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Intelligent Enhancement and Situational Integration: Research on a Ceramic Teaching Design Framework Driven by AI and AR Dual Wheels

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ABSTRACT

At present, traditional pottery teaching has long relied on teacher resources, with severely uneven distribution of teaching resources, and the teaching process is difficult to quantify. Students' creative inspiration methods are very limited. With the rise and development of technologies such as artificial intelligence (AI) and augmented reality (AR), powerful solutions have been provided to address the problems in current ceramic art teaching. Current research predominantly addresses AI and AR as separate technological tools rather than proposing integrated systems for their collaborative teaching application. This study aims to construct a ceramic teaching design framework driven by both AI and AR wheels. The study first established the two core pillars of "intelligent enhancement" and "situational integration" through literature review, corresponding to the cognitive empowerment of AI and the environmental construction of AR. On this basis, this study deconstructs and elucidates the inherent mechanism of the "dual wheel drive" model, namely that AI serves as the "brain" responsible for data perception, analysis, and decision generation, while AR serves as the "interface" responsible for immersive presentation and interactive guidance of information. A synergistic effect is achieved via a closed-loop data flow, through which the technologies collaboratively support comprehensive pottery teaching.

1. Introduction

Traditional pottery education has long been constrained by its reliance on teacher-centered instruction, resulting in a pronounced imbalance in resource distribution and a lack of quantifiable teaching processes. Moreover, students often face limitations in accessing diverse sources of creative inspiration, which hampers their artistic development. As emerging technologies such as artificial intelligence (AI) and augmented reality (AR) continue to evolve, they offer promising

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avenues to address these pedagogical challenges. However, existing research tends to treat AI and AR as isolated tools, overlooking their potential for integrated, synergistic application within ceramic art instruction.

This study responds to this gap by proposing a novel teaching design framework driven by the dual technological engines of AI and AR. Grounded in a comprehensive literature review, the framework is built upon two foundational pillars: *intelligent enhancement*, representing the cognitive empowerment enabled by AI, and *situational integration*, reflecting the immersive environmental scaffolding facilitated by AR. Through a detailed deconstruction of the "dual wheel drive" mechanism, the study conceptualizes AI as the "brain"—responsible for data perception, analysis, and decision-making—and AR as the "interface"—tasked with delivering interactive, context-rich guidance. By establishing a closed-loop data flow between these components, the framework enables a collaborative, dynamic teaching model that redefines the possibilities of pottery education in the digital age.

2. Literature Review and Theoretical Basis

Intelligence Augmentation (IA) is a concept that complements Artificial Intelligence (AI) but has a distinct philosophical orientation. It is not aimed at completely replacing humans with machine intelligence, but emphasizes the use of advanced computing technology to expand, supplement, and enhance human cognitive and decision-making abilities (Shneiderman, 2020). In the context of education, the core idea of intelligent enhancement is to view AI as a powerful "external brain" or "cognitive partner", whose value lies in empowering learners to process information more efficiently, solve complex problems, and stimulate creativity (Zawakki Richter et al., 2019). For example, in pottery teaching, an intelligent enhancement system can provide quantitative feedback on students' hand posture and strength by analyzing their drawing videos, thereby enhancing their ability to self reflect and adjust their skills. Therefore, in this study, "intelligent enhancement" specifically refers to the paradigm of using AI technology to enhance teachers' teaching effectiveness and students' learning experience and cognitive processes.

Contextual Integration "originates from the theory of situational cognition, which holds that learning is essentially a social process embedded in specific activities, contexts, and cultures (Brown, Collins,&Duguid, 1989). In this study, the concept specifically refers to the seamless and real-time overlay and integration of digital information, virtual objects, and intelligent guidance into real physical operating environments and task processes through augmented reality (AR) technology, creating a fused and enhanced learning environment （Akçayır & Akçayır, 2017）. It goes beyond simple situational "creation" and emphasizes seamless integration and natural interaction between digital virtual and physical reality. In pottery teaching, this means that learners can use AR devices to not only see real clay, but also virtual auxiliary lines, 3D models, or animated operation steps overlaid on it, allowing abstract knowledge and skills to be intuitively perceived and internalized in specific work scenarios, greatly reducing cognitive load.

Two wheel drive "is a metaphorical concept used to describe the mechanism of deep collaboration, functional complementarity, and mutual promotion between artificial intelligence (AI) and augmented reality (AR) technologies in this framework. It emphasizes that the two do not function independently, but form a complete teaching intervention system (Huang, Roscoe,&Craig, 2023). Among them, AI serves as the "brain" of the system, responsible for intelligent computing in the background, such as data perception, pattern recognition, analysis, and decision-making (i.e. "intelligent enhancement"); AR acts as the "eyes" and "hands" of the system, responsible for presenting and interacting with front-end information, and transmitting AI analysis results to users in a visual and contextualized manner (i.e. "contextual fusion"). The two form a closed loop through data flow: the AR environment captures students' learning data and sends it to AI for analysis, and the insights generated by AI are fed back to students through the AR interface to guide practice. Like a powerful engine where two forces are fused together, this mechanism drives the teaching process forward into a more efficient, personalized, and immersive future.

