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Creative Sustainability Expressions: Student Projects Crafted from Waste Materials in Basic Design Studios

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Abstract

Integrating the circular economy concepts into basic design/art courses, which are foundational to creativity-oriented disciplines, is crucial for introducing students to sustainability. This study employs a case study within the Basic Design Studio of the Interior Architecture and Industrial Design Departments to examine the process and outcomes of crafting student work leftovers. A mixed-method approach with a single-group pre-test post-test model was employed in an experimental design. Fifteen students collected waste from various exercises throughout the semester. The materials, mostly paper, and its derivatives, were stored for a workshop to be transformed into new creative works on two- or three-dimensional plane. Drawing on four main theoretical frameworks—sustainability, aesthetics, basic design, and visualization in design education—the study emphasizes the aesthetics of sustainability. By examining this hybrid area, this study contributes to students' creative expressions of sustainability, awareness about conscious material use and sustainable practices in their future careers.

Keywords: *Sustainability, aesthetics, basic design, visualization.*

Yaratıcı Sürdürülebilirlik Anlatımları: Temel Tasarım Stüdyolarında Atık Malzemelerden Üretilen Öğrenci Projeleri

Öz

Yaratıcılığa yönelik disiplinlerin temelini oluşturan temel tasarım/sanat derslerine döngüsel ekonomi kavramlarını entegre etmek, öğrencileri sürdürülebilirlikle tanıştırmak için çok önemlidir. Bu çalışma, öğrenci çalışmalarından arta kalan artıkların kullanıldığı bir atölyenin sürecini ve sonuçlarını incelemek için İç Mimarlık ve Endüstriyel Tasarım Bölümlerinin Temel Tasarım Stüdyosu'nda bir vaka çalışmasını ele almaktadır. Deneysel bir tasarımda, tek gruplu ön test son test modeliyle karma yöntemli bir yaklaşım kullanılmıştır. On beş öğrenci, yarıyıl boyunca çeşitli egzersizlerden atık toplamıştır. Çoğunlukla kağıt ve türevleri olan malzemeler, iki veya üç boyutlu düzlemde yeni yaratıcı çalışmalara dönüştürülmek üzere bir atölyede kullanılmak üzere saklanmıştır. Tasarım eğitiminde sürdürülebilirlik, estetik, temel tasarım ve görselleştirme olmak üzere dört ana teorik çerçeveden yararlanan çalışma, sürdürülebilirliğin estetiğini vurgulamaktadır. Bu hibrit alanı inceleyerek, bu çalışma öğrencilerin sürdürülebilirliğe ilişkin yaratıcı ifadelerine, bilinçli malzeme kullanımına ve gelecekteki kariyerlerinde sürdürülebilir uygulamalar konusunda farkındalıklarına katkıda bulunmaktadır.

Anahtar kelimeler: *Sürdürülebilirlik, estetik, temel tasarım, görselleştirme.*

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1. Introduction

Integrating sustainability principles into art and design education is becoming increasingly important. As global focus shifts toward a circular economy, with a focus on repurposing and regaining, it is crucial for future designers to master sustainable practices. This study examines the role that art and design can play within this framework, particularly through the application of the 9R principles (Table 1).

Basic Design Studio courses often generate considerable waste material from student projects. This study examines the potential for creatively reusing these materials by transforming them into new art forms such as collage, décollage, assemblage, and accumulation. By focusing on these techniques, the study aims to embed sustainability concepts within the educational framework and foster students' understanding of the circular economy. The study is based on four main theoretical contexts: sustainability, aesthetics, basic design, and visualization in design education. It addresses several key issues, including the role of art and design education in promoting sustainable practices that reduce waste and environmental impact. The study also explores the effectiveness of interactive and experiential learning methods in teaching sustainability principles within a creative context. Additionally, it examines changes in students' knowledge and attitudes toward sustainability before and after participating in the workshop. Finally, it looks at the practical application of the 9R principles in students' creative projects, as well as their willingness to incorporate these practices into their future professional work. By examining this hybrid area, the study aims to enhance the efficiency, originality, and benefit of the discussions, by emphasizing the aesthetics of sustainability. The research, conducted with first-year students from the Interior Architecture and Industrial Design Department at a university, uses a mixed-method approach with a single-group pre-test post-test design through a workshop, offered as an optional short session after a term-long studio. Participant-centered training methods, such as workshops, aim to enhance participants' knowledge levels and raise awareness. These types of trainings encourage learning and make the educational process more effective. The most significant contribution of this training environment is that it helps increase student motivation and fosters a deeper understanding (Sadri & Sadri, 2010). The workshop includes a preliminary test, a presentation on the circular economy, a hands-on application phase, and a final test to measure the workshop's impact. This study underscores the importance of incorporating experiential, hands-on learning activities into the art and design curriculum to promote a sustainable, environmentally conscious future.

