordination
Phase 3: Ideate	5–7	Mind mapping, SCAMPER, rapid sketching, collaborative brainstorming	Cognitive + Behavioral	Ideation diversity assessment	90-minute double periods
Phase 4: Prototype	8–10	Multi-media experimentation, iterative creation, revision documentation	Behavioral	Process portfolio	Material and space resources
Phase 5: Test	11–12	Structured peer critique, exhibition, reflective revision	Affective + Behavioral	Peer feedback + self-evaluation	Exhibition venue and assessment policy

2.3. Research Design and Participants

Assessing the intervention's efficacy requires both objective outcome evaluation and in-depth process understanding, leading to a mixed-methods design for a quasi-experiment (Creswell & Creswell, 2018). Two intact Grade 7 classes from the same urban public middle school served as experimental (n = 38) and control groups (n = 36). The experimental group completed a 12-week design-thinking curriculum, while the control group received traditional textbook-based instruction over the same period. Both conditions were taught by the same teacher, with two 90-minute sessions per week.The control group was included to account for maturation effects, history effects, and testing effects that could not be controlled by within-group pre-post comparison alone.A post-hoc power analysis was conducted using G*Power 3.1. With the observed effect size (partial η^2=0.21, corresponding to f=0.52), alpha level of 0.05, and total sample size of 74, the achieved statistical power exceeded 0.95, confirming that the sample size was adequate to detect the reported effects.

2.4. Data Collection Instruments

The evaluation design employed two quantitative tools.The Innovative Literacy Scale (ILS) consisted of 18 Likert-type items measuring three dimensions of innovative literacy on a 5-point scale, adapted from existing scales for creativity and self-efficacy (Beghetto & Kaufman, 2014). The ILS was administered as a pretest in Week 0 prior to the intervention and as a posttest in Week 13 following the intervention for both the experimental and control groups. Cronbach's alpha values were 0.84 for the cognitive subscale, 0.81 for the affective subscale, 0.79 for the behavioral subscale, and 0.87 for the total scale, indicating acceptable to good internal consistency.Artwork was evaluated using an artwork assessment rubric measuring originality, process quality, iteration evidence, and presentation on a scale of 1 to 10 using Two independent raters scored all artworks, and inter-rater reliability was assessed using the Intraclass Correlation Coefficient (ICC), which is a measure of the consistency between two or more raters scoring the same set of items. The ICC values ranged from 0.82 to 0.91 across the four dimensions, indicating good to excellent agreement.

The purpose of the qualitative data was twofold: exploring the nature of student-level literacy development and exploring the nature of institutional-level governance. Student-level data were drawn from five reflective journal entries (one per phase) completed by each student. Semi-structured post-intervention interviews were conducted with three participants: the implementing teacher, the school's academic affairs director responsible for timetabling decisions, and the art department head responsible for coordinating assessment policy revisions. Classroom observations were conducted twice weekly across the 12-week

period, totaling 24 observation sessions. Observation notes focused on student engagement behaviors, peer interaction patterns, and teacher facilitation strategies. Quantitative analysis included independent-samples t-test for equivalence of the pretests, ANCOVA with pretests as covariates for the comparison of the groups, and Cohen's d for effect size. Braun and Clarke's (2022) thematic coding was used for the qualitative data.

2.5. Data Analysis

All quantitative analyses were performed using SPSS 27.0. Baseline equivalence was tested using independent-samples t-tests. ANCOVA with pretest scores as covariates was used for between-group comparisons. Cohen's d was calculated for effect size estimation. Qualitative data from reflective journals, interviews, and observation notes were analyzed using Braun and Clarke's (2022) six-phase thematic analysis procedure. Two researchers independently coded a subset of the data and reached consensus through discussion before coding the full dataset.

2.6. Ethical Considerations

This study was conducted as part of regular school curriculum development and did not require formal ethics committee review under the institution's policy. The research was carried out in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from all participating students' parents or legal guardians, and assent was obtained from the students themselves. The implementing school's administration provided written approval for the curriculum modification and data collection procedures. All student data were anonymized and stored securely in compliance with institutional data protection policies.