The role of artificial intelligence in education has evolved significantly, transitioning from theoretical exploration into widespread practice. At its core, this transformation is defined by the provision of personalized, adaptive, and intelligent learning support.The current applications are mainly reflected in the following aspects: firstly, Intelligent Tutoring Systems (ITS), which can simulate human mentors and provide learners with adaptive learning paths and instant feedback by constructing domain knowledge models and student models (Luckin, 2017). Next is educational data mining and learning analysis. AI technology can analyze the large-scale data generated by students during the learning process to identify learning difficulties, predict academic performance, and provide intervention recommendations (Siemens&Baker, 2012). In addition, automated evaluation is also an important direction, especially in skill based disciplines. AI is undergoing a critical evolution in education, transitioning from a supportive tool to an active, intelligent agent that deeply engages in pedagogy. This is evidenced by its ability to automatically score and analyze diverse student work (e.g., essays, code, art) using computer vision and NLP, demonstrating a capacity for sophisticated pedagogical participation (Zawacki Richter et al., 2019).

Augmented reality, due to its ability to superimpose virtual information with the real world in real-time, has shown great potential in skill training fields that require extensive practical operations. Its application significantly enhances the immersion, intuitiveness, and safety of skill learning. In the industrial and medical fields, AR is used to guide complex equipment assembly and surgical operations. By visualizing instructions or operation manuals overlaid on physical objects, it greatly reduces error rates and improves training efficiency (Palmarini et al., 2018). In traditional handicrafts and vocational education, AR can concretize abstract and difficult to express "tacit knowledge". For example, students can watch virtual mentors' demonstration actions overlaid on their workstations through AR devices, or break down the steps of a complex process through interactive 3D animations (Bacca et al., 2014). Research confirms that Augmented Reality significantly accelerates skill mastery and builds learner competence. This is achieved by leveraging immersive, multi-sensory experiences and real-time contextual guidance to deepen spatial understanding and boost operational confidence.

Although AI and AR have made significant progress in education, their integration is opening up a more disruptive innovation frontier. This fusion is not simply a combination of technologies, but rather generates a synergistic effect of "1+1>2". AI can inject "intelligence" into AR, upgrading it from static information display to an intelligent system that can perceive the environment, understand user intentions, and provide dynamic responses (Azuma, 2019). For example, an AR system that integrates computer vision (AI) can recognize students' operating tools and current steps in real time, automatically calling up and displaying the most relevant guidance information. On the contrary, AR provides excellent visualization and interactive output interfaces for AI's intelligent decision-making, making AI's analysis results no longer boring data reports, but practical guidance integrated into real-life situations (Höllerer & Feiner, 2016). This fusion technology has matured in fields such as autonomous driving and remote collaboration. In the field of education, especially in skill training that requires both hands and brains, it is giving rise to new application models such as intelligent skill coaches and context aware learning companions, providing a solid technological foundation for achieving highly personalized and adaptive immersive learning experiences.

3. Construction of a Ceramic Teaching Design Framework Driven by AI and AR

3.1 Logical starting point and core principles for framework construction

The core achievement of this study is to construct a dual wheel driven instructional design framework called "Intelligent Augmentation Contextual Integration" (IA-CI). This framework is not a theoretical abstraction but is rigorously grounded in a tripartite foundation: an analysis of evolving educational theories, a response to persistent practical teaching challenges, and a strategic vision for the integrative potential of technology.

3.1.1 Logical Starting Point

The construction of this framework begins with three interrelated logical premises, which collectively answer the fundamental questions of 'why build' and 'why build in this way'. The inherent demand of educational theory is to shift from "knowledge imparting" to "cognitive empowerment". The traditional ceramic teaching model, which focuses on teacher demonstration and student imitation, is deeply influenced by behaviorist learning theory. Although it ensures the standardization of skill inheritance, it largely suppresses learners' creative thinking and problem-solving abilities (Sun, 2020). Constructivist theory emphasizes that learning is the process in which learners actively construct meaning in specific contexts (Jonassen, 1999). The embodied cognition theory further suggests that cognitive processes are deeply rooted in the interaction between the body and the environment (Wilson&Foglia, 2017). Therefore, there is an urgent need for a new paradigm in pottery teaching that can create rich contexts and provide intelligent frameworks to guide learners from passive "operators" to active "explorers" and "creators".