1.1. Sustainability and Design

Design and sustainability are interconnected concepts gaining increasing attention in fields such as product design, fashion design, interior design, and architecture. Sustainable design aims to create products, services, and environments that minimize environmental impact, enhance social well-being, and ensure economic viability throughout their lifecycles (Ceschin & Gaziulusoy, 2016).

In product design, sustainable practices have evolved to include broader system innovations, emphasizing the entire lifecycle of a product to reduce environmental impact and promote sustainability. This includes integrating sustainable design into product development to address challenges and apply appropriate methods and tools (Gaziulusoy & Öztekin, 2019; Chatty et al., 2022). Sustainable design addresses environmental, social, and economic impacts, promoting practices that consider user behavior and local contexts through design strategies (Faludi, Hoffenson, Kwok, Saidani, Hallstedt, Telenko, … & Martinez, 2020; Lilley, 2009; Klerks, Slingerland, Kalinauskaite, Hansen, & Schouten, 2022). Effective design principles can promote sustainable strategies by engaging consumers through emotional connections with products, thereby contributing to environmental conservation. Emotional durability and culturally sustainable design help extend product lifecycles and reduce the need for new products (Agost & Vergara, 2020; Haines-Gadd, Chapman, Lloyd, Jon, & Aliakseyeu, 2018; Tu, Nagai & Shih, 2018; Wu et al., 2021; Yang, Peng & Hsu, 2019). Design education for sustainability is vital in aligning with the UN’s 2030 Agenda for Sustainable Development, which addresses goals such as ensuring access to quality education and ending environmental degradation. This agenda involves a plan of action for people, planet, and prosperity, aiming to strengthen universal peace and freedom. Master's programs and integrative design courses emphasize sustainability

principles, material selection, and innovative interventions that reduce environmental impacts and promote healthier environments (Conway, Leahy & McMahon, 2021; Micklethwaite, 2022; Celadyn, 2020). However, despite a growing desire for sustainable practices, sustainability often ranks low among industrial designers (Kuys & Renda, 2021), highlighting the need for greater emphasis in design education. By incorporating sustainability principles into education, product development, and infrastructure planning, design education can drive innovation and contribute to a more sustainable future.

1.2. Circular Design and 9Rs

A circular economy is an economic model aimed at maximizing ecosystem functionality and human well-being by integrating sustainability and resource efficiency principles throughout the life cycle of products and services (Murray, Skene, & Haynes, 2015; Onesmo, Mabhuye, & Ndaki, 2023; Afteni, Păunoiu & Afteni, 2022). This model involves processes such as planning, sourcing, manufacturing, and reprocessing to ensure that materials and resources remain in use, generate value, and are replenished at the end of their service lives. In contrast, the linear economy is a system where resources are extracted to produce goods that eventually become waste, moving in a one-way direction from raw material to disposal. This polluting system degrades natural resources and drives global challenges (EMAF, 2023). Although there is no universally agreed definition, the circular economy has gained noteworthy attention for its role in sustainable public policies, addressing the environmental impacts of mass production and a disposable society (Maitre-Ekern, 2019). It is seen as a sustainable approach to economic growth (CIRAIG, 2015; COM, 2014; COM, 2015; EMAF, 2015) and recognized as a new sustainability paradigm (Geissdoerfer, Savaget, Bocken & Hultink, 2017). The change toward a circular economy provides substantial benefits over an entirely linear model by reducing waste and fostering resource regeneration.

