Saudi Art and Design Journal

جامعة الأميرة نورة بنت عبدالرحمن
Princess Nourah bint Abdulrahman University

المجلة السعودية للفن والتصميم، 2026، المجلد 6، العدد 1، 349 – 387
https://pnu.edu.sa/ar/Departments/ScientificSocieties/SaudiArtDesignJournal/Pages/home.aspx

المعادن المعاد تدويرها في تعليم الفنون الإبداعية: مدخل تربوي نحو التعلم المستدام في دولة الكويت

Recycled Metalwork in Creative Art Education: A Pedagogical Approach to Sustainable Learning in Kuwait

Dol 10.57194/ 2351–006–001–010

منيره غازي العيار
ORCID https://orcid.org/0000-0003-2846-9655
Email: mg.alayar@paaet.edu.kw
أستاذ مساعد – تصميم المعادن والمجوهرات
قسم التربية الفنية – كلية التربية الأساسية
الهيئة العامة للتعليم التطبيقي والتدريب
دولة الكويت.

Moneerah Ghazi Alayar
ORCID https://orcid.org/0000-0003-2846-9655
Email: mg.alayar@paaet.edu.kw
Assistant Professor . Metal & Jewelry Design
Department of Art Education - College of Basic Education The Public Authority for Applied Education and Training Kuwait..

النشر Published	القبول Accepted	الاستقبال Received	رقم البحث Article No
June 2026	15 May 2025	21 April 2025	2025-24

الملخص

أصبحت الاستدامة محورًا أساسيًا في تعليم الفنون الإبداعية، ولا سيما مع توجه المؤسسات التعليمية إلى تحويل الوعي البيئي إلى ممارسات تعليمية تطبيقية داخل بيئات الاستوديو. وعلى الرغم من تزايد توظيف المواد المعاد تدويرها في تعليم الفن والتصميم، فإن القيمة التربوية للمعادن المعاد تدويرها ما تزال بحاجة إلى مزيد من البحث، خصوصًا في السياق التعليمي الكويتي. هدفت هذه الدراسة إلى استكشاف دور المعادن المعاد تدويرها في دعم الإبداع، وتنمية المهارات التقنية، وتعزيز حل المشكلات، وتطوير الوعي البيئي لدى الطالبات، مع تقديم مدخل تربوي يربط بين إعادة توظيف الخامات والتعلم التجريبي وممارسات الاستدامة. اعتمدت الدراسة المنهج النوعي، وشملت 25 طالبة من طالبات تخصص التربية الفنية المسجلات في مقرر أشغال المعادن في إحدى مؤسسات التعليم العالي في دولة الكويت. شاركت الطالبات في مشروع استوديو قائم على استخدام المعادن المعاد تدويرها وخامات مهملة متنوعة لإنتاج أعمال حُلي وأشكال نحتية. جُمعت البيانات من خلال التحليل البصري للأعمال الفنية، والتأملات المكتوبة، والملاحظات الصفية، وتوثيق مراحل العمل، ومراجعة مقيمين متخصصين. وتم تحليل البيانات وفق إطار ترميز موضوعي مدعوم بإطار تقييم نوعي ركز على التحول المادي، والتماسك البنائي، والدقة التقنية، والأصالة الإبداعية، والتفكير المستدام، وتطوير حل المشكلات. أظهرت النتائج أن المعادن المعاد تدويرها عززت التجريب الإبداعي، والتكيف التقني، واتخاذ القرار التأملي. كما أسهمت خصائص المعدن ومقاومته المادية في دعم التعلم التكراري القائم على التجربة والتعديل والتنقيح. وتخلص الدراسة إلى أن المعادن المعاد تدويرها تمثل مدخلًا تربويًا فاعلًا يدمج بين استكشاف الخامة والتعلم التجريبي والوعي بالاستدامة في تعليم الفنون الإبداعية داخل مؤسسات التعليم العالي، بما يدعم مواءمة الممارسة الفنية مع توجهات التنمية المستدامة ورؤية دولة الكويت التنموية الوطنية 2035.

الكلمات المفتاحية

إعادة التوظيف، التعلم القائم على الاستوديو، الوعي البيئي، تنمية الإبداع، تعليم الفن.

Abstract

Sustainability has become a central concern in creative art education as educational institutions seek to translate environmental awareness into studio-based learning experiences. Despite the growing use of recycled materials in art and design education, the pedagogical value of recycled metalwork remains insufficiently examined, particularly within the Kuwaiti educational context. This study investigated the role of recycled metalwork in supporting creativity, technical development, problem-solving abilities, and environmental awareness while proposing a pedagogical approach aligned with experiential learning and sustainable practice. A qualitative research design was adopted, involving 25 undergraduate female students enrolled in a metalwork course within an Art Education program in Kuwait. Students participated in a studio-based project using recycled metal and discarded materials to produce jewelry pieces and sculptural forms. Data were collected through visual analysis of artworks, reflections, classroom observations, process documentation, and expert review. The data were analyzed using thematic coding supported by an evaluation rubric focusing on material transformation, structural coherence, technical refinement, originality, sustainability-oriented thinking, and problem-solving development. The findings indicate that recycled metalwork enhanced experimentation, technical adaptation, reflective decision-making, and students' engagement with sustainable design thinking. The physical resistance and structural properties of metal encouraged iterative learning processes in which students developed artistic solutions through experimentation, modification, and refinement. The study concludes that recycled metalwork can function as an effective pedagogical approach integrating material exploration, experiential learning, and sustainability awareness in creative art education while supporting alignment with Kuwait Vision 2035 and sustainable educational development goals within contemporary education contexts and studio-based learning environments

Keywords

Art education, Creative development, Environmental awareness Material reuse, Studio-based learning

Introduction

Contemporary education systems are increasingly expected to address global environmental challenges through sustainable pedagogical practices. As concerns regarding waste production, resource depletion, and ecological responsibility continue to grow, sustainability has become a major priority across different educational disciplines. Within this broader educational context, art and design education has emerged as an important field for promoting environmental awareness through creative, material-based, and experiential learning approaches (Smith, 2021).

Within art and design education, sustainability has increasingly influenced discussions surrounding teaching practices and material engagement. However, this growing emphasis has often remained at the level of discourse rather than being fully embedded in pedagogical practice. As environmental challenges continue to intensify, educational systems have increasingly sought to integrate sustainable practices into teaching and learning processes, particularly in relation to waste management and resource optimization (El-Kanj et al., 2024). One of the most prominent approaches has been the incorporation of recycled materials into educational contexts, as a means of promoting ecological awareness and encouraging innovative thinking (Ahn et al., 2022; Ruano & García, 2023). Similarly, Al-Saud et al. (2024) demonstrated how recycled wood and metal materials can support both aesthetic innovation and sustainability-oriented learning within design education, emphasizing the educational value of material reuse in creative practice.

Within this context, art education offers a distinctive platform for engaging students in experiential learning through hands-on creative practices that emphasize reuse, transformation, and material exploration (Purchase et al., 2022). Previous studies in art education have demonstrated the role of metalwork-based learning in enhancing students' creative skills and artistic awareness (Alazmi & Alayar, 2025). Yet, the pedagogical implications of engaging with specific materials remain insufficiently examined.