3. Results and Analysis

3.1. Baseline Equivalence

Prior to the intervention, independent-samples t-tests were conducted on pretest data from the Innovative Literacy Scale. Results indicated no significant differences between the experimental and control groups on the ILS total score ($t=0.43$, $p=0.67$) or on the cognitive ($t=0.51$, $p=0.61$), affective ($t=0.38$, $p=0.71$), or behavioral dimensions ($t=0.29$, $p=0.77$), with all p-values exceeding 0.05, confirming baseline comparability.

3.2. Intervention Effects on Innovative Literacy

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ANCOVA, with pretest scores as a covariate, showed that the adjusted posttest ILS total score of the experimental group was significantly higher than that of the control group ($F(1, 71) = 18.67$, $p < 0.001$, partial $\eta^2 = 0.21$). The cognitive dimension showed the greatest effect ($F(1, 71) = 22.34$, $p < 0.001$, Cohen's $d = 0.68$), which is in line with the curriculum's logic because Phases 1–3 (Empathize, Define, and Ideate) span the first seven weeks, having the greatest impact on the students' problem identification and thinking skills. The behavioral dimension showed the second greatest effect ($F(1, 71) = 14.52$, $p < 0.001$, Cohen's $d = 0.53$), which is also logical because the iterative processes in Phases 4–5 (Prototype and Test) significantly impact the students' creative behavioral patterns. The affective dimension also indicated significance ($F(1, 71) = 7.89$, $p < 0.01$, Cohen's $d = 0.38$), although the small to moderate effect size indicates that profound attitudinal changes in creative self-efficacy and ambiguity tolerance may take longer than 12 weeks to emerge.

Artwork evaluation results provided convergent external validation of these findings. The experimental group achieved significantly higher in originality ($t = 3.12$, $p < 0.01$, Cohen's $d = 0.52$), process quality ($t = 4.07$, $p < 0.001$, Cohen's $d = 0.61$), and iteration evidence ($t = 4.45$, $p < 0.001$, Cohen's $d = 0.64$). No significant between-group difference was found in presentation dimension ($t = 1.24$, $p = 0.22$, Cohen's $d = 0.15$). This finding is theoretically discriminative in that technique-oriented instruction is sufficient in cultivating visual presentation skills but cannot evoke originality or iteration processes. The unique value of design thinking education is in cultivating innovation process abilities that extend beyond technique skills.

The complete quantitative results are summarized in Table 2, where all the data on the pre-test baselines, post-test scores, statistical test values, and effect sizes on all seven dimensions are provided. The change trajectories from pre-test to post-test on all dimensions are visualized in the grouped bar chart in Figure 2.

Table 2

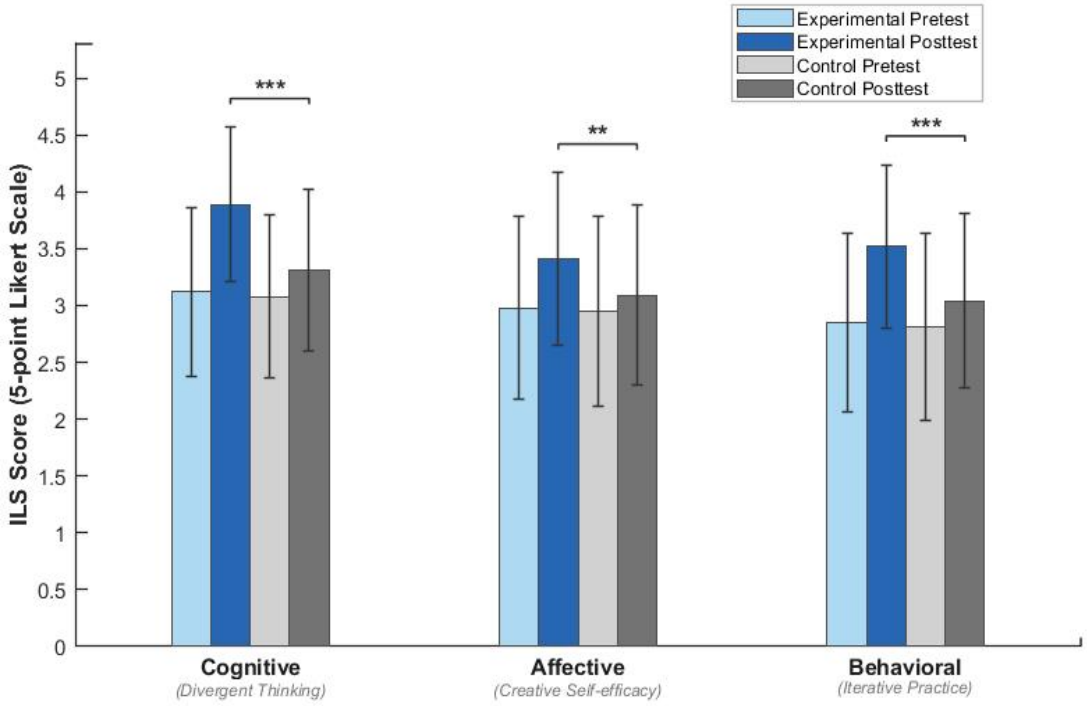
Comprehensive Evaluation Results Across Multiple Assessment Dimensions