The circular economy system operates through two main cycles: the technical cycle, where products and materials are reused, repaired, reproduced, and recycled, and the biological cycle, where biodegradable materials are returned to the Earth to renew nature (EMAF, 2022). The "R" principles provide strategies for waste management and resource optimization, forming a hierarchy that prioritizes resource efficiency. Various R frameworks, such as 4R, 6R, and 9R, have been proposed in both academic and practical contexts to support the transition to a circular economy (Kirchherr, Reike, & Hekkert, 2017; Sihvonen & Ritola, 2015; Van Buren et al., 2016; Potting, Hekkert, Worrell, & Hanemaaijer, 2017). These frameworks emphasize maintaining material quality and reusability, aiming for the ideal of circularity (Table 1). In a circular economy, discarded materials ideally retain their quality for reuse, eliminating the need for new resources and preventing waste. Although achieving perfect circularity may be challenging, it remains the ideal goal (Potting et al., 2017).

Table 1. Circularity strategies in order of priority in the production chain (9R Framework) (Potting et al., 2017, p. 5)

Smarter use and production	R1	Refuse	Making the product redundant by eliminating its function or offering the same function with a different product (e.g., digital) or service
	R2	Rethink	Intensify the use of the product (e.g., through product-as-a-service, reuse and sharing models, or by launching multifunctional products)
	R3	Reduce	Increase efficiency in the manufacture or use of products by consuming fewer natural resources and materials
Extending the life of products and parts	R4	Reuse	Reuse a product that is still in good condition and fulfills its original function (non-waste) for its intended purpose
	R5	Repair	Repair and maintain the defective product so that it can be used with its original function
	R6	Refurbish	Restore an old product and bring it up to date (to a specified quality level)
Useful applications with materials	R7	Remanufacture	Use parts of an idle/sold-out product in a new product with the same function (as in new condition)
	R8	Repurpose	Use a leftover/inert product or its parts in a new product with different functions
	R9	Recycle	Recover materials from waste products to convert them into new products, materials, or substances through reprocessing for the original product or other purposes. This includes the reprocessing of organic material but excludes

	energy recovery and the reprocessing of materials for use as fuel or in backfilling operations.

Design practices play an essential role in the transition to a circular economy by focusing on production processes, consumption patterns, policy support, and education (Dam et al., 2020). Historically, design has contributed to short product lifespans, but its potential for driving sustainable solutions is now recognized (Ceschin & Gaziulusoy, 2016). Concepts such as "green design," "eco-design," and "sustainable design" aim to reduce environmental and societal damage (Moreno, Rios, Rowe, & Charnley, 2016). Core competencies include designing for multiple use cycles, recovery, cyclical impact assessment, circular business models, user participation, collaboration, and effective communication (Sumter, Koning, Bakker & Balkenende, 2021). Designing with circularity in mind and developing strategies for transitioning business models are essential components (Sumter, Bakker & Balkenende, 2018; Bocken et al., 2016). Integrating circular economy principles early in the design process is crucial for creating sustainable, long-term solutions, as early design decisions have a considerable impact on the lifecycle of products and services (Deniz, 2021).

1.3. The Place of Art and Design in the Circular Economy

The integration of art and design within the framework of the circular economy is crucial for driving sustainable practices, fostering innovation, and promoting resource efficiency across industries. Design plays a central role in transitioning from linear to circular systems, shifting the focus from a take-make-dispose model to one that emphasizes closing resource loops and creating sustainable, long-term solutions (Deniz, 2021). Key areas where design can drive circular economy goals include circular production processes, circular consumption, policy support for the circular economy, and circular economy education (Dam, Simone, Keskin, Baldassarre, Niero & Morelli, 2020). Design for product circularity focuses on facilitating the reinsertion of products, components, and materials into appropriate circular economy loops, such as maintenance, reuse, remanufacturing, or recycling, to prolong product lifecycles and minimize waste generation (Saidani & Kim, 2021).In the realm of art, the concept of the circular art economy coexists with the circular environmental economy, leading to changes in the aesthetics and poetics of artwork. Upcycling practices, such as transforming art waste into high-value objects, exemplify how circular economy principles can be integrated into creative processes (Panneels, 2023). The craft sector, with its roots in traditional manufacturing and contemporary design approaches, serves as a model for purposeful sustainability, engaging with financial, environmental, and social aspects of sustainability rooted in place (Knošková, 2020). By embedding sustainable economy principles early in the design process, designers contribute to closing resource loops, minimizing waste, and developing long-term, sustainable solutions (Saidani, Kim, Cluzel, Leroy, & Yannou, 2020). Additionally, by adapting products to generate revenue and promoting strategies that prolong product lifecycles, designers play a crucial role in advancing circular economy principles (Moreno et al., 2016). Art and design education for the circular economy is essential for equipping designers with knowledge of sustainability, social responsibility, and key circular economy concepts to drive positive change within this framework (Shivarov, 2020). Sustainability education that emphasizes life cycle thinking provides individuals with the skills necessary to design products and systems aligned with circular economy principles, fostering resource efficiency and sustainable practices (Kopnina, 2018). Competencies in circular design include circular impact assessment, design for recovery, multiple use cycles, circular business models, user engagement, collaboration, and communication. By fostering these competencies, educational programs can foster a deeper understanding of circular economy principles and promote sustainable design practices (Sumter et al., 2021). Integrating circular economy concepts into design education is essential for developing a new generation of designers who are well-versed in sustainability and social responsibility (Vicente, 2020). This study focuses on introducing competencies such as design for recovery and multiple use cycles through a workshop where participants transformed leftover materials from the Basic Design studio into creative works.

