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A Smart-Teaching Competency Framework for Pre-Service Visual-Arts Teachers under Transformative Pedagogy A Modified Delphi Study and GreenComp Alignment

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SUMMARY: *To address the lack of discipline-specific, operational competency frameworks for transformative pedagogy among Chinese pre-service visual-arts teachers in the ESD context, we developed and conducted a preliminary examination of a smart-teaching competency framework. We used a two-round modified Delphi (N=20; 100% response rate in both rounds) to gather expert ratings and revision comments across five dimensions—Teaching Awareness, Teaching Knowledge and Skills, Teaching Organization, Teaching Assessment, and Holistic Education Ability. Item retention and revision were based on item means and the coefficient of variation (thresholds: mean ≥ 3.50; Vi < 0.25); Cronbach's α and the expert authority coefficient (Cr; Cr ≥ 0.70 indicates high authority) were reported. The study yielded a five-dimensional, twenty-indicator framework with discipline-specific operational definitions, and round-two results showed higher α and more convergent expert judgments. The framework is conceptually aligned with GreenComp's values–complexity–futures–action pathway and is applicable to course Goal–Activity–Evidence (GAE) blueprints and practicum observation rubrics; indicator weights and student outcomes were not reported, and future work will conduct AHP weighting and structural validity testing. This framework provides a teachable, assessable, and improvable implementation pathway for the development of sustainability competencies (GAE/REM).*

KEYWORDS: *Education for Sustainable Development (ESD); GreenComp; pre-service visual arts teachers; smart teaching; competency framework; modified Delphi*

1 Introduction

Amid the continuing momentum of Education for Sustainable Development (ESD) and the EU's GreenComp framework, a central challenge for teacher education in higher education is to translate sustainability competences into teacher competences that are teachable, assessable, and improvable, while closing the loop across curriculum, practicum, and evaluation [1]. This challenge is particularly complex in visual-arts education, which emphasizes multisensory creation, aesthetic guidance, and material ethics [2]. On the one hand, China's education-digitalization agenda and policies such as Teachers' Digital Literacy (2022) are pushing competence development beyond mere tool use toward deeper integration of technology, pedagogy, and moral education. On the other hand, existing preparation systems and assessment instruments remain insufficiently adapted to discipline-specific classrooms, especially with respect to integrating AI into art-pedagogical approaches and shifting from tool operation to instructional design and evidence use [3]. These gaps often produce a

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"last-mile" disconnect between competence structures and classroom enactment.

Throughout this article, the term "pre-service visual-arts teachers" refers to teacher candidates in Chinese higher education who are preparing to teach K-12-especially upper-secondary-visual-arts subjects (e.g., painting, drawing); it does not include non-visual-arts subjects such as music, dance, or drama.

To respond to these gaps, the study adopts transformative pedagogy as an overarching lens and uses GreenComp's values–complexity–futures–action logic as a reference for competence alignment [4]. We propose a pathway that translates abstract sustainability literacy into actionable instructional evidence: values orientation and self-efficacy provide the inner drive; instructional design and diagnostic practices convert value claims into executable learning pathways; and organizational routines and assessment mechanisms leverage process evidence and feedback cycles for continuous improvement. In visual-arts contexts, studio-based projects, peer-critique–iteration–exhibition routines, material ethics, portfolio assessment with analytic rubrics, and virtual/physical curation serve as critical channels for externalizing competences into observable evidence [5].

Accordingly, we conducted a two-round modified Delphi to develop the framework and to preliminarily examine content validity. Under expert anonymity and independent judgment, panelists rated the importance and clarity of items and provided revision suggestions. Item retention and merging followed thresholds of mean ≥ 3.50 and Vi < 0.25 (coefficient of variation). We report Cronbach's α and the expert authority coefficient (Cr), with Cr ≥ 0.70 indicating high authority, to support semantic calibration and item finalization. Additionally, we inspected inter-round stability indicators to safeguard consensus robustness and reduce potential halo effects during item convergence. The outcome is a Smart-Teaching Core-Competency framework for pre-service visual-arts teachers comprising five first-order dimensions and twenty second-order competencies, each with discipline-contextualized operational definitions and evidence mappings to enhance usability and transferability.