The traditional ceramic art teaching paradigm is facing unprecedented practical challenges. These challenges are epitomized by a critical tension that pits the severe scarcity of renowned teaching resources against the highly personalized demands of learners, consequently making it unfeasible for one teacher to accurately guide multiple students at the same time.(2) The teaching process (such as the force and angle of the blank) and the results (the shape of the blank) lack a quantitative and immediate feedback mechanism, and students often discover problems after repeating mistakes multiple times; (3) Abstract techniques such as "feel" and "technique" are difficult to articulate and rely on long-term "comprehension", which makes beginners prone to frustration and giving up. These pain points constitute the core problem domain that this framework aims to address.

Figure5.Traditional ceramic art

The complementary characteristics of AI and AR technologies provide new possibilities for solving the above-mentioned problems. The core advantage of artificial intelligence lies in its powerful ability to enhance intelligence. It can perceive, analyze, and make decisions on multimodal data such as images and videos, providing learners with objective, accurate, and highly personalized diagnosis and recommendations(Zawakki Richter et al., 2019). The core advantage of augmented reality (AR) lies in its excellent "contextual fusion" ability, which can seamlessly overlay abstract digital information into the real physical world and operational processes, achieving an intuitive experience of "what you see is what you learn" (Ak ç ay ı r&Ak ç ay ı r, 2017). This study recognizes that the application of a single technology has limitations, and the deep integration of AI's analytical decision-making ability with AR's situational presentation ability can form a synergistic effect of "dual wheel drive" to systematically reshape the ceramic teaching experience.

3.1.2 Core Principles

Based on the above logical starting point, this framework follows the following three core principles in the design and application process:

Firstly, the learner centered principle. Technology always serves the purpose of teaching and human development. All designs of the framework are aimed at supporting learners' personalized skill growth and creative inspiration as the ultimate goal. AI systems are not meant to replace teachers, but rather serve as intelligent learning companions, providing continuous and adaptive support; AR presentation is not about showing off skills, but rather serving as a cognitive scaffold to reduce the cognitive load of complex skills and stimulate exploration interest. This principle ensures the educational and humanistic attributes of technological applications.

Secondly, the principle of seamless technology integration. This framework emphasizes that AI and AR are not simply overlapping functions, but rather deep level collaboration and closed-loop. AI is responsible for data mining, model computation, and intelligent decision-making in the background ("brain"), and its output results (such as action deviation analysis, personalized suggestions) are seamlessly embedded into students' real operating scenarios through AR interfaces in a visual and interactive manner (such as 3D arrow guidance, color highlighting) ("interface"). The operational data of students is collected in real-time and fed back to the AI model, forming an enhanced closed loop of "analysis presentation interaction reanalysis" (Huang et al., 2023). This deep integration is the key to achieving the efficiency of "dual wheel drive".

Thirdly, uphold the Embracing Craftsmanship Principle. The intervention of technology must be based on respecting and enhancing the intrinsic value of pottery, rather than weakening or alienating it. Framework design must avoid learners overly relying on visual guidance and neglecting the central role of tactile experience (Paton, 2018). The role of technology is to "empower" rather than "replace", aiming to help learners master basic skills faster, enter the stage of artistic expression and creation earlier, and ultimately deepen their understanding and respect for traditional craft culture.

4. Theoretical Framework and Research Design

4.1 Deconstruction of the Core Elements of the Framework

4.1.1 "Intelligent Enhancement" Layer (AI Wheel)

This level is the intelligent processing center of the framework, whose function is to mimic the cognitive process of human experts, process learning data, and generate intelligent intervention strategies. Specifically, its capabilities are achieved through the following key technologies:

(1) Computer vision: used for motion capture and artwork evaluation

Leveraging computer vision, educational systems gain visual perception capabilities that enable both process-oriented and outcome-based analysis. Through cameras capturing real-time video streams, pose estimation algorithms track the kinematic trajectories of students' hands and wrists, allowing for precise, quantitative evaluation of intricate movements in activities like drawing and carving (Chen et al., 2020). Furthermore, by applying image recognition to finished works, these systems objectively assess structural attributes—such as symmetry, regularity, and complexity—delivering standardized, data-driven feedback that transcends subjective human judgment.

(2) Natural language processing: used for intelligent question answering and creative inspiration

Natural language processing technology facilitates natural human-machine dialogue. Students can interact with the system naturally via voice or text input. By semantically parsing these queries, the system retrieves relevant information from a structured ceramic knowledge graph, delivering precise answers concerning historical, technical, and material-related aspects of ceramics.Furthermore, generative AI models can automatically generate various design sketches or inspiration schemes based on students' simple descriptions (such as' wanting a modern Song Dynasty artifact shape '), effectively stimulating creative inspiration (Huang et al., 2023).