1.4. Creative Methods to Reuse Paper Waste

In the world of art and design, specific techniques have emerged that enable everyday materials to be transformed into works of art. Collage is defined as a work made from various pieces of paper or similar materials, glued in accordance with the structure of a painting or the combination of different structures from various periods (Turani, 1993, p. 73). The technique, whose roots trace back to Japanese calligraphy in the 10th century, gained widespread popularity with the works of Pablo Picasso and Georges Braque during the Cubism movement in the 1900s (Craig, 2008, p. 7). Décollage, originating from the French word meaning "to dismantle" or "remove," is a type of collage but differs in its method. Unlike collage, which integrates different materials into a cohesive whole, décollage focuses on scraping, tearing, and separation (Şahin, 2022, p.1). Assemblage, in its broadest definition, is the three-dimensional form of collage, and involves combining various elements to create a three-dimensional artwork (Zelef, 1997, p. 249). The term "art of combining" is also used to describe this process. Accumulation, characterized by aggregation, piling up, and gathering, is another technique used in the art world to incorporate waste materials. Artists use all types of waste—both natural and industrial objects, including biological waste—in their work through this technique (Toluyağ, 2021, p. 186). Through the organized piling of materials such as garbage and scrap, accumulation-based works often emphasize global issues related to consumption, production, and the consumption cycle. Assembly (Montage), though often difficult to distinguish sharply from other techniques, involves the meaning of the word: "to install or attach." In this technique, unrelated parts are assembled to develop a new reality, often losing their original functions in the process (Yılmaz, 2015, p. 190). The importance of these techniques, in terms of sustainability and art, lies in their ability to transform ready-made materials into art objects, providing a unique way to incorporate waste into the fields of art and design.

2. Material and Method

2.1. Sustainability within the Scope of the Basic Design Course

The study was conducted during the first-year compulsory Basic Design course at a university in the Interior Architecture and Industrial Design Departments, involving 90 students. The course, held for eight hours weekly during the fall and spring semesters, includes both theoretical and practical sessions. It covers two-dimensional applications using visualization techniques such as marker, watercolor, and gouache, as well as three-dimensional techniques such as paper folding, kirigami, and pop-up. Despite the use of digital techniques, traditional methods remain crucial for skill acquisition. The course generates three main types of waste: paper waste from sketchbooks and assignments left in the studio, expired technical materials (e.g., pencils, brushes), and reusable or repairable technical materials (e.g., rulers, plastic-based items). Focusing on the 9R principles, this study is specifically limited to paper waste, the most commonly encountered type in the course (Figure 1). The main objective of this study is to emphasize the hierarchy of the 9R principles and demonstrate this hierarchy. Rather than focusing on specific types of waste (plastic or others), we aimed to provide participants with an environment where they could experience different "R" concepts. Waste, in this context, is not the main goal but a tool to teach these concepts.