This study is grounded in a Chinese expert sample and higher teacher-education settings. By design, it does not report indicator weights, student-level learning outcomes, or causal inferences; generalizability and structural validity will be examined in follow-up work (e.g., AHP weighting and confirmatory validity testing), enabling cautious claims today and cumulative evidence tomorrow. The contributions are threefold: theoretically, we conceptually align discipline characteristics with Green-Comp's competency pathway, clarifying what matters and why; methodologically, we employ a modified Delphi to yield reusable competency items and harmonized evidence templates; practically, we provide a structured reference directly applicable to GAE (Goals–Activities–Evidence) course planning and to practicum observation rubrics, turning framework into action.Research Questions

This study addresses the following questions:

- How can a smart teaching competency framework for pre-service visual arts teachers be constructed under a transformative pedagogy and ESD orientation so that it is teachable, assessable, and improvable?
- In what ways can the framework be demonstrably aligned—at a conceptual (non-causal, non-weighting) level—with GreenComp's four areas (values, complexity, futures, action), while clarifying its boundaries and use cases?

2 Theoretical Underpinnings and Model

2.1 Theoretical Underpinnings

Guided by transformative learning, this study foregrounds a reconstructive cycle of "critical reflection → perspective transformation → new practice," through which learners restructure frames of reference. Within the Education for Sustainable Development (ESD) agenda, education is not only about knowledge transmission but also about cultivating sustainability competences through instructional goals and learning experiences-enabling learners to think in value-based ways, embrace complexity, imagine futures, and take action [6]. Accordingly, we conceptualize the preparation of pre-service visual-arts teachers (K–12, with an emphasis on upper-secondary) as a teaching–learning cycle that links value orientation, complexity understanding, futures anticipation, and action refinement: values and ethics provide the anchor; authentic socio-ecological issues organize practice; and evidence drives iterative improvement. This cycle is consistent with the four clusters of key ESD competences-systems thinking, anticipation, normative (values) competence, and strategic action [7].

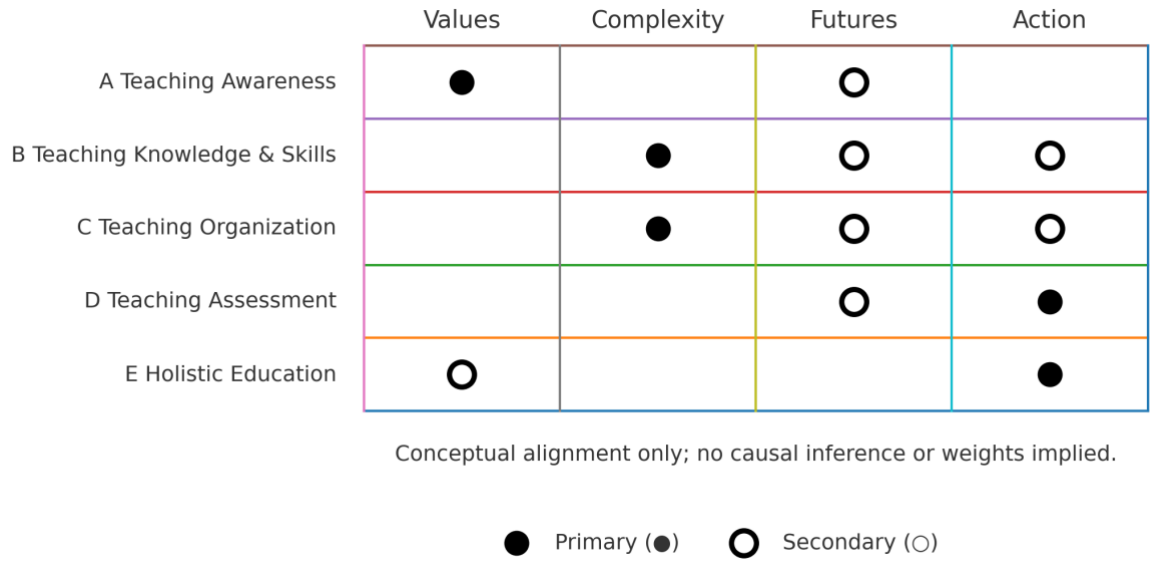
Visual-arts education provides a distinctive site for the formation of ESD competences: material and medium practices and visual-cultural inquiry nurture systems thinking, polyphonic perspectives, and future-oriented imagination; through embodied making and public presentation, these dispositions translate into visible social action [8]. Yet existing teacher-competence frameworks are largely generic, underspecifying discipline-specific operational definitions and evidence-based assessments for art education [9]. The gap is especially salient at the pre-service stage, where a "last-mile" disconnect persists between value orientation, complexity understanding, and action competence. This motivates a framework that is aligned with international discourse (ESD/GreenComp) and that is actionable in coursework and practicum for pre-service visual-arts teachers.