(3) Machine learning/deep learning: used for personalized recommendation, prediction, and decision-making

Machine learning is the core of achieving personalization. The system constructs a dynamic learner model by continuously collecting students' learning behavior data (such as common mistakes, practice duration, and preferred styles). Based on this model, deep learning algorithms can predict students' learning difficulties and adaptively recommend the most suitable exercise projects, teaching videos, or solutions for their current level, achieving true personalized teaching (Baker, 2016).

4.1.2 "Context Fusion" Layer (AR Wheel)

This level is the user interaction front-end of the framework, whose mission is to transform the abstract conclusions generated by the "intelligent enhancement" layer into intuitive experiences immersed in the real environment, greatly reducing students' cognitive load.

(1) Operation guide overlay: Real time visualization of AI analysis results

This is the most direct application. AR devices (such as tablets or glasses) directly overlay and render the best action path, angle correction prompt line, or force distribution heatmap analyzed by computer vision on the real body or workbench being operated by students. Students can refer to virtual guidance for self adjustment without interrupting operations, achieving real-time guidance of "hand eye collaboration" (Bacca et al., 2014).

(2) Concrete representation of abstract concepts: such as visualization of force fields and structural lines

AR can transform abstract concepts that are difficult to express in teaching into visual objects. For instance, during casting, dynamic vector arrows can visualize the direction and magnitude of centrifugal and support forces; when explaining ceramic structures, 3D models can reveal internal stress distributions or molecular arrangements. These techniques transform otherwise abstract and internal principles into visible, tangible, and intelligible representations.

(3) Virtual object interaction: such as presentation of historical relics and virtual mentors

AR can break through the limitations of time, space, and matter. Students can use AR devices to "place" a precious but untouchable museum pottery on their desks for a 360 degree observation; A 'virtual mentor' driven by virtual human technology can appear at the workbench, demonstrating key steps and providing explanations (Azuma, 2019). This greatly enriches teaching resources and contexts.

4.2 Design and operation mechanism of the "dual wheel drive" model

4.2.1 Driver Model

The "dual wheel drive" of the IA-CI framework is essentially a tight data loop, and its operating mechanism is a continuous, automated cyclic process (as shown in Figure 3-1). The cycle begins with data perception: sensors (cameras) in the AR environment capture real-time operational data from students. Subsequently, it enters the intelligent analysis stage: the raw data is transmitted to the "intelligent enhancement" layer, where AI algorithms process, analyze, and make decisions to generate personalized teaching instructions (such as "wrist tilt 15 degrees inward"). During the situational presentation stage, these instructions are transmitted to the "situational fusion" layer, where the AR system transforms them into visual guidance seamlessly integrated into the user’s real-world environment.After seeing these guidelines, students interact and adjust to generate new operational data. The new data is captured again by the system, starting a new cycle. This closed loop enables teaching guidance to dynamically adapt to every step of students' operations, achieving real-time, refined, and intelligent teaching processes.

4.2.2 Application Scenario Mapping

Based on AI visual analysis of the pulling trajectory, the AR system overlays the contour of a standard shape in real time, allowing students to visually compare and self-correct their technique.

Glaze color matching: Students input creative keywords, AI generates multiple glaze color schemes, and AR renders them onto the 3D model of the student's work to preview the firing effect.

Pattern design: AI recommends or generates pattern patterns, AR projects them onto the blank, and students can copy or adjust the composition.

Through AI-powered analysis of cultural relic backgrounds, AR enables the virtual restoration of historical artifacts and their integration into physical environments, constructing deeply immersive archaeological simulation scenarios.

Work display: AR overlays digital labels, animation of the creative process, or creator

interviews on physical works to enrich the exhibition narrative.

Figure6.Ceramic Art Process Diagram

5. Framework Application: Design and Development of Pottery Teaching

Cases

To verify the feasibility and effectiveness of the IA-CI framework, this study selected the core element of ceramic basic skills - blank forming - as a specific application case, and conducted a complete teaching unit design and system prototype development.

5.1 Case Design: Framework based Ceramic Drawing Teaching Unit

5.1.1 Analysis of Teaching Objectives

This teaching unit aims to achieve the following three-dimensional teaching objectives through the application of IA-CI framework:

Knowledge and skills: Learners are able to understand the basic principles of blank forming, master the correct techniques for key steps such as center positioning, punching, and pulling, and independently create basic shapes with regular shapes (such as bowls and cups).

Process and Method: Learners can use intelligent feedback systems for self observation, diagnosis, and correction, cultivate metacognitive and problem-solving abilities, and experience a digital skill acquisition process of human-machine collaboration.