Figure 1. The workshop process with the participants (Yılmaz Barış, 2024)

The study employed a mixed-method approach using both quantitative and qualitative methods. Balcı (2022, p. 44) described this model as employing qualitative research at one stage and quantitative paradigms at another. The study applied a single-group pre-test post-test experimental design, measuring the same group before and after the intervention. Although Fraenkel, Wallen & Hyun (2012, p. 269) reported that this design is considered weak, it is preferable to a one-off case study as it allows for the observation of changes over time. The quantitative analysis was based on surveys, with the reliability of the results potentially affected by self-assessment, as novice designers may overestimate or underestimate their understanding.

Considering the data collection tools frequently used in similar studies in the literature, as stated in the study involving a systematic review on the impact of education practices for Sustainable Development on students, the mixed-methods research approach is the most commonly used research model, the pre-test post-test quasi-experimental design is the most preferred research design, and the most widely used data collection tool is the scale (Tecimer Altınel, Hamalosmanoğlu, & Kızılay, 2024). The selected research method in our study aims to evaluate participants' levels of knowledge and awareness. The pre-test post-test design was employed to identify differences between the initial and final states of the participants, as measured by the applied instruments. The participants were an interdisciplinary group of 15 first-year students (six industrial designs and nine interior designs).

To strengthen the findings, the survey results were cross-referenced with observations and evaluations from the workshop coordinators, who were also basic design studio tutors and experts in the field, as well as the study's authors. This workshop was an optional short session following a term-long studio that integrated sustainability principles into its exercises. The workshop consisted of four main sections: a preliminary test, a presentation, an application phase, and a final test. The preliminary test measured students' knowledge and awareness of the circular economy and its principles. Following the test, a presentation was given to improve students' understanding of waste material use in art and design and the 9R principles of the circular economy (Table 2). In the application phase, students used waste materials from their basic design course, applying the theoretical information from the presentation. The study participants were asked to create a composition in a 30x30 (2D) or 30x30x30 (3D) area using the techniques conveyed in the presentation. They were not restricted from making 2- or 3-dimensional works, as long as they used the given techniques and materials. The concept was left open-ended, allowing for creative freedom. The workshop was conducted over one day, with the waste materials collected by students from the basic design studio being the only materials used. A final test assessed the relationship between the students' practical work and the 9R principles, evaluating the awareness they developed about using these principles in future design projects.

Table 2. Workshop second part presentation topics

1	**Concept of Sustainability**	General definition of sustainability, What is sustainable development?
2	**Concept of Circular Economy**	Definition of circular economy, Difference between linear and circular economy, Design for a circular economy, Principles of Circular Economy-9R (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle), The role of art and design in circular economy
3	**Relating Basic Design Course with Concepts of Sustainability and Circular Economy**	Basic design course waste materials, techniques for artistic production using these materials (Collage, Décollage, Assemblage, Accumulation, Assembly)

3. Findings and Discussion

The previous sections follow a general-to-specific thread, including: a) the role of art and design in the circular economy and sustainability; b) the incorporation of circular economy and sustainability principles in art and design; c) the integration of these principles in design education; d) the aesthetics and emerging topics of a “sustainable approach” through techniques used to transform paper materials (collage, décollage, assemblage, accumulation, assembly/montage); and e) the creative use of paper, the most abundant waste material in the basic design studio, within the framework of these topics. These threads aim to clearly articulate the thesis and ensure consistency in the arguments. The following discussions, focusing on threads d and e, with a particular emphasis on the creative expression of sustainability, will streamline the hypothesis and improve the discussion flow.

The study started with a pre-test to evaluate the knowledge and awareness levels of first-year students in the interior architecture and industrial design departments about the principles of the circular economy. According to the pre-test results, while 93.3% of students had encountered the concept of sustainability, their self-assessed knowledge levels varied: 14.3% reported having "no knowledge," 35.7% had "limited knowledge," 28.6% had a "moderate level of knowledge," and 21.4% had "considerable knowledge." None of the students reported they had "extensive knowledge" of sustainability. Regarding the circular economy, 73.3% of students had encountered the concept, but when asked about their knowledge, 78.6% reported "none," 14.3% had "limited knowledge," and only 7.1% had a "moderate level of knowledge." No students reported having "considerable" or "extensive" knowledge of the circular economy. When different testing phases measured students' knowledge of the 9R principles (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, and recycle), the data (Figure 2) showed an increase in students' understanding following the presentation and workshop. The most notable improvement was observed in the "refuse" principle, where all students who initially reported having "no or limited knowledge" showed "considerable" or "extensive" knowledge in the final test. This suggests that the presentation and workshop successfully raised awareness of the importance of the refuse principle in the circular economy. The data also highlights the effectiveness of hands-on learning experiences in enhancing students' understanding and retention of key concepts. The increase in students selecting "considerable" and "extensive" knowledge in the final test shows a substantial improvement in their understanding, highlighting the positive impact of interactive and engaging learning methods on student learning outcomes.