2.2 Conceptual Alignment: Principles, Mapping, and Boundaries

GreenComp, underpinned by a systematic review and expert consultation, synthesizes sustainability competences into four interrelated domains: embody sustainability values, embrace complexity, envision futures, and act for sustainability [10]. Using GreenComp as a reference, we mapped the five first-order dimensions and twenty second-order competencies of our framework—A. Teaching Awareness; B. Teaching Knowledge and Skills; C. Teaching Organization; D. Teaching Assessment; and E. Holistic Education—using a primary–secondary scheme and guided by three principles:

1. Functional equivalence: map constructs by their functional role in teaching (value internalization, modeling complexity, envisioning futures, driving action).
2. Disciplinary contextualization: ensure mappings materialize as observable activities and evidence in visual-arts coursework/practicum (e.g., process portfolios, learning journals, peer assessment, analytic rubrics, concise learning analytics).
3. Evidence-based operationalization: support each mapping with operational definitions and evidence types to facilitate verification and reuse.

Accordingly, we specified a primary–secondary mapping Figure 1.



* Note: Conceptual alignment only—no causality, identity, or weights implied; markers denote primary (●) and secondary (○); see Figure 2 and the Appendix for definitions and evidence.

Figure 1: Primary–Secondary Mapping

Boundary statement. The mapping serves conceptual alignment and communicative convenience only; it does not imply causal pathways, structural identity, or weight ordering. Figure 2 and the Appendix tables mark primary/secondary relations and provide evidence cues.

2.2.1 Value Orientation and Teaching Awareness

GreenComp conceptualizes "values" as orienting learning and action through ethics, responsibility, and care [11], consistent with ESD scholarship on normative/values competence. In our framework, A. Teaching Awareness maps primarily to this domain: it encompasses professional ethics, self-efficacy, data and AI ethics, and self-development. For pre-service visual-arts teachers, values are not merely abstract declarations; they are evidenced in classroom-observable practices—such as material ethics, studio conduct norms, and critical reflection on visual-cultural issues—for example, records of material selection and waste management, ethics statements, and reflective notes. These practices align with Studio Thinking "habits of mind" in art education (reflection, persistence, expression) [12]. Accordingly, we specify A (Teaching Awareness) as primarily aligned with Values and secondarily with Futures, underscoring the guiding role of value commitments in futures envisioning.

2.2.2 Complexity Thinking and Teaching Practice

GreenComp defines "embracing complexity" as understanding systemic interrelations, balancing stakeholders' rights, and integrating multisource information under uncertainty. Within the ESD literature, this domain corresponds to systems thinking and strategic competence [13]. In our framework, B. Teaching Knowledge and Skills (TKS) and C. Teaching Organization map primarily to Complexity: B emphasizes evidence-based Goals–Activities–Evidence (GAE) design, resource integration, and technology use; C emphasizes

full-process orchestration—diagnosis, contextualization, activity design, regulation, and consolidation. Studio-based practice in visual-arts education naturally scaffolds systems thinking: through inquiry, making, critique, and exhibition, complex issues are decomposed and recomposed, reducing interpretive latitude and improving evidentiary accessibility [14]. Accordingly, we assign B and C as primary alignments to Complexity, with secondary alignments to Futures and Action to signal the progression from complexity modeling toward prototyping and sustainable action.

2.2.3 Future-oriented Vision and Instructional Design

GreenComp stresses envisioning multiple futures through anticipation and imagination, and making choices accordingly [15], aligning with the ESD notion of anticipatory competence. In art education, prototyping, staged exhibitions, and public dialogue are effective means for externalizing and stress-testing visions [16]. In our framework, the Futures domain receives secondary alignment from A. Teaching Awareness (values–identity–self-efficacy) and from the design and organizational work in B/C: A sets direction and value boundaries for envisioning, while B/C translate visions into executable plans and chains of evidence via contextualized tasks and iterative prototyping (e.g., sketches → maquettes → exhibition feedback). This pathway is consistent with GreenComp's definition and with the learning culture and evidence ecology of the art classroom.

2.2.4 Action Competence and Educational Practice

GreenComp characterizes Action as the capacity to plan, implement, and evaluate concrete sustainability initiatives. In our framework, D. Teaching Assessment and E. Holistic Education map primarily to Action. D leverages formative assessment and high-quality feedback to close the loop from evidence to next-step action [17]; this is supported by DigCompEdu competence areas—Assessment, Empowering Learners, and Professional Engagement—which enable evidence capture and visualization. E mobilizes school–family–community partnerships and service-learning to translate classroom outputs into public action; empirical studies show that such approaches significantly enhance sustainability-related participation and behavioral intentions [18]. Accordingly, D/E are primary to Action, with secondary alignments to Futures and Values: assessment provides the technical route to the "next step," whereas collaborative practice furnishes the social arena for action.