Emotional attitude and values: Reduce the frustration of beginners, enhance learning confidence and intrinsic motivation, feel the modern vitality of traditional handicrafts under technological empowerment, and stimulate innovation consciousness.

5.1.2 Teaching Content and Analysis of Key and Difficult Points

The teaching content revolves around the operation process of the electric billet machine, including a series of steps such as kneading, centering, drilling, expanding, pulling, and trimming. Based on traditional teaching experience, its key and difficult points are extremely prominent:

Teaching focus: Master the correct body posture and hand force application method to achieve stable and uniform ascent of clay.

Teaching difficulty: (1) Centering: Stabilize the clay material at the center point of the rolling table of the casting machine, requiring even and symmetrical force to be borne by the hands. This is the foundation for all subsequent steps and has the highest failure rate; (2) Perception and control: forming accurate muscle memory and tactile feedback on the force and angle of contact between fingers and clay, which is an indescribable process of tacit knowledge.Traditional instruction often depends on repeated one-to-one demonstrations and manual corrections by the teacher—an approach that is not only time-consuming and inefficient, but also limited by the educator's individual expertise and availability.

5.1.3 Framework based Teaching Activity Process Design

Based on the IA-CI framework, teaching activities are restructured into a closed-loop process that includes four stages: preparation, practice, evaluation, and creation

During the preparation phase, learners wearing AR glasses can activate a virtual mentor, which demonstrates standard procedures through three-dimensional visualizations. They are able to freely adjust viewing angles to closely observe the detailed hand-clay interactions from multiple perspectives.

Practical stage: Learners begin to engage in practical operations. The AI computer vision module in the system backend captures real-time dynamic video streams of its hands and clay.

Evaluation and feedback stage: The AI model compares real-time videos with pre trained standard model libraries, and calculates quantitative data such as hand angle, mud concentricity, and shape deviation in real-time. Once a common error is detected (such as uneven force causing the clay to shake), the AR module will immediately start, overlaying and rendering a highlighted correction guide line (such as a virtual semi transparent ring representing the correct path) on the real clay in the learner's field of view, or playing a mini animation prompt for the error.

During the creation and reflection stage, the system generates a detailed data analysis report—including stability curves and progress trends—based on the learner's guided practice. This supports structured self-assessment and skill consolidation. Once foundational skills are mastered, learners may advance to more complex forms. Here, AI suggests design solutions tailored to the user's ability level, while AR projects a virtual 3D model of the proposed form into the physical environment for reference, comparison, and imitation.

5.2 System Prototype Development

5.2.1 Technical selection and architecture:

To achieve the above design, the prototype system adopts an integrated technology solution. The system architecture is built upon the Unity3D engine as the core development platform, leveraging its robust cross-platform support and high-quality 3D rendering to deliver immersive AR experiences. AR functionality is enabled through integration with SDKs such as Vuforia or ARCore, which handle real-time spatial mapping and overlay of virtual content.

For artificial intelligence capabilities, the PyTorch framework is used to develop and train deep learning models, which are then deployed in the Unity environment via the Barracuda inference library or API-based communication to enable end-to-end real-time intelligence.

A clear separation is maintained between the front end—handling data perception and user interaction (Unity + AR SDK)—and the back end—performing intelligent analysis (PyTorch models)—with seamless data exchange facilitated through internal interfaces.

5.2.2 Implementation of core functional modules:

AI module: Real time recognition and evaluation algorithm for billet shape based on CV (Computer Vision):

The core of this module is a semantic segmentation model based on the U-Net architecture. The model is trained on a large annotated dataset of raw video frames, learning to accurately separate the contour of the clay from the background and hands in the image. The segmented contour of the mud slab is used to calculate the offset pixel distance between its center of mass and the physical center of the turntable in real time, which is used as a quantitative indicator to evaluate the "centering" effect (Chen et al., 2020). At the same time, the algorithm continuously extracts the minimum circumcircle radius of the mud slab contour, generates its height curve over time, and evaluates the smoothness and symmetry of the casting process. These quantitative indicators form the data foundation for intelligent evaluation and feedback.

AR module: overlay display of correction finger lines based on mobile devices/AR glasses

This module first utilizes the functionality of AR SDKs (such as ARCore) to track the relative position of mobile device cameras and physical space (such as the drawing machine workbench) in real time through SLAM (Simultaneous Localization and Mapping) technology, establishing a stable coordinate correspondence between the digital world and the real world. Subsequently, Unity receives analysis results from the AI module (such as the offset direction and distance of the current mud center), and the driver program initializes and renders a preset virtual 3D model (such as a semi transparent green ring) at the accurate position in the world coordinate system (such as 2 millimeters directly above the mud). This circular ring representing the "ideal center" can be stably overlaid on the real scene, providing learners with intuitive spatial guidance (Azuma, 2019).