Among various recycled materials, metals present unique opportunities for artistic and educational engagement. Unlike more malleable materials, metal

introduces resistance, structural constraints, and technical complexity that actively shape the learning process. Their structural properties, durability, and versatility allow for diverse forms of creative expression while simultaneously challenging students to develop technical and problem-solving skills. Research on alternative and recycled materials in jewelry and design education has highlighted their role in supporting creative experimentation and material exploration (Moreno Castillo, 2023). In addition, the use of recycled metals in art practices has been shown to foster innovation, critical thinking, and environmental responsibility, as students actively reinterpret discarded materials into meaningful artistic outcomes (Tu et al., 2020). These practices are closely aligned with experiential learning approaches, which emphasize learning through experimentation, reflection, and iterative development (Gemmell & Kolb, 2020). However, the relationship between material constraint and creative development remains under-theorized in current art education research.

In the context of Kuwait, such educational approaches align with the national development framework outlined in Kuwait Vision 2035, which emphasizes sustainability, innovation, and environmental awareness as key priorities (AlManssoor, 2020). However, the translation of these strategic priorities into material-based teaching practices remains limited, particularly within studio-based art education. Integrating recycled metalwork into art education can therefore contribute to these broader goals by equipping students with both creative competencies and ecological consciousness. Moreover, collaborative and studio-based projects using discarded materials encourage students to critically reconsider consumption patterns and engage with design thinking in addressing real-world environmental challenges (Elwakeel et al., 2023).

Within this framework, this study positions recycled metalwork not merely as a material practice, but as a pedagogical tool capable of linking artistic production with sustainability-oriented learning in higher education. More specifically, it examines how material properties function as active drivers of learning, shaping both technical engagement and creative decision-making. This study therefore contributes by framing recycled metalwork as a structured pedagogical approach within a context-specific higher education setting.

Research Problem

Despite the increasing emphasis on sustainability in art and design education, its pedagogical implementation remains largely generalized, particularly in relation to material engagement. Existing research has demonstrated the value of recycled materials in fostering creativity and environmental awareness; however, these materials are often treated as a homogeneous category, with limited attention to how specific material properties shape pedagogical processes within studio-based learning environments (Purchase et al., 2022; Ruano & García, 2023). More specifically, previous studies have not sufficiently examined how material-specific constraints influence students' problem-solving strategies, technical adaptation, reflective experimentation, and creative decision-making during the artistic process. As a result, the pedagogical role of materials in shaping experiential learning and technical engagement remains insufficiently theorized in art education research.

This limitation overlooks a critical pedagogical dimension: materials actively influence how students engage in problem-solving, technical adaptation, reflective experimentation, and creative decision-making. In the case of metal, its structural rigidity and technical demands introduce constraints that require precision, planning, and iterative adaptation, fundamentally linking technical challenge with creative development. In this sense, constraint is not merely a limitation but a productive condition that shapes creative learning processes. Yet, current literature offers limited insight into how recycled metal, as a material-specific condition, shapes students' experiential learning within structured art education.

This gap is particularly evident within the Kuwaiti context, where sustainability agendas such as Kuwait Vision 2035 emphasize innovation and environmental responsibility but lack clear translation into material-based educational practices. This disconnect highlights the absence of pedagogical models that operationalize sustainability through material engagement rather than abstract policy alignment.

Accordingly, the core problem addressed in this study lies in the absence of a material-specific pedagogical framework that explains how recycled metalwork supports experiential learning, technical adaptation, creative problem-solving, and

sustainability awareness in art education.

Significance of the Research

This study holds significance at both educational and societal levels. By focusing on recycled metalwork as a specific material practice, it contributes to the development of more targeted pedagogical approaches that support creativity, technical proficiency, and environmental awareness. It also extends current discussions by shifting the focus from general sustainability practices to material-specific learning processes. Integrating such practices into art education enables students to engage in hands-on problem-solving while developing a deeper understanding of sustainable design principles (Gemmell & Kolb, 2020; King et al., 2025).

In the Kuwaiti context, the study aligns with national priorities related to sustainability and innovation, demonstrating how art education can actively contribute to achieving these goals (AlManssoor, 2020). Importantly, it provides a model for translating policy-level objectives into studio-based educational practices. It also provides practical insights for educators seeking to implement sustainable art practices within their curricula, highlighting the potential for interdisciplinary learning that connects art, environmental studies, and design thinking (Elwakeel et al., 2023).

By emphasizing the educational value of recycled metal as a distinct medium, the study advances current discussions on material-based learning and contributes a context-sensitive perspective to the field of sustainable art education.

Research Aims and Objectives

The primary aim of this study is to examine the educational and environmental role of integrating recycled metalwork into art education, with particular emphasis on creativity, sustainability, and its alignment with Kuwait Vision 2035. More specifically, it seeks to understand how engagement with metal as a material condition shapes both creative processes and technical learning.

The study attempts to achieve the following objectives:

To examine the creative and technical development demonstrated in student artworks utilizing recycled metals, particularly in relation to material transformation, structural coherence, creative expression, and problem-solving processes.

To assess the contribution of recycled metal-based projects to students'

environmental awareness and critical thinking.

To explore the alignment between sustainable art practices and the national goals of Kuwait Vision 2035.

To propose a pedagogical approach for integrating recycled metalwork into art education within higher education contexts.

Research Questions

- Based on the qualitative nature of the study, the research is guided by the following questions:
- How did the use of recycled metalwork influence students' creativity and technical skills in art education?
- In what ways did working with recycled metals contribute to students' environmental awareness and critical thinking?
- How can recycled metal-based art practices be aligned with the objectives of Kuwait Vision 2035?
- What pedagogical insights can be derived from integrating recycled metalwork into art education?

Literature Review

A growing body of research has examined the integration of recycled materials in art education as a means of fostering creativity, sustainability, and environmental awareness (Ahn et al., 2022; Iskander, 2024; Purchase et al., 2022). In this respect, Çebi (2025) further explored how recycled materials can enhance students' creativity and artistic expression in art education, demonstrating the role of waste-based artistic practices in supporting imaginative thinking and sustainable awareness. However, much of this literature approaches recycled materials as a broad, undifferentiated category, with limited attention to how specific material properties shape learning processes and pedagogical outcomes. Ruano and García (2023) emphasized the importance of circular design education in promoting sustainable learning environments, highlighting the importance of ecological literacy within sustainable learning environments. Their work, however, remains focused on systemic frameworks rather than material-specific learning processes. Similarly, Moreno Castillo (2023) examined the use of

modular and alternative materials in jewelry design, emphasizing how engagement with unconventional materials can influence creative experimentation and design development. This perspective supports broader discussions on material-based learning in art education, where interaction with diverse recycled materials contributes to students' creative decision-making and experiential learning processes. However, while Moreno Castillo (2023) focused primarily on alternative materials in jewelry design, the present study extends this discussion by examining recycled metalwork specifically as a pedagogical condition that shapes technical adaptation, experiential learning, and sustainability-oriented thinking within higher education art practice.

From a pedagogical perspective, experiential and hands-on approaches have been widely recognized as effective in enhancing students' problem-solving and critical thinking abilities. Recent research by Alayar et al. (2025) highlighted the role of alternative metals in enhancing creativity and sustainability in art education, emphasizing how material experimentation can support students' environmental awareness and creative engagement through hands-on artistic practice. King et al. (2025) argued that material-based experimentation strengthens the connection between technical skill development and creative innovation. In addition, Tu et al. (2020) framed the circular economy as a valuable model for art education, suggesting that teaching students to reinterpret waste materials contributes to environmental sustainability as well as the development of socially responsible individuals. Similarly, Schoch (2024) emphasized the value of project-based learning approaches in teaching metal recycling within design education, highlighting how hands-on engagement with recycled metal materials can support experiential learning and sustainability-oriented thinking. Yet, these approaches largely emphasize learning processes without examining how material constraints actively shape those processes.