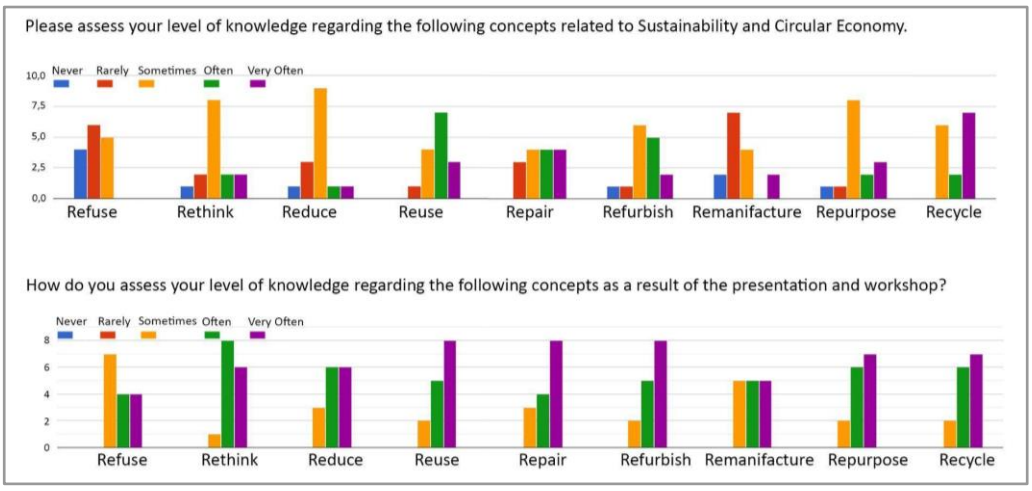

Figure 2. 9R knowledge level: pre-test, post-test comparison (none, limited knowledge, moderate level of knowledge, considerable knowledge, extensive knowledge) (Yılmaz Barış, 2024)

When comparing the different testing steps in measuring the techniques used to transform Basic Design Studio waste into art or design objects, and explaining them in the presentation, the preliminary test results showed that most students were unfamiliar with techniques beyond collage. However, in the final test, students showed a more even knowledge of the techniques explained in the workshop, showing increased awareness (Figure 3). This increased awareness was further reflected in the open-ended question at the end of the final test, where all 15 students answered "yes" to the question, "Did the presentation and workshop give you any new ideas on how to use sustainability in your future art or design work?" In response to the question, "What do you think about future work on this subject?" all students expressed excitement and interest in incorporating sustainability into their future art or design projects. Some mentioned specific techniques they learned in the workshop that they planned to use, while others emphasized the importance of considering sustainability in their creative process. The responses indicated a newfound understanding and appreciation for the role of sustainability in art and design.

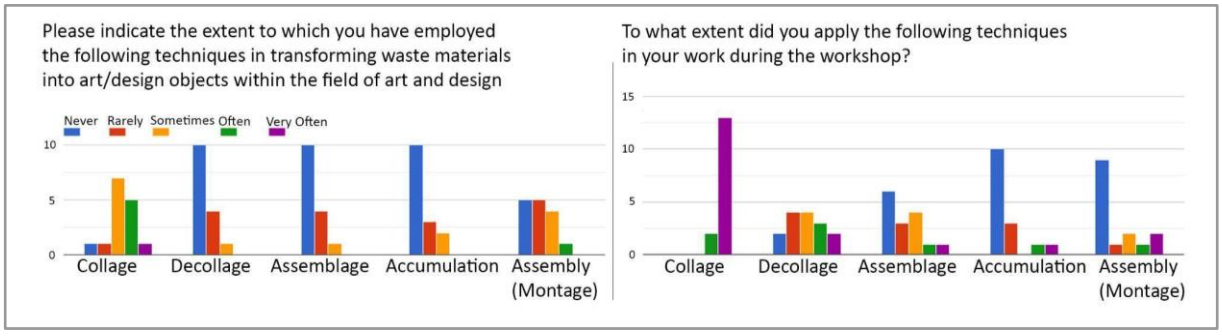

Figure 3. Paper waste usage techniques and awareness level: pre-test, post-test comparison (Yılmaz Barış, 2024)