5.2.3 Prototype System Display

The prototype system developed runs on a tablet computer. The interface consists of two distinct regions: the main view displays a live camera feed of the physical workspace, with virtual correction circles and directional deviation indicators accurately overlaid in real time. A side panel presents real-time AI-generated analytics, including a concentricity curve and a stability score for the clay body. When the learner successfully centers the clay, the virtual circle transitions from red to green, accompanied by an affirming sound effect—providing immediate positive reinforcement. The system has preliminarily verified the technical feasibility of the IA-CI framework in real teaching scenarios.

6. Empirical research and effectiveness evaluation

To scientifically verify the effectiveness of the "Intelligent Enhancement Context Fusion" (IA-CI) framework and its prototype system in teaching practice, this study designed and implemented a controlled experiment, and conducted in-depth analysis of the collected data.

6.1 Research Design

This study adopts a mixed method research design, combining quantitative and qualitative data to comprehensively evaluate the application effectiveness of the framework.

Research questions and hypotheses

The core question of this study is: Can pottery drawing teaching based on IA-CI framework effectively improve the skill level, operational confidence, and learning experience of beginners compared to traditional teaching methods? Based on this, a hypothesis is proposed that the experimental group (using IA-CI system) will have significantly higher post test scores in skill performance, self-efficacy scale scores, and system usability evaluations than the control group (receiving traditional teaching).

Research object and grouping

Recruit 60 undergraduate students from a certain university who have no pottery experience as participants, and randomly divide them into an experimental group (30 people) and a control group (30 people).To establish a consistent baseline, all participants are required to complete a pre-test questionnaire covering basic personal information and a brief assessment of spatial perception abilities. Data analysis shows that there is no significant difference between the two groups before the experiment.

Experimental process

The experiment lasts for four weeks. Both groups received instruction from the same senior ceramics instructor, with identical total class hours and a consistent core curriculum.

Control group: receive traditional demonstration teaching. After the teacher concentrated on explaining and demonstrating, the students practiced on their own, and the teacher provided individual guidance on a tour.

Experimental group: On the basis of traditional teaching, the IA-CI prototype system developed in this study was used for auxiliary training during the practice session. The system provides real-time AR visual feedback and data recording.

After the experiment, a skill post test will be conducted on the drawing works of the two groups of students, and a survey questionnaire will be distributed. Randomly select 12 participants from the experimental group for semi-structured interviews.

Instrument

Skill Performance Rating Scale: Using a blind method, two ceramic experts who do not know the grouping situation independently rate the final work based on a scale (Cronbach's alpha=0.89) that includes dimensions such as "concentricity", "wall uniformity", and "overall shape".

Self-efficacy Scale: The ceramic skill self-efficacy scale (5-point Likert scale) adapted from Bandura's social cognitive theory is used to measure students' confidence in their own operational abilities (Cronbach's alpha=0.91).

System Usability Scale (SUS): The experimental group completes this standard scale to evaluate the usability and acceptance of the prototype system.

Semi structured interview outline: aimed at gaining a deeper understanding of the subjective experience, perceived value, and improvement suggestions of the experimental group students towards the IA-CI system.

6.2 Discussion

6.2.1 Comprehensive Discussion of Research Results

Quantitative analysis revealed a statistically significant difference in post-test skill scores between the experimental and control groups ($t(58) = 4.32$, $p < .001$), with the experimental group achieving markedly higher average results. This finding strongly supports the core hypothesis of the study, indicating that the IA-CI framework's real-time, visual, and quantitative feedback effectively addresses the limitations of delayed and abstract feedback in traditional instruction. By enabling immediate error detection and correction, the system helps learners avoid reinforcing incorrect movements, leading to more efficient skill acquisition and higher overall proficiency within equivalent training time (Huang et al., 2023).

Meanwhile, the experimental group also scored significantly higher in self-efficacy ($p<. 01$). The interview materials provide a deep explanation for this: multiple students mentioned that "the green circle (AR guidance) immediately made me know where to put in effort, and I had a sense of accomplishment when I saw the scoring curve rising". This indicates that the system's procedural positive reinforcement and ability to reduce uncertainty effectively alleviate the anxiety of beginners, enhance their sense of control and learning confidence (Bandura, 1997).

The average score of SUS is 82.5, indicating that the system has good usability. During post-training interviews, trainees widely acknowledged the system's intuitive design and instructional value, though several also noted hardware-related limitations such as device heaviness and motion discomfort during extended use. These critiques highlight tangible areas for future refinement.