Despite these contributions, there remains a clear gap in research examining the specific role of recycled metalwork in art education. Most existing studies do not sufficiently address how metal, as a material with distinct structural and technical characteristics, may influence learning outcomes differently from other recycled materials. This gap is further evident in the limited number of context-specific studies

linking material-based practices to local sustainability agendas such as Kuwait Vision 2035.

This gap highlights the need for focused, context-sensitive research that examines recycled metalwork not only as an artistic medium but also as a pedagogical tool capable of supporting creative development and sustainability-oriented learning within higher education. Such a shift requires recognizing materials not as passive resources, but as active conditions that shape how learning unfolds in studio-based environments.

Theoretical Framework

This study is grounded in David Kolb's (2014) Experiential Learning Theory, which conceptualizes learning as a cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation (Gemmell & Kolb, 2020). Within art education, this framework provides a basis for understanding learning as an iterative process shaped through material engagement and reflective practice. The process of designing and constructing artworks using recycled metals reflects this cycle, as students actively experiment with materials, evaluate their outcomes through reflective observation and studio-based feedback, and refine their approaches through continuous reflection. In this context, engagement with metal extends beyond practice, functioning as an active element that shapes the cycle of experimentation and creative decision-making.

In addition to experiential learning, the study draws on the principles of the circular economy, which advocate for minimizing waste and maximizing the reuse of resources (Tu et al., 2020). Within art education, this perspective reframes discarded materials as sites of creative and conceptual transformation rather than passive resources. The application of circular economy principles within art education supports the development of sustainable design thinking and promotes responsible material use. More importantly, it positions material reuse as an active component of the learning process rather than an external objective.

By combining experiential learning theory with circular economy principles, this study establishes a dual theoretical framework that links practical artistic processes

with broader sustainability objectives. This integration provides a framework for interpreting how material constraints, particularly those associated with metal, shape both creative processes and technical learning.

Methodology

This study adopted a qualitative research design as the most appropriate approach for examining educational experiences associated with the use of recycled metal in art education. The study involved 25 undergraduate students and explored how engagement with recycled metal and repurposed materials influenced students' creative processes, technical skill development, and environmental awareness within a studio-based learning environment. A qualitative approach enabled an in-depth examination of students' lived experiences, artistic decision-making, and meaning-making processes throughout the project (Creswell, 2014).

Participants and Context

The participants consisted of 25 undergraduate female students enrolled in an Art Education program and registered in a metalwork course at a higher education institution in Kuwait. The sample was selected through purposive sampling, as all participants were directly involved in a structured studio-based project aligned with the aims of the study.

The researcher was also the course instructor, which provided direct access to the learning process and facilitated sustained observation of students' development. To address potential researcher bias associated with this dual role, the study incorporated peer review and collaborative evaluation. Two faculty members specializing in sculpture and three-dimensional design were invited to review selected student works and contribute to the interpretive process, thereby enhancing the credibility and trustworthiness of the findings.

The faculty reviewers independently examined selected student artworks and coded samples according to the thematic framework presented in Table (2), focusing on indicators related to material transformation, technical skill development, creative expression, environmental awareness, and problem-solving processes. The reviewers' evaluations were compared with the researcher's interpretations to examine the

consistency of the identified themes across the selected artworks. Consistency was observed particularly in relation to material transformation, creative expression, and environmental awareness, while minor differences emerged in the interpretation of technical refinement and problem-solving processes. These differences were subsequently discussed and resolved through collaborative review and repeated examination of the visual data until consensus was achieved.

Table (1) presents a comparison of the reviewers' evaluations and the areas of agreement and minor interpretive differences identified during the collaborative review process.

Table (1): Comparison of Reviewer Evaluations

Evaluative Dimension	Areas of Reviewer Agreement	Areas of Minor Difference	Resolution Process
Material Transformation	Strong agreement regarding students' ability to reinterpret recycled materials creatively	Minor variation in evaluating the extent of structural modification	Resolved through collaborative visual review
Creative Expression	Consistent identification of originality and inventive design approaches	Differences in interpreting compositional balance in selected works	Discussed collectively until interpretive consensus was reached
Environmental Awareness	Shared agreement regarding evidence of sustainability-oriented thinking	Limited variation in interpreting reflective statements	Reviewed through comparison of visual and reflective data
Technical Refinement	General agreement regarding structural coherence and material handling	Minor differences in evaluating finishing quality and technical precision	Resolved through repeated examination of visual documentation

Evaluative Dimension	Areas of Reviewer Agreement	Areas of Minor Difference	Resolution Process
Problem-Solving Processes	Agreement regarding evidence of experimentation and adaptation	Variation in interpreting the complexity of iterative development	Clarified through collaborative discussion

Learning Intervention and Materials

The study was conducted within the framework of a structured studio-based project in which students were required to design and produce artistic works using recycled materials, with a primary emphasis on metal. These works included jewelry pieces and sculptural forms developed over iterative stages of experimentation, refinement, and final production.

Students utilized a range of recycled materials, including metal components such as wires, nails, aluminium fragments, and industrial remnants. Additional materials—such as wood, plastic, and organic elements—were incorporated to support mixed-media exploration. The selection of materials was intentionally open-ended to encourage experimentation, material transformation, and the development of sustainable design thinking.

To ensure safe material handling within the studio environment, students received guidance on the appropriate use of recycled materials and metalworking tools prior to the practical activities. Safety procedures included inspecting materials for sharp edges or hazardous components, removing or covering sharp edges, excluding rusted or contaminated items, using protective gloves and safety glasses when necessary, and ensuring continuous supervision throughout the project. Materials selected for the activities were screened to avoid excessively hazardous waste, and students were instructed in safe handling techniques during cutting, assembling, and construction processes.

Data Collection

Data were collected through multiple qualitative sources to ensure depth and triangulation. The first source consisted of visual data derived from students' artworks

at different stages of development, including initial experiments, intermediate constructions, and final outcomes. These works were systematically documented and analyzed in relation to material use, structural composition, and evidence of creative transformation.

The second source involved student reflections, which served as a complementary source of data rather than the sole basis for interpretation. These reflections documented students' creative processes, technical challenges, and evolving perspectives on sustainability. In addition, informal studio discussions were conducted to further explore students' experiences and clarify their responses.

Throughout the project, students received ongoing instructional guidance during studio sessions, including demonstrations of material handling techniques, discussions of structural and compositional considerations, and feedback on design development and technical problem-solving. This guidance was intended to support students' experimentation while allowing flexibility for independent creative exploration.

In addition, observational notes were recorded by the researcher throughout the duration of the project, capturing students' engagement with materials, problem-solving strategies, and iterative development. The use of multiple data sources enabled methodological triangulation and strengthened the overall validity of the study.

Data Analysis

Data analysis followed an interpretive qualitative approach using thematic analysis (Braun & Clarke, 2006). Both visual and textual data were systematically examined to identify recurring patterns and conceptual themes related to creative development, technical skill acquisition, and environmental awareness.

A structured coding framework was developed to guide the analysis process. This framework defined key themes, coding categories, and criteria for data inclusion and exclusion, as presented in Table (2). The coding process involved repeated review of visual and textual data to ensure consistency in interpretation and alignment with the research objectives.