Assessment Dimension	Instrument	Experimental PretestM±SD	ControlPretestM±SD	Experimental PosttestM±SD	ControlPosttestM±SD	F / t	p	Cohen's d
Cognitive (Divergent Thinking)	ILS-Cognitive	3.12 ± 0.74	3.08 ± 0.72	3.89 ± 0.68	3.31 ± 0.71	F=22.34	<0.001	0.68
Affective (Creative Self-efficacy)	ILS-Affective	2.98 ± 0.81	2.95 ± 0.78	3.41 ± 0.76	3.09 ± 0.79	F=7.89	<0.01	0.38

Behavioral (Iterative Practice)	ILS-Behavioral	2.85 ± 0.79	2.82 ± 0.75	3.52 ± 0.72	3.04 ± 0.77	F=14.52	<0.001	0.53
Originality	Artwork Rubric	4.83 ± 1.42	4.79 ± 1.39	6.71 ± 1.35	5.47 ± 1.51	t=3.12	<0.01	0.52
Process Quality	Artwork Rubric	4.56 ± 1.38	4.51 ± 1.35	7.12 ± 1.21	5.23 ± 1.44	t=4.07	<0.001	0.61
Iteration Evidence	Artwork Rubric	3.92 ± 1.53	3.88 ± 1.49	7.34 ± 1.18	4.89 ± 1.47	t=4.45	<0.001	0.64
Presentation	Artwork Rubric	5.21 ± 1.36	5.18 ± 1.33	6.43 ± 1.29	6.18 ± 1.32	t=1.24	0.22	0.15

Figure 2

Pre-post comparison of Innovative Literacy Scale scores by dimension and group



3.3. Qualitative Findings

Table 3

Thematic Coding Framework for Qualitative Data

Data Source	Theme	Representative Codes
Reflective Journals	T1: Scaffolded entry into creation	"knew where to start," "observation gave me direction"
Reflective Journals	T2: Reframing revision as improvement	"changing is not failing," "each version got better"

Reflective Journals	T3: Inclusive participation	"ideas matter more than drawing skill," "genuinely included"
Teacher Interviews	T4: Governance enablers and barriers	"double period was essential," "portfolio grading created tension"
Classroom Observations	T5: Behavioral shifts in engagement	Increased peer consultation, extended time-on-task, reduced off-task behavior

3.3.1. Findings from Reflective Journals

The most prominent experiential change was identified at the initial stage of the creative process, as determined by the thematic analysis of student journals. Under conventional instruction, students commonly expressed anxiety when confronted with the blank sheet of paper, as reflected in their uncertainty regarding "what to draw" and whether the result would be "good enough." Phases 1–2 (Empathize and Define) provided structured cognitive scaffolding before the creative process began, where students documented the scene and framed the problem, allowing them to enter the ideation phase with clear thematic guidance.