2.3 Smart Teaching Support Mechanisms: Digital Competence and Evidence Literacy

In visual-arts settings, teachers' digital competence provides an operational scaffold for multimodal resource integration, process portfolios, and learning analytics, mapping well onto DigCompEdu's six areas—Digital Resources, Teaching and Learning, Assessment, Empowering Learners, Facilitating Learners' Digital Competence, and Professional Engagement [19]. Studio-based learning further emphasizes "Studio Habits of Mind" (e.g., Envision, Reflect, Observe, Persist) and "studio structures," which help systematize digital creative processes and the organization of evidentiary artifacts (sketches, process records, portfolios, exhibition texts), thereby linking making–evidence–reflection into an assessable learning chain [20].

With respect to evidence literacy and formative assessment, sustained, specific, and actionable classroom feedback has a substantial positive impact on learning—an effect repeatedly confirmed in large-sample syntheses and meta-analytic studies [21]. Effective formative assessment depends on clear success criteria, timely and specific feedback, and

teachers' data and assessment literacy as preconditions, enabling the transformation of evidence into instructional and learning improvements [22]. In visual arts, analytic rubrics and staged critique routines provide shared standards and evidence-organization practices for complex outputs, alleviating the long-standing challenge of "hard-to-assess" artistic learning.

At the classroom–society transfer level, service-learning is a key ESD pedagogy shown to improve sustainability-related knowledge, attitudes, and action intentions, translating course outputs into public action in authentic contexts [23]. Moreover, ESD projects that incorporate artistic practice have been found to foster systems thinking, multiple perspectives, and future-oriented imagination, thereby providing an art-infused conduit for the values–complexity–futures–action cycle [24].

3 Materials and Methods

3.1 Study Design and Ethics

This study was designed as a framework-development study with a preliminary examination of content validity. A two-round, modified Delphi technique was employed to refine items and calibrate item wording/semantics. The process was conducted under conditions of anonymity and independent ratings, with structured feedback and re-rating to foster consensus. Prior to implementation, institutional ethics approval and informed consent were obtained. All data were de-identified and used solely for academic research.

3.2 Expert Panel and Measurement Instruments

Sampling and organization of the expert panel followed principles of representativeness, seniority, and diversity across disciplines and regions [25]. Inclusion criteria required one or more of the following: recognized expertise in education/art education/educational technology/curriculum and assessment; ≥ 5 years of practice and research; high familiarity with smart teaching/ESD/transformative pedagogy; and recent engagement in relevant projects or peer-reviewed outputs. The Delphi panel was tasked with rating item importance and wording clarity and proposing revisions. To minimize contamination, identities among experts were concealed. As corroborative evidence for the credibility of judgments, an expert authority coefficient (Cr) was computed as:

$$Cr = \frac{Ca+Cs}{2}$$

Here, Ca denotes the judgment-basis coefficient (weighted by theoretical analysis, practical experience, literature grounding, and intuitive judgment) and Cs denotes the self-rated familiarity coefficient. A threshold of Cr ≥ 0.70 was interpreted as high authority; individual cases below the threshold warranted additional clarification during feedback or were examined in sensitivity analyses.

Expert sources and coverage. Twenty experts participated in the Delphi survey; panel retention across both rounds was 100%. Coverage spanned China's eastern, central, northeastern, and western macro-regions, including universities, K–12 institutions, and education-governance bodies in Beijing, Shanghai, Jiangsu, Guangdong, Sichuan, Anhui, Jilin, and Shaanxi. Several members held senior ranks (professor/associate professor), and at least ten had led or participated in ministerial/provincial key projects. Areas of expertise encompassed education, art education, educational technology, and curriculum/assessment, with substantial classroom and research experience. This breadth supported construct

triangulation, mitigated single-discipline bias, and strengthened the practical relevance of the consensus.

Questionnaires and rating items. Items were organized around five first-order dimensions and twenty second-order indicators. The initial item pool was derived from competence theory, international and domestic teacher-competence/smart-teaching standards, and art-education literature. To enhance disciplinary fit, operational definitions tailored to art classrooms were provided (e.g., studio-based units; critique–iteration–exhibition routines; sustainable materials management; process portfolios and analytic rubrics). A 5-point Likert-type scale supported quantitative judgments (example anchors: 1 = very unimportant/unclear/inoperable; 5 = very important/very clear/highly operable), with an open-ended field for revision suggestions. Questionnaire versioning and a variable dictionary were maintained for reproducibility.

3.3 Procedure and Data Analysis

Data collection proceeded in two rounds. In Round 1, experts rated all items and suggested modifications. After collation, we adjusted semantics, redundancy, and domain assignments based on the statistics and expert comments. Subsequently, structured feedback—containing distributional summaries and key revision points—was returned to the panel, and Round-2 ratings were completed to promote consensus and finalize items. For each round, response rates and missingness were recorded. Sporadic missingness was handled via pairwise deletion and documented in the operations log.