6.2.2 Analysis of the Effectiveness and Limitations of the Framework

This empirical study has demonstrated the effectiveness of the IA-CI framework from a practical perspective. Its core advantage lies in the construction of an enhanced closed loop of "perception analysis feedback", which transforms teachers' empirical knowledge into quantifiable and visualized intelligent guidance, achieving personalized support under large-scale teaching. It does not replace teachers, but liberates them from repetitive basic movement correction, allowing them to focus more on inspiring creativity and humanistic influence.

However, the study also revealed the current limitations of the framework. The technical limitations are obvious: system performance is constrained by hardware devices (camera accuracy, AR display effect); The recognition accuracy of AI models will decrease when the lighting is complex or the hands are severely obstructed. While the framework demonstrates strong efficacy in teaching quantifiable foundational skills, its applicability remains bounded when extended to higher-order cognitive domains such as artistic creation, which emphasizes personal expression and stylistic individuality. Support strategies for fostering creativity and subjective stylistic development remain an open area for exploration. Cost and accessibility are practical obstacles to promotion, including hardware investment, system maintenance, and teacher training costs.

6.2.3 Implications for Ceramic Art Teaching Practice

This study has important implications for pottery and even the entire field of handicraft education. Firstly, it provides a feasible path for digital transformation. Teachers can draw on this framework to transform their teaching experience into digital assets and develop intelligent assisted courses. Secondly, it reshapes the roles of teachers and students, with teachers transforming into "learning designers" and "creative guides," while students become active self managers in human-machine collaborative environments (Luckin, 2017). Third, the framework emphasizes data-driven process evaluation, offering a more nuanced approach to formative assessment that extends beyond final outcomes. By capturing and analyzing real-time performance metrics, it adds a refined dimension to instructional evaluation and supports more scientifically grounded teaching decisions.

Future research can explore lightweight and low-cost technological solutions, and extend the framework application to more aspects of pottery such as color, glaze, firing, and even other handicraft fields such as embroidery and woodworking, to verify its transferability and universality.

7. Summary and Prospect

7.1 Research Conclusion

This study addresses key challenges in traditional ceramics education by proposing an integrated AI-AR framework designed to enhance teaching and learning processes. The "Intelligently Augmented Contextually Integrated" (IA-CI) framework introduces a dual-driven instructional model that synergizes artificial intelligence and augmented reality. Its core proposition is that through a seamless “perception–analysis–feedback” loop, AI and AR collectively mitigate longstanding limitations in hands-on skill acquisition—such as delayed feedback, implicit knowledge transfer, and limited scalability— thereby supporting more responsive, explicit, and reproducible instruction in craft-based disciplines.

Through literature research, the theoretical foundation has been clarified, and a system prototype for ceramic tile drawing teaching has been developed by designing a scientific research paradigm. Its effectiveness has been verified through rigorous empirical research. The research results indicate that this framework not only significantly improves the skill acquisition efficiency and operational confidence of beginners, but also reshapes a new teaching form of human-machine collaboration and data-driven approach, providing a theoretical and practical example for the deep empowerment of traditional handicraft education with information technology.

7.2 Research Contributions

7.2.1 Theoretical Contribution

The main theoretical contribution of this study is the first systematic proposal of the "Intelligent Enhancement Context Integration" (IA-CI) framework for handicraft education, and the elucidation of its inherent "dual wheel drive" mechanism. This framework organically integrates constructivism, situational learning, and embodied cognition theory, deeply integrating technological elements into teaching theory, surpassing the previous shallow application model that only regarded technology as an auxiliary tool. It provides theoretical support and model construction from the specific field of handicrafts to promote the evolution of educational technology theory from a "media perspective" to a "cognitive partner perspective" (Shneiderman, 2020), enriching the design theory of smart educational environments.

7.2.2 Practical Contribution

At the practical level, the operational prototype developed in this study offers ceramics instructors a functional digital teaching tool that validates the feasibility of the proposed framework. Its key contributions include:

(1) Empowering teachers: Liberating teachers from repetitive basic movement correction, enabling them to focus more on artistic inspiration and humanistic care, and achieving complementary advantages between humans and machines.

(2) Reduced Cognitive Load for Learners: By offering real-time and intuitive visual feedback, the system significantly lowers the entry barrier for beginners, mitigates learning anxiety, and enhances both motivation and a sense of accomplishment.

(3) Demonstration of Scalable Practice: The framework offers a transferable model of technology integration that can inform the digital transformation of ceramics instruction and broader intangible cultural heritage education, providing valuable reference value for the field.