To enhance analytical rigor and reduce potential bias, selected samples of coded data and corresponding visual analyses were independently reviewed by two faculty

members specializing in sculpture and three-dimensional design. Any discrepancies in interpretation were discussed collaboratively until a shared understanding was reached.

The evaluation of student artworks was guided by qualitative criteria related to structural coherence, material transformation, creative originality, technical refinement, and evidence of sustainability-oriented thinking, as reflected in the thematic coding framework. The interpretation of findings was further informed by Kolb's experiential learning theory and principles of circular design. These theoretical perspectives provided a conceptual lens for understanding how students engaged in iterative experimentation, reflection, and material transformation throughout the creative process (Gemmell & Kolb, 2020; Ruano & García, 2023).

Table (2): Thematic Coding Framework and Operational Definitions

Theme	Code	Operational Definition	Indicators (Included Data)	Excluded Data
Material Transformation	MT	The extent to which students actively manipulated and reconfigured recycled metal materials beyond their original function	Evidence of reshaping, combining, restructuring, or reinterpreting materials into new forms	Direct or unaltered use of materials without significant transformation
Technical Skill Development	TS	Demonstration of technical competence in handling metal and constructing stable, coherent forms	Structural stability, joining techniques, finishing quality, and material control	Incomplete constructions or lack of technical refinement
Creative Expression	CE	Degree of originality and innovation in the conceptual and formal qualities of the artwork	Unique forms, personal interpretation, inventive design solutions	Repetitive, imitative, or conventional design approaches

Theme	Code	Operational Definition	Indicators (Included Data)	Excluded Data
Environmental Awareness	EA	Evidence of understanding sustainability concepts through material use and reflective articulation	References to reuse, waste reduction, sustainability awareness in reflections or design intent	General statements unrelated to environmental considerations
Problem-Solving Processes	PS	The ability to address and resolve design and material challenges through iterative experimentation	Adaptation, modification, trial-and-error, and improvement strategies	Unresolved issues without attempts to refine or improve

This coding framework was systematically applied to both visual and textual data to ensure consistency in analysis and alignment with the study's research objectives.

To strengthen the consistency and transparency of the qualitative evaluation process, a qualitative assessment rubric was developed to support the interpretation of student artworks. The rubric provided descriptive indicators for judging the extent to which the artworks demonstrated material transformation, structural coherence, technical refinement, creative originality, sustainability-oriented thinking, and problem-solving development. Table (3) presents the qualitative evaluation rubric used during the collaborative review process.

Table (3): Qualitative Evaluation Rubric for Student Artworks

Criterion	High Level Indicator	Medium Level Indicator	Low Level Indicator
Material Transformation	Recycled materials are substantially reshaped and reinterpreted into new artistic forms.	Materials are modified or combined, but their original form remains partially visible.	Materials are used with minimal transformation or direct reuse.

Criterion	High Level Indicator	Medium Level Indicator	Low Level Indicator
Structural Coherence	Artwork demonstrates strong balance, stability, proportion, and compositional organization.	Artwork demonstrates partial stability and organization with minor structural inconsistencies.	Artwork lacks stability, proportional balance, or coherent organization.
Technical Refinement	Joining, finishing, and construction techniques are executed with precision and control.	Technical execution is acceptable but includes visible weaknesses in finishing or assembly.	Technical execution appears incomplete, weak, or inconsistent.
Creative Originality	Artwork demonstrates highly original concepts and inventive design solutions.	Artwork demonstrates some originality but relies partly on familiar approaches.	Artwork appears repetitive, imitative, or conceptually limited.
Sustainability-Oriented Thinking	Artwork clearly reflects awareness of reuse, waste reduction, and sustainability concepts.	Artwork demonstrates partial awareness of sustainability through material selection.	Artwork shows limited or unclear connection to sustainability concepts.
Problem-Solving Development	Student demonstrates repeated experimentation, adaptation, and refinement throughout the process.	Student demonstrates some adjustment and experimentation during development.	Student demonstrates limited evidence of experimentation or revision.

The rubric functioned as an interpretive guide to support consistency during the collaborative review and thematic analysis process without converting the study into a quantitative assessment model.

Findings

The findings of this study are presented based on the analysis of students' artworks and their documented creative processes. The analysis focuses on how engagement with recycled metal shaped both the creative process and the final outcomes in an interconnected way. The analysis was guided by the thematic coding framework outlined in Table (2), allowing for the identification of recurring patterns related to material transformation, technical skill development, creative expression, environmental awareness, and problem-solving processes.

Process-Based Development

The analysis of students' work revealed that artistic development occurred through a sequence of progressive stages, beginning with initial experimentation and advancing toward more refined constructions. However, this progression was shaped by the physical and structural properties of metal, which influenced how students approached each stage of development. Across the dataset, early-stage experimentation was consistently associated with material transformation (MT) and initial problem-solving processes (PS), as students explored the structural and formal possibilities of recycled materials. Unlike softer or more flexible materials, metal imposed immediate structural limitations, requiring students to consider balance, weight, and connection from the outset. This indicates that early experimentation was already structured by constraints, where feasibility and structural logic played a central role alongside visual intent.

In the early stages, students engaged in basic material exploration, focusing on structural balance and form. As shown in Figure 1 (Upcycled Metal Sculpture Part 1), recycled industrial materials such as nuts and bolts were arranged to test stability and spatial composition.

This stage reflects a shift from idea-first approaches to material-led exploration, as students did not begin with fully formed concepts but instead developed ideas through direct interaction with resistant materials.

Figure 1: Upcycled Metal Sculpture Part 1. Work in progress during the creation of a metal sculpture. Student used recycled nuts and bolts to experiment with form and structure as part of the practical art project. (Source: Author)

As the work progressed, students began refining their initial constructions by adjusting proportions and reinforcing structural connections. This stage is illustrated in Figure 2 (Upcycled Metal Sculpture Part 2), where the composition became more stable and visually coherent. This stage also reflects the emergence of technical skill development (TS), as students demonstrated increased control over structural connections and material handling. At this stage, technical skill and creative decision-making developed together, as students adjusted their designs in response to structural challenges. This suggests that technical competence emerged through the need to resolve design problems rather than through isolated skill practice.

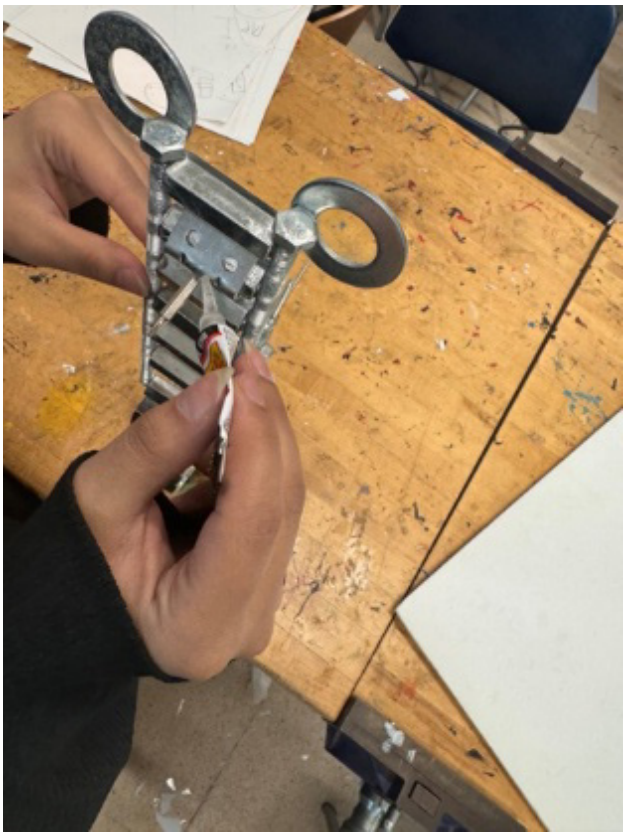

Figure 2: Upcycled Metal Sculpture Part 2. Continued progress in constructing a metal sculpture using recycled nuts and bolts. The image captures the refinement of the structure and the addition of detailed elements during the creative process. (Source: Author)

A similar progression can be observed in Figure 3 (Bottle Cap Flower Sculpture Part 1), where students experimented with arranging recycled bottle caps to explore initial compositional possibilities. Across Figures 1–3, a consistent pattern emerges in which early exploration is shaped by structural concerns, requiring students to consider connection and stability from the beginning.