Content-validity and consensus criteria were preregistered as a multi-metric scheme, defined and applied as follows:

- Mean importance (Ci) captured the central tendency of expert ratings, computed as [26]:

$$Ci = \frac{1}{m}\sum Cij$$

Here, Ci denotes the aggregated score for the i-th indicator, Cij the rating from expert j on indicator i, and m the number of experts. Larger Ci indicates a more important indicator.

- Coefficient of variation (Vi) reflected relative dispersion (coordination) among experts for indicator i, computed as [27]:

$$Vi = \frac{Si}{Ci}$$

Here, Si denotes the standard deviation of scores for indicator iii, and Ci denotes the mean importance of that indicator. A smaller coefficient of variation indicates greater agreement among experts; conversely, a larger value suggests greater divergence of opinions.

- Specifically, Ci is the mean importance and Si is the score standard deviation for indicator i; the coefficient of variation is computed as:

$$Si = \sqrt{\frac{1}{mi\text{-}1}\sum_{j=1}^{m}(Cij\text{-}Ci)^2}$$

To ensure relevance and credibility, decision rules combined quantitative thresholds with expert consensus: retain items with Ci ≥ 3.50 and Vi < 0.25; borderline items (means near the

threshold or slightly elevated Vi) were revised and re-rated; delete items with Ci < 3.50 or Vi ≥ 0.25. New or modified items were incorporated only when structured feedback and subsequent re-rating converged on agreement.

4 Discussion

Across two Delphi rounds, response rates were 100% (20/20; 20/20), indicating strong engagement and response stability. The mean expert authority coefficient was Cr = 0.860 (Cs = 0.880; Ca = 0.840), suggesting credible judgments. Between rounds, the mean coefficient of variation (Vi) decreased from 0.147 to 0.118, and Cronbach's α increased from 0.893 to 0.916, indicating convergence of opinions and improved internal consistency. Key methodological indicators are summarized in Table 1.

Table 1: Summary statistics for two-round modified Delphi

Metric	Round 1	Round 2	Notes
Effective response rate	100% (20/20)	100% (20/20)	Full retention across both rounds
Expert authority coefficient Cr (Cs/Ca)	0.860 (0.880/0.840)	—	Corroborative evidence of judgment credibility
Mean coefficient of variation (Vi)	0.147	0.118	Improved coordination (convergence)
Cronbach's α	0.893	0.916	Higher internal consistency
Number of items	23	20	Three items removed after Round 1
Mean range (5-point scale)	—	4.40–4.85	All items surpassed retention thresholds
Max Vi (≤)	—	0.155	Good agreement among experts

Note: Cr = (Ca + Cs). Thresholds and definitions follow the Methods section and Supplementary materials.

4.1 Round 1 (23 → 20 items): Filtering and Revisions

Applying the retention criteria (mean > 3.50; Vi < 0.25) and integrating open-ended suggestions, three items were deleted due to conceptual overlap or excessive abstraction: A5 "Teaching Thinking," B6 "Teaching Cognition," and D4 "Personalized Assessment." Item semantics and labels were calibrated in multiple places, e.g., A1 "Teaching Confidence" was standardized to "Self-efficacy," C5 "Teaching Consolidation" to "Post-lesson Consolidation," and E1 "Comprehensive Guidance" was refined to "Learning Guidance." Several indicators already exhibited high agreement in Round 1—for example, E3 "Home–School Communication" (Vi ≈ 0.063) and D2 "Evidence Appraisal" together with C5 "Post-lesson Consolidation" (Vi ≈ 0.085).