Collaborative brainstorming during Phase 3 (Ideate) transformed creation from an individual high-stakes activity to a collaborative iterative one. Upon beginning Phase 4 (Prototype), the most significant change for the students was the reinterpretation of the word "revision" from correction of mistakes to the concept of betterment, with the students realizing that the knowledge of the possibility of further changes gave them a sense of relief. A key finding concerns students who identified themselves as having lower artistic skills on the pretest reported the most dramatic increase in participation, realizing that the curriculum was more concerned with "ideas and process" rather than "how well you can draw" and that they were therefore "genuinely included." This is particularly relevant with respect to inclusive participation, as the cultivation of innovative literacy benefits all students, not just the artistically talented.

These positive changes in students were closely dependent on particular governance conditions.

3.3.2. Findings from Interviews

Three interviews revealed three pairs of enabling factors and corresponding barriers. Regarding timetabling, a 90-minute double period was critical for sustained prototype phase creation; however, timetabling conflicts with other subject necessitated proactive administrative coordination. In assessment policy, leadership support for portfolio evaluation created space for process-oriented evaluation; however, the persistent requirement to translate portfolio evaluation into percentage scores created an ongoing tension between two evaluation logics. Finally, in professional development, the implementing teacher identified facilitation of open-ended ideation as the most challenging curriculum component. Unfamiliar with

moving beyond a demonstration-and-follow approach, the teacher had no judgment criteria for "when and how much to intervene." Moreover, other art teachers had concerns about design thinking's use of 'standard skills training' time, which suggests professional culture constraints on innovative practices even when administrative reform space is created.

3.3.3. Findings from Classroom Observations

Systematic observation across 24 sessions documented behavioral shifts in student engagement. During the ideate phase (Weeks 5–7), voluntary peer consultation increased notably compared with the early empathize phase. Students spontaneously formed small groups to share sketches and provide feedback without teacher prompting. During the prototype phase (Weeks 8–10), time-on-task increased as students became absorbed in iterative revision cycles. Off-task behavior decreased markedly from the ideate to the prototype phase. During the test phase (Weeks 11–12), students who had been reluctant to share work in earlier phases voluntarily participated in exhibition and critique activities.

4. Discussion

4.1. Theoretical Interpretation of Differential Effects

The differential pattern of effect sizes across the three dimensions of innovative literacy can be meaningfully interpreted through the theoretical frameworks outlined in Section 1.1. The cognitive dimension yielded the largest effect (d=0.68), which is consistent with Creative Cognition Theory's premise that structured cognitive operations such as problem identification and divergent ideation are trainable through explicit pedagogical scaffolding (Ward et al., 1999).The design thinking model devoted Phases 1–3 (Empathize, Define, Ideate) to cognitive processes, providing sustained and deliberate practice in these operations over seven weeks.

The behavioral dimension showed the second largest effect (d=0.53).Phases 4–5 (Prototype and Test) provided iterative cycles of creation, revision, and feedback that fostered behavioral patterns of persistence and systematic refinement. This finding aligns with research on deliberate practice in creative domains (Henriksen et al., 2017).

The affective dimension produced the smallest effect (d=0.38). This outcome can be interpreted through Self-Determination Theory (Ryan & Deci, 2000). While the curriculum design addressed all three basic psychological needs, the 12-week timeframe may have been sufficient to initiate changes in autonomy and relatedness perceptions but insufficient for deep restructuring of competence beliefs. Attitudinal change typically requires longer exposure periods and repeated success experiences to consolidate (Beghetto & Kaufman, 2014).

The absence of significant effect on the presentation dimension (d=0.15) confirms the theoretical boundary of design thinking pedagogy. Its contribution is concentrated in innovation process competencies rather than in technical execution skills, which conventional instruction already addresses adequately.

4.2. Comparison with Existing Studies

The overall positive effects are consistent with findings reported in systematic reviews of design thinking in K-12 education (Li & Zhan, 2022). This study extends the literature in two respects. First, it demonstrates design thinking transferability to art education as a distinct disciplinary domain, requiring reconceptualization of "prototype" as expressive artwork and "test" as peer critique. Second, it identifies school governance conditions as a critical mediating factor, resonating with the proposition that systemic coherence in educational change requires alignment across multiple institutional levels (Fullan, 2015).