Figure 3: Bottle Cap Flower Sculpture Part 1. The initial stage of a new project, where a student began assembling a floral design using recycled bottle caps, showcasing the early exploration of form and material. (Source: Author)

In Figure 4 (Bottle Cap Flower Sculpture Part 2), the design developed into a more structured form, with clearer organization and added elements that contributed to a more defined composition.

Figure 4: Bottle Cap Flower Sculpture Part 2. The second stage of the project, where the student refined the design by assembling a floral arrangement using recycled bottle caps and incorporating naturalistic details. (Source: Author)

This development reflects a broader shift across the dataset from exploratory assembly toward intentional design, highlighting the development of creative expression (CE) through more refined compositional decisions. This suggests that creative expression was shaped through working within material constraints, where limitation acted as a driver for design decisions rather than a restriction.

The conceptual stage of the creative process is evident in Figure 5 (Chain and Pearl Necklace Part 1), where students produced initial sketches outlining their design ideas. These sketches served as a visual guide for subsequent stages of production. However, the translation from sketch to material form was not direct, as the properties of metal required continuous modification of initial ideas. This indicates that design development was iterative, with ideas evolving through interaction with the material rather than

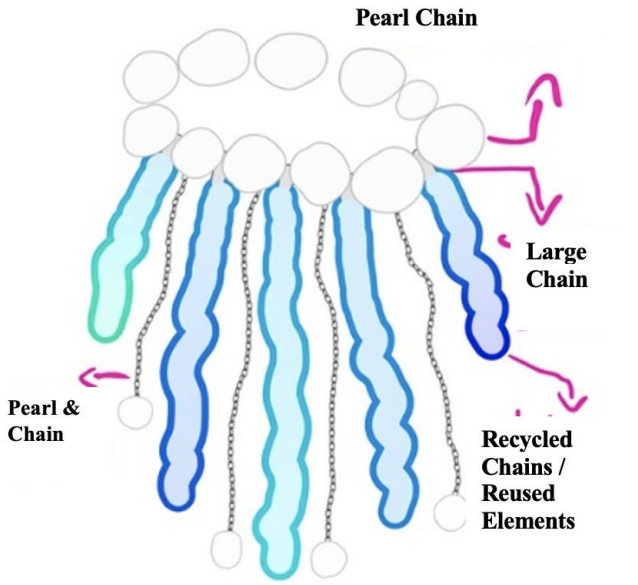

Figure 5: Chain and Pearl Necklace Part 1. Initial conceptual sketch created by a student for a new project, outlining the design idea using recycled materials such as recycled chains, aluminium pins, and pearls. (Source: Author)

In Figure 6 (Chain and Pearl Necklace Part 2), students translated their conceptual sketches into preliminary physical models, testing material combinations and structural feasibility.

Figure 6: Chain and Pearl Necklace Part 2. Preliminary model created by the student to experiment with materials and design elements, focusing on the integration of pearls and chains. (Source: Author)

This phase illustrates the integration of conceptual thinking with material experimentation, where students engaged in iterative problem-solving (PS) to test feasibility and refine their design ideas. Across this stage, repeated testing and adjustment highlight a pattern of iterative problem-solving, where design decisions were continuously revised in response to material feedback.

Final Artistic Outcomes

The final stage of the projects resulted in completed artworks that demonstrated the transformation of recycled materials into cohesive artistic forms. In Figure

7 (Upcycled Metal Sculpture Part 3), the final sculpture reflects the integration of structural elements into a unified composition, showing a stable and balanced form constructed from recycled industrial components.

Across the final outcomes, a clear pattern is evident in which material transformation (MT), technical skill (TS), and creative expression (CE) converge in the resolution of both structural and visual challenges. This suggests that successful completion depended on the integration of these dimensions rather than their separation.

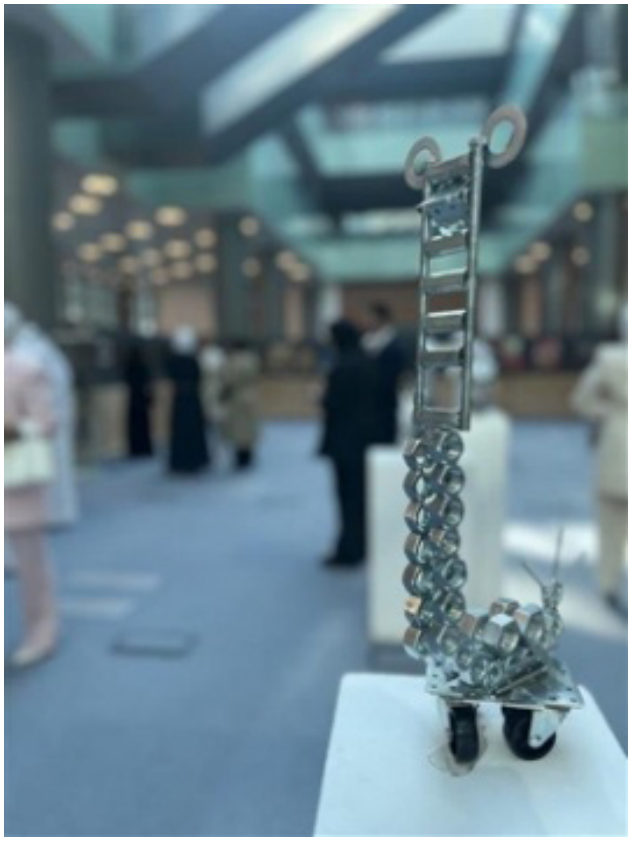

Figure 7: Upcycled Metal Sculpture Part 3. Final sculpture made from recycled nuts and bolts, demonstrating the integration of sustainable material use and coherent structural composition. (Source: Author)

The completed work demonstrates a high level of material transformation (MT), where industrial components were recontextualized into a unified sculptural form,

alongside strong evidence of technical skill (TS) in achieving structural stability. This indicates that transformation operated at both a physical and conceptual level, as materials were not only reshaped but also reinterpreted in meaning.

In Figure 8 (Bottle Cap Flower Sculpture Part 3), the final floral sculpture displays a symmetrical arrangement, where recycled bottle caps were organized into a visually coherent decorative structure.

Figure 8: Bottle Cap Flower Sculpture Part 3. The final floral sculpture created by the student, featuring additional flowers and a symmetrical design with blooms on both sides. The project exemplifies creativity and skillful use of recycled bottle caps. (Source: Author)

The completed jewelry design in Figure 9 (Chain and Pearl Necklace Part 3) illustrates the transition from conceptual sketch to finalized wearable piece, combining chains and pearls into a structured and cohesive form.