4.2 Round 2 (Finalization of 20 Items)

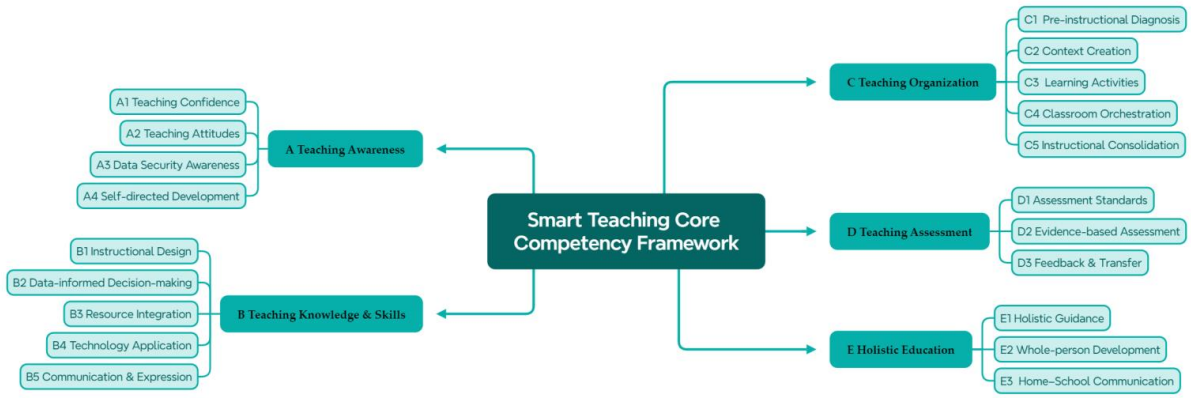
With structured feedback, all 20 items surpassed retention thresholds in Round 2, with means ranging from 4.40 to 4.85 and Vi ≤ 0.155. Stable endorsement was observed across dimensions: (A) Teaching Awareness—Self-efficacy, Teaching Attitude, Data Security Awareness, Self-development; (B) Teaching Knowledge & Skills—Instructional Design, Data-based Decision-making, Resource Integration, Technology Application, Language Expression; (C) Teaching Organization—Pre-lesson Diagnosis, Context Building, Learning

Activities, Classroom Regulation, Post-lesson Consolidation; (D) Teaching Assessment—Assessment Standards, Evidence Appraisal, Feedback & Transfer; (E) Holistic Education—Learning Guidance, Holistic Quality Cultivation, Home–School Communication.

4.3 Smart Teaching Core Competncy Framework

As shown in the figure, based on a two-round modified Delphi, we ultimately established a Smart-Teaching Core-Competency framework for pre-service visual-arts teachers comprising five first-order dimensions and twenty second-order competencies. All items in Round 2 met the retention thresholds (mean ≥ 3.50; Vi ≤ 0.25) and underwent necessary semantic calibration and relabeling. The five first-order dimensions were: (A) Teaching Awareness (Self-efficacy, Teaching Attitudes, Data Security Awareness, Self-directed Development); (B) Teaching Knowledge & Skills (Instructional Design, Data-informed Decision-making, Resource Integration, Technology Application, Communication & Expression); (C) Teaching Organization (Pre-instructional Diagnosis, Context Creation, Learning Activities, Classroom Orchestration, Post-lesson Consolidation); (D) Teaching Assessment (Assessment Standards, Evidence Appraisal, Feedback & Transfer); and (E) Holistic Education (Learning Guidance, Whole-person Development, Home–School Communication).

To facilitate direct use and scholarly auditing, we operationalized the "five-dimension, twenty-competency" secondary indicators based on consensus from a two-round modified Delphi. For each indicator, the following paragraphs specify discipline-specific, observable behaviors alongside typical learning activities and tasks, yielding a closed-loop articulation of "definitions–tasks–evidence." The content was aligned with the GAE model (Goals–Activities–Evidence) and with practicum/field-observation rubrics to support formative evaluation and iterative improvement during instruction. To aid interpretation and visual summary, Figure 2 presents the finalized framework and its alignment to activities and evidence.



* Note: A = Teaching Awareness; B = Teaching Knowledge & Skills; C = Teaching Organization; D = Teaching Assessment; E = Holistic Education. Item codes A1–E3 denote the twenty second-order competencies.

Figure 2: Smart Teaching Core Competncy Framework

(A) Teaching Awareness emphasizes stability and self-direction in authentic settings. Teachers demonstrate Teaching Confidence across contexts by adjusting strategies in response to evidence and feedback to reliably meet targets; adopt a learner-centered stance that reflects academic integrity, social responsibility, and respect for diversity (Teaching Attitudes); comply with data-protection and copyright rules to use AI/digital tools safely and safeguard

privacy (Data Security Awareness); and pursue continuous professional learning and reflection with an actionable personal plan (Self-directed Development). Typical activities include micro-teaching with peer feedback and challenge-task open classes; co-creating a classroom compact and discussing social issues and art ethics; micro-case analyses in data/AI ethics with licensing checks; and an annual PD plan with "read–practice–share" mini-projects.

(B) Teaching Knowledge & Skills centers on evidence-informed design and technical fluency. Teachers conduct outcomes-based, structured Instructional Design that aligns Goals–Activities–Evidence; make Data-informed Decision-making for instructional adjustment and individualized support; integrate multi-source, cross-disciplinary materials through Resource Integration across in-/out-of-school and online/offline channels; apply Technology Application appropriately—using digital and AI tools to support art teaching and assessment; and communicate clearly through Communication & Expression, presenting rationale and evidence with rigorous visualization. Typical activities include OBE-aligned unit design with storyboarding/blueprinting; formative data dashboards and tiered support interventions; resource-map building and museum–school/community liaison; digital/AI tool demonstration lessons with artifact-process documentation; and oral explanations paired with written statements and visualized evidence.