4.3. Limitations

Several limitations should be acknowledged. The single school and single grade design limits generalizability. The 12-week period may not have been sufficient for profound attitudinal change. Intact class grouping could not completely eliminate selection bias. Self-report measures may have been subject to social desirability bias. Reliance on a single implementing teacher limits assessment of cross-teacher replicability.

5. Conclusion

This study investigated the integration of design thinking methodology into middle school art education to cultivate students' innovative literacy. A 12-week quasi-experimental intervention was conducted with 74 Grade 7 students in a Chinese urban public middle school.Integrating quantitative and qualitative findings collectively reveal three key contributions.At the curriculum level, the study provided evidence that the five-phase design thinking model can be successfully transferred from the STEM domain to art education. This transfer required substantial disciplinary adaptation, where "prototype" became "expressive artwork" and "test" became "peer critique and reflective revision." The process of adaptation revealed boundary conditions for cross-disciplinary design thinking adoption. The second contribution, from the effectiveness level, is the evidence of the differential effectiveness of the five dimensions of design thinking, where the cognitive dimension has the strongest effect, followed by the behavioral, and then the affective, with the least effect on the presentation dimension in artwork assessment. This pattern reveals the time sensitivity of different

competency types to instructional intervention, where the cognitive and behavioral dimensions can be more easily improved in a relatively shorter period of time, and the change in attitude, such as in the affective dimension of creative self-efficacy, requires a longer period of time for development. The absence of effect on the presentation dimension in artwork assessment reveals the boundary of the contribution of the five-phase model of design thinking, where its value does not lie in the training of technique skills but in the construction of innovation process competencies, which conventional instruction alone cannot provide. The third contribution, from the governance level, is the qualitative evidence of the sustainability of curriculum innovation depending on whether the school governance system can provide institutional space for innovative teaching (Rusmann & Ejsing-Duun, 2022), where the tripartite governance structure of flexible timetabling, process-oriented assessment policy, and peer-based professional development becomes an empirical corroboration of the theoretical proposition of systemic coherence in educational change (Fullan, 2015).

These results have differential implications for different professionals. The curriculum framework that has been created in this study offers a replicable operational reference for school administrators, but the governance prerequisites for timetabling flexibility and dual-track assessment must be addressed prior to implementation, as pedagogical innovations cannot be sustained in the absence of institutional support. The implications for policymakers are that the art education assessment standards must be adapted to accommodate process evaluation, creating space for innovation-oriented pedagogy in art education (Darling-Hammond et al., 2020). The implications for teacher training systems are that the priority is to support art teachers in making the transition from “technique demonstrators” to “innovation facilitators,” and the competencies that are required for this transition, such as open-ended ideation facilitation and constructive critique organization, are still relatively unaddressed in existing training systems.There are four possible avenues for further research: extending the scope of study to multiple grades and schools to verify the reliability of results, designing digital design thinking courses to reduce dependence on governance conditions (OECD, 2023), exploring cross-regional comparisons to investigate the applicability of governance models, and tracking the developmental path of innovative literacy after the completion of intervention.

There are four possible avenues for further research: extending the scope of study to multiple grades and schools to verify the reliability of results, designing digital design thinking courses to reduce dependence on governance conditions (OECD, 2023), exploring cross-regional comparisons to investigate the applicability of governance models, and tracking the developmental path of innovative literacy after the completion of intervention.

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Author contributions

Conceptualization, Y.F.; methodology, Y.F.; formal analysis, Y.F.; investigation, Y.F.; data curation, Y.F.; writing—original draft preparation, Y.F.; writing—review and editing, Y.F.; visualization, Y.F.; project administration, Y.F. Y.F. is the sole author and performed all roles. The author has read and agreed to the published version of the manuscript.

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Data availability

The data are not publicly available because the participants are minors and the datasets contain potentially identifying classroom and interview material. De-identified data are available on reasonable request from the corresponding author.

Declarations

Conflict of interest

The author declares that there is no conflict of interest.

Ethics approval

Formal ethics committee approval was not required for this study, which involved regular classroom curriculum activities. The study was conducted in accordance with the Declaration of Helsinki and approved by the participating school's administration.

Consent to participate

Informed consent was obtained from all participants' parents or legal guardians.

Consent for publication

Not applicable.

Additional information

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