Figure 9: Chain and Pearl Necklace Part 3. Final jewelry design, transformed from the conceptual sketch into a fully realized necklace. The student successfully brought the design to life using chains and pearls. This example further supports the pattern observed across projects, where initial concepts were refined through iterative testing into resolved final designs. (Source: Author)

Additional works (Figures 10–15) reinforce these patterns across different materials and formats, confirming the consistency of the observed learning processes. In Figure 10, recycled wood and metal components were combined to create a structured composition emphasizing texture and form.

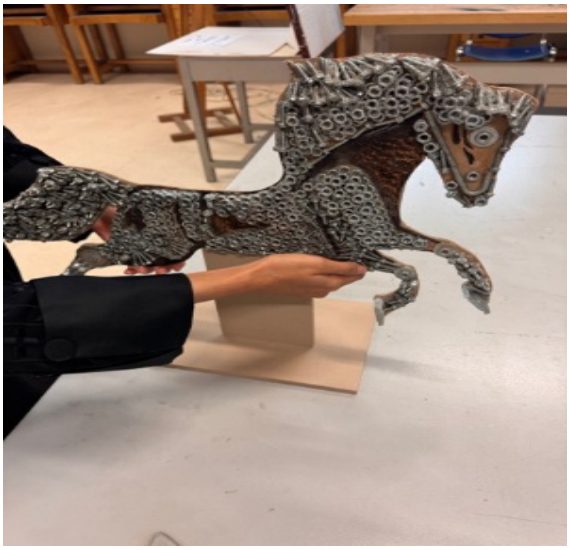

Figure 10: Diversity of Material. A creative design using recycled wood, nails, screws, nuts and bolts, showcasing the student's exploration of texture and structure through sustainable materials. (Source: Author)

In Figure 11, aluminium can tabs were used to produce a detailed design that reflects careful arrangement and repetition of material elements.

Figure 11: Aluminium Necklace. A creative design crafted using recycled aluminium can tabs, emphasizing sustainability and innovation in jewelry design.

(Source: Author)

In Figure 12, a functional lamp structure was created using recycled nuts, bolts and an existing base, resulting in a combination of structural and utilitarian design.

Figure 12: Nut Bolt Lamp. A lamp shade created by a student using recycled nuts, bolts, and an old lamp base, showcasing a fusion of industrial and functional design elements. (Source: Author)

In Figure 13, mixed materials including aluminium elements and wire were arranged into a decorative composition characterized by layered textures and contrasting surfaces.

Figure 13: Aluminium Cupcake Flower. A decorative artwork created by a student using recycled aluminium cupcake liners, metal wire, gold spray paint, and a wooden base, showcasing an elegant fusion of texture and design. (Source: Author)

In Figure 14, a sculptural lamp was constructed using recycled lighting components and a circular frame, forming a visually distinctive structure.

Figure 14: Bicycle Wheel LED Light. A decorative lamp sculpture created by a student using recycled fairy lights and a broken bicycle wheel, combining functionality with an artistic repurposing of materials. (Source: Author)

Finally, Figure 15 presents a mixed-media artwork composed of various recycled materials, including metal elements, arranged to form a layered visual composition.

Figure 15: Coin Portrait Wall Art. A mixed-media artwork created by a student using non-usable coins, chains, copper sheet, and an aluminium sheet to transform a damaged canvas into a sustainable and visually striking piece. (Source: Author)

Across these varied examples, students demonstrated the ability to work across different material combinations while maintaining a focus on sustainability, indicating the presence of environmental awareness (EA) in both conceptual and practical aspects of their work. Environmental awareness (EA) emerged through direct engagement with materials, where sustainability was experienced as a practical outcome of reuse and transformation rather than as an abstract concept.

Discussion

The findings of this study suggest that the integration of recycled metalwork into art education supports a form of learning that is simultaneously technical, conceptual, reflective, and materially mediated. Rather than functioning merely as a medium for artistic production, recycled metal actively shaped the learning process itself by introducing material conditions that required students to negotiate form, structure, balance, and meaning through continuous experimentation and revision. In this sense,

the educational value of recycled metalwork lies not only in the final artistic outcomes produced by students, but in the ways the material itself influenced how students thought, adapted, reflected, and responded throughout the creative process.

Pedagogically, these findings indicate that recycled metalwork supported learning beyond the production of finished artistic objects. The physical resistance and structural rigidity of metal required students to slow down, plan, test, revise and justify their decisions, transforming studio activity into a process of reflective and inquiry-based learning. Rather than simply applying pre-existing design ideas, students continuously negotiated between intention and material possibility. This process appears to have strengthened learner autonomy, as students were repeatedly required to make independent judgments concerning structure, proportion, connection, balance, and visual coherence. In relation to Kolb's (2014) experiential learning cycle, students moved through concrete material experience, reflective observation, conceptual adjustment, and active experimentation. However, the findings further suggest that each stage of this cycle was materially mediated by the properties of metal itself. Concrete experience emerged through direct bodily interaction with resistant materials; reflective observation occurred when instability, imbalance, or technical difficulty required reconsideration; abstract conceptualization appeared as students reformulated design strategies in response to material limitations; and active experimentation was demonstrated through repeated testing, modification, reconstruction, and refinement. This indicates that experiential learning within the project was not externally imposed through instructional sequencing alone, but internally generated through ongoing interaction with the material conditions of recycled metalwork.

The results also suggest that the use of recycled metal encouraged embodied learning, as students learned through direct physical engagement with resistant materials. Handling, bending, joining, balancing, assembling, and stabilizing metal components required students to understand artistic problems through bodily interaction rather than through verbal explanation alone. This form of learning appears particularly relevant within studio-based art education because it connects

technical skill, sensory awareness, spatial reasoning, and conceptual development. Students' progression from experimentation to refined outcomes suggests that learning occurred through repeated cycles of trial, error, feedback, adaptation, and adjustment. As a result, the project appears to have contributed to the development of technical persistence, practical confidence, and a more critical understanding of sustainability as both an artistic and educational practice.

Unlike softer or more easily manipulated recycled materials such as paper, cardboard, or fabric, recycled metal introduced persistent structural resistance that slowed down the learning process and required sustained negotiation between intention and feasibility. Students could not immediately impose preconceived ideas onto the material. Instead, they were repeatedly required to reassess weight, balance, proportion, structural stability, and methods of connection throughout the construction process. This suggests that the material itself actively reshaped cognitive engagement by encouraging anticipatory thinking, reflective judgment, iterative decision-making, and adaptive problem-solving. In this context, learning did not emerge solely from creative freedom, but from the necessity to respond to material resistance and uncertainty. Recycled metal therefore functioned not only as a sustainable resource, but also as a material condition that structured how students perceived challenges, evaluated possibilities, and constructed artistic solutions.

These findings are consistent with previous research emphasizing the role of material-based experimentation in supporting creative learning and sustainability awareness (Alayar et al., 2025; Schoch, 2024). However, the present study extends these discussions by demonstrating that recycled metal introduces forms of structural resistance and technical constraint that actively shape reflective learning and creative decision-making. While many previous studies approach recycled materials as a generalized category primarily associated with environmental awareness or creative experimentation, the present findings suggest that the specific physical properties of metal fundamentally influence the learning process itself. The contribution of this study therefore lies not only in promoting sustainability-oriented practice, but also in demonstrating how material properties can function as active pedagogical agents

within experiential learning environments.