(C) Teaching Organization highlights task-centered classroom operation. Before instruction, teachers perform Pre-instructional Diagnosis by collecting and interpreting baseline data and learner backgrounds to design differentiated activities; build Context Creation around authentic issues to foster meaning-making; orchestrate Learning Activities—inquiry, creation, and collaboration—to promote deep learning and problem solving; manage the room through Classroom Orchestration—questioning, pacing, and resource allocation—to sustain focus and interaction; and strengthen learning via Instructional Consolidation through review, transfer exercises, and iterative work. Typical activities include pretests/interviews/observations to build learner profiles; authentic-scenario design with problem/task construction; team inquiry–creation–exhibition with peer assessment; pacing management and group rotation with questioning/scaffolding strategies; and iterative products, transfer practice, and debrief meetings.

(D) Teaching Assessment stresses standards alignment and evidence-driven improvement. Teachers establish transparent Assessment Standards with level anchoring for both formative and summative uses; conduct Evidence-based Assessment by collecting, screening, and interpreting multiple sources to make fair and consistent judgments; and translate results into Feedback & Transfer with concrete, actionable improvements that close the loop. Typical activities include co-constructed rubrics with anchor-example calibration; evidence collection with triangulation and double-scoring consistency checks; and feedback action plans with ongoing tracking and showcases.

(E) Holistic Education targets whole-person growth and community partnership. Teachers provide Holistic Guidance for learning and career planning, supporting self-regulation and goal management; advance Whole-person Development through art practice that cultivates communication, collaboration, civic literacy, and aesthetic appreciation; and build Home–School Communication mechanisms with families and communities to enable co-education and social participation. Typical activities include learning/career counseling with goals–pathways–milestones planning; interdisciplinary collaboration and public-art/curatorial projects; and home–school bulletins alongside community open classes/exhibitions.

These behaviors and tasks align with the GAE model and can be embedded directly in practicum/field-observation rubrics to support formative evaluation and continuous improvement.

5 Discussion

5.1 Consensus Formation and a Preference for Evidence-Ready Items

Across two consultation rounds, three stable, data-supported patterns emerged. First, terminology and boundaries stabilized rapidly—abstract, overlapping, or hard-to-operationalize statements were deleted or merged; although the number of items decreased, construct coverage was not impaired, indicating a consensus preference for second-order competencies with clear extension and behavioral cues. Second, consensus clustered on instructional nodes that are both executable and amenable to evidence: items directly coupled to classroom flow and capable of producing observable evidence (e.g., pre-lesson diagnosis, learning activities and classroom regulation, evidence appraisal, home–school communication) received stronger support, whereas items that were difficult to observe or weak in evidentiary chains failed to achieve agreement even after revision. Third, the chained structure of "design–organization–assessment" was endorsed as a set—operational definitions and evidence types tended to appear in suites, reflecting the internal coupling of Goals–Activities–Evidence (GAE) and a widely accepted feedback–improvement loop. Taken together, consensus was not uniformly distributed across all competence statements but concentrated along axes of operationalizability and evidence-readiness.

5.2 Theoretical Interpretation of the Observed Patterns

These patterns can be explained by a values–complexity–futures–action mechanism chain. First, value and identity commitments in transformative pedagogy provide a normative "anchor," enabling teachers to apply consistent criteria when selecting topics and evidence, thereby constraining the direction of consensus. Second, studio-based practice and contextualized tasks in visual arts decompose complex issues into controllable making and critique activities (diagnosis–context–activity–regulation–consolidation), substantially reducing interpretive latitude; experts therefore more readily agree on these process nodes. Third, formative assessment institutionalizes a traceable routine from evidence to next-step action via explicit standards, exemplars, and actionable feedback, generating intersubjectively verifiable agreement about "what to assess, how to assess, and what to do after assessment". Finally, school–family–community collaboration and service-learning externalize classroom outputs into public action, supplying an evidentiary interface with real-world contexts; related items (e.g., home–school communication, learning guidance) thus gain easier endorsement. In short, value anchoring shapes the direction of consensus, complexity modeling and studio workflows determine its carriers, formative assessment determines its evidentiary form, and social transfer determines its scope of applicability. The chain of these four factors underlies the convergence–stabilization–modularization we observed.