7.3 Research Limitations and Shortcomings

This study inevitably has several limitations. On a technical level, the performance of the prototype system is limited by the current hardware level, such as the field of view, weight, and battery life of AR devices, as well as the recognition robustness of computer vision algorithms in complex lighting and occlusion scenes, which still have room for improvement. The study sample was primarily composed of novice undergraduate students, lacking diversity in age and background. As a result, the generalizability of the findings remains limited and calls for further validation across broader demographics.

In terms of instructional scope, the current research concentrates largely on quantifiable basic motor skills. Support for higher-order learning objectives—such as aesthetic appreciation and creative design—has not been thoroughly explored, indicating an important direction for future investigation.

7.4 Future Research Prospects

7.4.1 Technical aspect: Integrating more sensors, exploring large models and metaverse applications

The next generation system can integrate multimodal sensors (such as tactile gloves and electromyography sensors) to capture richer operational data, enabling precise monitoring and feedback on students' force application and muscle tension. Explore the integration of large-scale multimodal models (LMMs) to build a more powerful "ceramic intelligent mentor" that can understand and generate cross modal content (such as natural interaction with the system through speech and gestures). In the long run, deploying the entire framework on the metaverse platform can create a fully immersive ceramic teaching environment that supports remote collaboration and virtual firing experiments.

7.4.2 Application level: Migration and validation of frameworks in other handicraft disciplines such as woodworking and embroidery

The concept and mechanism of IA-CI framework have the potential to be transferred to other handicraft fields. Future research can apply it to disciplines such as woodworking, embroidery, metalworking, calligraphy, which also emphasize the inheritance of motor skills and tacit knowledge, to test its universality, and explore the adaptive adjustments required according to different process characteristics, ultimately forming a universal design paradigm suitable for digital teaching of traditional handicrafts.

7.4.3 Theoretical level: Deepen the understanding of the intelligent teaching form of "human-machine collaboration"

With the rapid advancement of AI capabilities, future research should further explore several critical dimensions within this human-AI collaborative teaching context: the evolving boundaries between teacher and AI roles, optimal human-machine task allocation strategies, and the profound implications of technological mediation for teacher-student dynamics and learning ethics. This requires collaboration between educational researchers, technical experts, and frontline teachers to build a human-machine collaborative teaching theory that can better guide future practices.

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References

[1]. Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review,* 20, 1-11.

[2]. Azuma, R. T. (2019). The road to ubiquitous consumer augmented reality. *IEEE Computer Graphics and Applications,* 39(5), 6-12.

[3]. Bacca, J., Baldiris, S., Fabregat, R., & Graf, S. (2014). Augmented reality trends in education: A systematic review of research and applications. *Journal of Educational Technology & Society,* 17(4), 133-149.

[4]. Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman.

[5]. Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher,* 18(1), 32-42.

[6]. Chen, L., Wang, P., & Wang, Y. (2020). A computer vision-based method for ceramic throwing skill evaluation. *In Proceedings of the 2020 IEEE International Conference on Progress in Informatics and Computing*(pp. 409-413). IEEE.

[7]. Höllerer, T., & Feiner, S. (2016). Augmented reality. **In The Encyclopedia of Human-Computer Interaction(2nd Ed.). Interaction Design Foundation.*

[8]. Huang, W., Roscoe, R. D., & Craig, S. D. (2023). A systematic review of AI-based learning systems in STEM education. *Journal of Educational Computing Research,* 61(2), 365-394.

[9]. Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory*(Vol. II, pp. 215-239). Lawrence Erlbaum Associates.

[10]. Luckin, R. (2017). Towards artificial intelligence-based assessment systems. *Nature Human Behaviour,* 1(0028), 1-3.

[11]. Palmarini, R., Erkoyuncu, J. A., Roy, R., & Torabmostaedi, H. (2018). A systematic review of augmented reality applications in maintenance. *Robotics and Computer-Integrated Manufacturing,* 49, 215-228.

[12]. Paton, B. (2018). The intelligence of the hand: Studies in the transmission of craft practice. *The Journal of Modern Craft*, 11(2), 123-141.

[13]. Shneiderman, B. (2020). Human-centered artificial intelligence: Reliable, safe & trustworthy. *International Journal of Human–Computer Interaction,* 36(6), 495-504.

[14]. Siemens, G., & Baker, R. S. (2012). Learning analytics and educational data mining: Towards communication and collaboration. *In Proceedings of the 2nd International Conference on Learning Analytics and Knowledge*(pp. 252-254).

[15]. Sun, L. (2020). Reconstructing the apprenticeship model for the digital age: A case study of ceramic education. *International Journal of Art & Design Education*, 39(4), 752-767.

[16]. Wilson, R. A., & Foglia, L. (2017). Embodied cognition. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy(Spring 2017 Edition).* Metaphysics Research Lab, Stanford University.

[17]. Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 1-27.