One of the most significant findings concerns material transformation. Students did not simply reuse discarded metal components; rather, they reinterpreted them through processes of manipulation, recombination, restructuring, and formal reconfiguration. This suggests that transformation operated on two interconnected levels: the physical transformation of the material itself and the conceptual transformation of its meaning. Discarded objects were no longer treated as unusable waste, but as resources possessing latent structural, aesthetic, and conceptual potential. Although this process aligns with broader principles of circular design and sustainability, its educational significance extends further. The findings suggest that learning emerged through acts of recontextualization, where students were required to move beyond the original function of materials and engage in more deliberate forms of design reasoning, reinterpretation, and material inquiry (Ruano & García, 2023).

The findings also reinforce the relevance of Kolb's experiential learning framework in understanding students' engagement with recycled metalwork. The progression from early experimentation toward more resolved outcomes reflects a recurring process of action, reflection, modification, and reapplication rather than a straightforward movement from idea to product (Gemmell & Kolb, 2020). Importantly, this cycle appears to have been materially driven. Students did not reflect in abstraction; rather, reflection was triggered by the resistance of the material, structural instability, technical limitations, and the demands of construction. This suggests that learning in this context became experiential not merely through participation in practice, but through repeated interaction with material difficulty and structural uncertainty. Recycled metal therefore appears to function as a pedagogical condition that actively structures experiential learning rather than simply supporting it.

A further important finding relates to technical skill development. Working with metal required precision, control, planning, and sustained attention, particularly in relation to joining, shaping, balancing, and stabilizing forms. However, technical skill did not emerge as an isolated outcome separate from creativity. Instead, the findings suggest that technical competence developed through the simultaneous need

to resolve artistic, structural, and material problems. This is significant because it challenges the common tendency within art education to separate technical training from creative development. In the present study, the material properties of metal made such separation difficult, since students could not progress conceptually without also progressing technically. These findings support previous research emphasizing the relationship between material experimentation and skill development (King et al., 2025), while further suggesting that technical difficulty itself may function as a productive and generative force within creative learning processes.

Creative expression was also shaped in distinctive ways through the use of recycled metal. Because the material did not offer standardized forms or predictable possibilities, students were required to respond inventively to irregular, resistant, and previously used components. Their creative processes therefore developed not from neutral or uniform resources, but through negotiation with unpredictable material conditions. This appears to have expanded the scope of ideation by requiring students to adapt their designs to material realities rather than impose fixed solutions from the outset. The originality evident in the final artworks may therefore be understood not simply as a result of unrestricted freedom, but as a response to constraint and limitation. In this sense, creative expression appears to have been strengthened through material restriction rather than diminished by it. These findings support studies linking non-traditional materials with divergent thinking and creative risk-taking (Purchase et al., 2022), while also suggesting that constraint itself may function as a productive pedagogical mechanism within studio-based learning.

The development of environmental awareness represents another important dimension of the findings. Students' reflections suggest a shift in perception from viewing discarded materials as unusable remnants toward recognizing them as meaningful artistic and educational resources. This shift is significant because sustainability was not introduced merely as an external ethical concept attached to the project, but rather encountered directly through the material practices of selection, reuse, experimentation, and transformation. Environmental awareness in this context therefore emerged through embodied engagement rather than abstract

instruction alone. Students appeared to learn sustainability by working through the possibilities and limitations of discarded matter itself. Such findings are particularly relevant within art education because they suggest that ecological understanding may be cultivated through practice-based experiences that connect material decisions with broader values of responsibility, resourcefulness, and sustainable thinking (Ruano & García, 2023).

The role of problem-solving further deepens the pedagogical significance of the findings. Students were consistently required to respond to structural instability, material incompatibility, technical limitations, and compositional uncertainty. These challenges were not incidental obstacles within the learning process; rather, they formed a central condition through which learning unfolded. The repeated need to test, fail, modify, reconstruct, and try again fostered adaptive modes of thinking in which solutions emerged through negotiation and engagement rather than through pre-planning alone. This suggests that the educational value of recycled metalwork lies partly in its capacity to resist immediate resolution. The material required students to remain within ongoing processes of inquiry, revision and persistence, where progress depended on sustained experimentation and reflective adjustment. Such findings highlight the educational importance of difficulty and uncertainty within creative learning environments.

When viewed within the broader educational context, these findings also contribute to discussions concerning the relationship between studio practice and national sustainability agendas such as Kuwait Vision 2035. The project demonstrates that policy-level goals related to sustainability, innovation, and creative development may be meaningfully translated into educational practice when embedded within material-based learning experiences (AlManssoor, 2020). Rather than treating sustainability as a broad institutional objective or rhetorical framework, the study illustrates how sustainability can be enacted concretely through pedagogical design and material engagement. This is particularly relevant within localized higher education contexts, where the challenge lies not only in endorsing sustainability conceptually, but in constructing learning environments through which students encounter sustainability

as an active, situated, and practice-based experience.

Overall, the discussion suggests that recycled metalwork should not be understood merely as an alternative material choice within art education. Its significance lies in the ways it reshapes the conditions of learning itself by linking material resistance, technical engagement, reflective experimentation, embodied cognition, creative adaptation, and environmental awareness within a single pedagogical process. The findings therefore support the argument that recycled metalwork may function as a material-specific pedagogical approach through which students develop not only artistic competence, but also more reflective, adaptive, and sustainability-oriented modes of thinking.

Research Limitations

While this study provides valuable insights into sustainable art education through the use of recycled metalwork, several limitations should be acknowledged, as they may have influenced the scope, interpretation, and transferability of the findings.

The availability of recycled materials was limited, particularly in terms of diversity, consistency, and material quality. This constraint may have influenced the range of artistic experimentation and the variety of design approaches explored by students (Moreno Castillo, 2023). In addition, because the study focused specifically on recycled metalwork, the findings should not be assumed to apply equally to other categories of recycled materials that may involve different forms of manipulation, technical engagement, or creative interaction.

Participants also entered the project with varying levels of prior experience in metalworking techniques. These differences appear to have influenced the complexity, refinement, and technical resolution of the final artworks and, in some cases, may have limited students' ability to fully realize their intended designs.

Access to tools and equipment was restricted to those available within the institutional setting. This limitation affected the range of technical processes that could be applied, including shaping, joining, balancing, and finishing techniques. As a result, certain forms of material experimentation may not have been fully explored.

The study was further constrained by a limited timeframe of three months due

to its alignment with a scheduled art exhibition. While this structure supported focused production, it restricted opportunities for extended experimentation, iterative refinement, and deeper reflective engagement throughout the learning process (Gemmell & Kolb, 2020).

In addition, the study was limited to a relatively small sample of undergraduate female students within a single higher education context in Kuwait. Although this enabled an in-depth qualitative exploration of students' experiences, the findings are context-specific and cannot be generalized across broader educational settings, student populations, or institutional environments.

The dual role of the researcher as both instructor and investigator may also have influenced aspects of data interpretation and classroom interaction. Although measures such as peer review, collaborative evaluation, and thematic comparison were employed to strengthen analytical credibility and reduce interpretive bias, the subjective nature of qualitative interpretation remains a consideration.

Despite these limitations, the findings suggest that recycled metalwork may still offer meaningful pedagogical possibilities within resource-constrained educational environments, particularly in supporting reflective experimentation, material engagement, and sustainability-oriented learning.

Conclusion

This study demonstrated the educational value of integrating recycled metalwork into art education by showing how engagement with discarded materials supports the development of creative expression, technical skill, and environmental awareness. Rather than functioning solely as a medium for artistic production, recycled metal shaped the learning process itself by requiring students to actively negotiate material constraints through experimentation, adaptation, and refinement. As a result, learning emerged through interaction with the material rather than through predefined outcomes.