5.3 Actionable Propositions

Drawing on the foregoing analysis, we articulate three propositions that directly inform course design and practicum implementation.

Proposition 1 (Operationalization): When second-order competencies are expressed as procedural task units (e.g., diagnosis–context–activity–regulation–consolidation) with explicit evidence types and rubric anchors, expert consensus increases markedly. Hence, competency frameworks should prioritize suite-based design via GAE blueprints and REM (Rubric–Evidence Mapping).

Proposition 2 (Evidence Loop): Within an evidence–feedback–improvement loop, formative assessment is a key driver of consensus and reliability. Accordingly, pre-service

programs should treat evidence literacy and digital competence (process portfolios, visualization, compliance) as transversal "base capacities" to secure observability and auditability of competence assessment.

Proposition 3 (Contextual Transfer): When course design embeds school–family–community collaboration and service-learning, evidentiary channels expand from the classroom into public contexts, enhancing the framework's applicability and explanatory power. Practicums and school-based projects should therefore systematically configure exhibition/curation, public communication, and community feedback to establish a stable "classroom → society" pathway.

5.4 Alignment with GreenComp and Practical Implications

The framework's conceptual alignment with GreenComp's four domains—values, complexity, futures, and action—supports three implementation pathways: course design, practice transfer, and evidence evaluation [28]. At the course level, embed the four domains within GAE (Goals–Activities–Evidence) and REM (Rubric–Evidence Mapping): clarify learning goals through value norms and material ethics (values); organize complex issues through contextual tasks and systems thinking (complexity); support vision-building through prototyping and staged exhibitions (futures); and close the loop with actionable feedback and subsequent action tasks (action). These moves align with the "studio learning–peer critique–public exhibition" structure of visual arts education and have been shown to cultivate systems thinking and future-oriented imagination and problem solving.

At the practice level, implement classroom-to-society transfer through practicum and service-learning/community projects, and track improvement using four sets of process indicators: supply stability, participation equity, retention & transfer, and social linkage. Prior research suggests that service-learning enhances sustainability-related competence and action intentions, and that digital enablement can amplify participation and outputs.

At the evaluation level, use formative assessment and high-quality feedback to close the evidence–action loop: clear rubrics and exemplars, timely and specific feedback, and baseline data/assessment literacy are preconditions for improving learning and teaching decisions [29]. Drawing on DigCompEdu's domains (digital resources, teaching strategies, assessment, empowering learners) [30], a minimal data pipeline (collection–visualization–improvement actions) can support cross-term and cross-school comparison and longitudinal improvement. The above correspondences serve as conceptual alignment and implementation guidance; they do not imply causality or weighting.

6 Conclusions

6.1 Summary of Findings

Guided by transformative pedagogy and the ESD orientation, this study developed a Smart Teaching Core Competency framework for pre-service visual arts teachers and conducted an initial examination of content validity. Through a two-round modified Delphi, we performed item reduction and semantic calibration, yielding a structured framework comprising five first-order dimensions and twenty second-order competencies, accompanied by discipline-specific operational definitions and evidence types. Cross-round results showed convergence of expert opinions and improved internal consistency, and the resulting framework can be directly embedded into course-level GAE (Goals–Activities–Evidence) blueprints and practicum assessment contexts.

6.2 Limitations

Given the staged publication plan and ethical/resource boundaries, the present paper is limited to the phases of development and content validity. Indicator weighting (AHP), structural modeling (EFA/CFA), and student-level outcomes and criterion-related evidence are beyond the current scope and will be reported separately as planned. Moreover, the expert sample was drawn from the Chinese context; therefore, generalizability requires further testing across school levels and cultural settings. Items related to "technology application/data-based decision-making" are susceptible to rapid evolution in the digital ecosystem and should be versioned to maintain definitional alignment and timeliness.

6.3 Future Work

Future research will proceed along three lines: (i) publish indicator weights and sensitivity analyses to inform course weighting and resource allocation; (ii) conduct cross-regional and multi-wave examinations of structural validity and measurement invariance, and establish criterion relationships and predictive models with artwork quality, learning motivation, and interdisciplinary literacies; and (iii) construct a reusable data pipeline and evidence repository, refine Rubric–Evidence Mapping, and evaluate the framework's transferability and long-term effects in curriculum reform and educational practicum.

About the Author

Jingze Sun was born in Jilin, China, in 1992. She received the M.A. degree from Yunnan University, China, in 2018, and the Ed.D. degree from Dhurakij Pundit University, Thailand, in 2025. Since 2019, she has been a Lecturer with the School of Fine Arts, Anqing Normal University, Anqing, China. Her research interests include art teacher education, smart teaching, teacher competency development, and educational technology in art education.

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