The findings further highlighted the role of experiential learning in structuring students' creative processes. The act of making, testing, and revising did not simply support skill development, but enabled students to construct knowledge through

iterative engagement with both material challenges and design decisions. In this context, recycled metal introduced conditions that linked technical difficulty with creative thinking, positioning problem-solving as an integral component of artistic development rather than a separate skill.

In addition, the study demonstrated that sustainability can be meaningfully embedded within art education through material-based practices. Students' engagement with discarded materials facilitated a shift in perception, where waste was reinterpreted as a resource for creative production. This indicates that environmental awareness was developed through practice rather than abstract instruction, reinforcing the role of art education as a site for cultivating sustainability-oriented thinking.

The study also reinforced the importance of aligning educational practices with national development frameworks such as Kuwait Vision 2035. By translating sustainability objectives into studio-based learning experiences, the integration of recycled metalwork provides a practical model for connecting policy-level goals with pedagogical implementation in higher education contexts.

Overall, this study contributes to the field by positioning recycled metalwork not simply as a material choice, but as a material-specific pedagogical approach that actively shapes how students think, create, and engage with sustainability. It establishes that material engagement, particularly with resistant and unconventional resources, can function as a central mechanism for integrating creativity, technical learning, and environmental awareness within contemporary art education.

Recommendations

Based on the findings of this study, several recommendations are proposed to support the integration of sustainable practices in art education.

First, art educators are encouraged to incorporate recycled metalwork projects into the curriculum as a means of promoting creativity, technical skill development, and sustainability awareness. Such projects can provide students with opportunities to engage in hands-on, design-based learning that connects artistic practice with real-world environmental issues.

Second, educational institutions should establish partnerships with recycling

centers, local industries, and environmental organizations to facilitate access to diverse materials and support sustainability initiatives within art education (Ruano & García, 2023).

Third, it is recommended that educators adopt comprehensive assessment strategies that evaluate both the creative process and the final artistic outcomes. This may include a combination of formative assessments, such as sketches and reflective journals, and summative evaluations, such as completed artworks and presentations.

Finally, professional development programs should be provided to support educators in implementing sustainable art practices. Training in material experimentation, environmental design principles, and contemporary pedagogical approaches can enhance the effectiveness of teaching and learning in this field (Elwakeel et al., 2023).

Future research is encouraged to further investigate material-specific pedagogical approaches, with particular attention to how the use of additional recycled materials beyond metal may shape different creative processes, technical learning experiences, and sustainability-oriented outcomes within art and design education.

References

- Ahn, N., Dodoo, A., Riggio, M., Muszynski, L., Schimleck, L., & Puettmann, M. (2022). Circular economy in mass timber construction: State-of-the-art, gaps and pressing research needs. Journal of Building Engineering, 53, 104562. https://www.sciencedirect.com/science/article/abs/pii/S2352710222005757
- Al-Saud, K., AlAli, R., Al Saud, A. M., Abouelela, A. S., Shehab, R. T., Moneim, D. A. A., & Hamid, A. E. M. (2024). Exploring the aesthetic and functional aspects of recycled furniture in promoting sustainable development: An applied approach for interior design students. Sustainability, 16(10), 4003. https://doi.org/10.3390/su16104003
- Alayar, M., Alrashidi, N., Alrashaidi, E., & Alazmi, K. (2025). The role of alternative metals in enhancing creativity and sustainability in art education: A qualitative study. Social Sciences & Humanities Open, 11, 101547. https://doi.org/10.1016/j.ssaho.2025.101547

- Alazmi, K., & Alayar, M. (2025). The visual inspiration of the elements of Dilmun civilization and its role in enriching the design of metal jewelry for art education students. Saudi Art and Design Journal, 5(2), 180–239. https://doi.org/10.57194004-002-005-2351/
- AlManssoor, A. (2020). Obstacles and opportunities in planning and implementing integrated sustainable municipal solid waste management (ISMSWM) in Kuwait – A Gulf Cooperation Council (GCC) country (Master's thesis, University of Waterloo). UWSpace. https://uwspace.uwaterloo.ca/items/c8f06f182-cdf-4f4f-b4e3-a27488d06da2
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.11911478088706/qp063oa
- Çebi, S. (2025). From waste to art: A study on student creativity and creative expression through recycled materials in art education. Art Vision, 31(54), 59–70. https://doi.org/10.32547/artvision.1542477
- Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approach (4th ed.). SAGE Publications. https://us2.sagepub.com/en-us/nam/research-design/book270550
- El-Kanj, H., Abdulqader, F., Albannai, A., Alarbash, A., & Aldaihani, M. (2024). An IoT-based smart waste management system with built-in segregation feature. Journal of Engineering Research. https://kuwaitjournals.org/jer/index.php/JER/article/view/20237
- Gemmell, R. M., & Kolb, D. A. (2020). Experiential learning and creativity in entrepreneurship. In E. G. Carayannis (Ed.), Encyclopedia of creativity, invention, innovation and entrepreneurship (pp. 937–944). Springer. https://doi.org/10.1007489_6-15347-319-3-978/
- Iskander, N. A. (2024). Musahamat al fann al tafauli fi ighna jamaliyyat al naht al muasir fi daw al tanmiyah al mustadamah. Saudi Art and Design Journal, 4(3), 19–65. https://pnu.edu.sa/ar/Departments/ScientificSocieties/SaudiArtDesignJournal/Documents/20241/.pdf
- King, P., Sim, J., Shahed, K. S., Harwood, C., & Manogharan, G. (2025). Hands-on

digital tools for metalcasting engineering education in foundry science. International Journal of Metalcasting, 19(5), 2531–2543. https://doi.org/10.1007/s40962-024-1-01488

- Moreno Castillo, E. (2023). The sustainable modular jewellery box for Pablo Joyería Relojería and Olby Design (Bachelor's thesis, University of Skövde). DiVA Portal. https://www.diva-portal.org/smash/get/diva2:1775753/FULLTEXT01.pdf
- Purchase, C. K., Al Zulayq, D. M., O'Brien, B. T., Kowalewski, M. J., Berenjian, A., Tarighaleslami, A. H., & Seifan, M. (2022). Circular economy of construction and demolition waste: A literature review on lessons, challenges, and benefits. Materials, 15(1), 76. https://doi.org/10.3390/ma15010076
- Ruano, D. S., García, C. I. M., & Christiam, I. (2023). Implementing circular design education and open resources for plastic circularity in a municipal laboratory. Blucher Design Proceedings, 11, 924.935- https://doi.org/10.5151/ead20235-GLA-05FULL_CircularDesignEducation_Ruano_Christiam
- Schoch, K. (2024). Circular economy from scratch: A novel project-based learning method for industrial design students in the context of metal recycling. International Journal of Technology and Design Education. https://doi.org/10.1016/j.mex.2024.103137
- Smith, R. (2021). Integrating environmental sustainability into art education: A new paradigm for societal change. Journal of Arts, Society, and Education Studies, 3(3), Article 65. https://www.journal-ases.online/365/3/
- Tu, J.-C., Chan, H.-C., & Chen, C.-H. (2020). Establishing a circular model and management benefits of enterprise from the circular economy standpoint: A case study of Chyhjiun Jewelry in Taiwan. Sustainability, 12(10), 4146. https://doi.org/10.3390/su12104146