When studying end-of-use works, it is evident that the two-dimensional collage technique is most frequently used, as paper waste constitutes the majority of the waste material. In addition to collage, intensive overlapping, cutting, tearing, or distortion of the material's physical structure were also identified as possible applications within the décollage technique (Figure 4). These innovative approaches not only challenge traditional methods but also highlight the importance of repurposing materials in a world where waste management is an increasing concern.

By exploring new techniques such as collage and décollage, the students considered the aesthetic expression of sustainability. Using recycled materials in their designs not only reduced waste but also served as a reminder of the importance of addressing environmental issues mindfully. It can be inferred that students have gained insight into the growing importance of sustainability, recognizing that as society continues to prioritize environmental concerns, the integration of repurposed materials in art and design will likely become more prevalent and influential in shaping the creative landscape.

Figure 4. Applications of collage and decollage techniques (Yılmaz Barış, 2024)

In addition to two-dimensional collages, works that create a third-dimensional perception by using various model wastes are compatible with assemblage and assembly techniques. It is evident that students' application of the accumulation technique remains largely conceptual, focusing on stacking and combining materials (Figure 5). While it is possible to create 3D volumes with paper, the predominance of 2D or 2.5D works, such as poster or relief-style works, can be explained by the time limitation of the workshop and the limitations of paper as a material. It was observed that participants required more time to develop a detailed combination plan to fully achieve a three-dimensional result with paper.

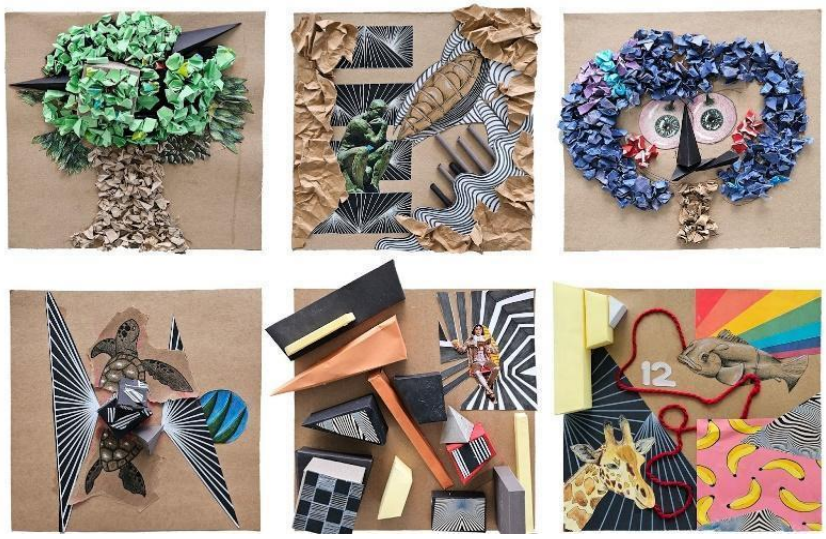

Figure 5. Applications of assemblage and assembly (montage) (Yılmaz Barış, 2024)

Although there was no concept limitation for the studies, when students were asked to describe their studies, they expressed it through concepts such as sustainability, recycling, climate change, environmental pollution, chaos, cycles, capitalism, and war (Figure 6). Some students mentioned that they randomly worked with objects they found, without choosing a specific concept. This approach exemplifies the conceptual use of the accumulation technique mentioned earlier.

Figure 6. Examples of studies that focus on conceptual aspects (climate change and environmental pollution, capitalism, war) (Yılmaz Barış, 2024)

When students were asked to associate their work with the 9R principles during the workshop, the principles they most commonly identified were reuse, repurpose, and recycle, while the least related principles were repair, reject, and renew (Figure 7). These results show that students were more drawn to the idea of transforming waste materials into something new rather than repairing or rejecting them altogether. This suggests a greater emphasis on the importance of giving new life to existing resources.

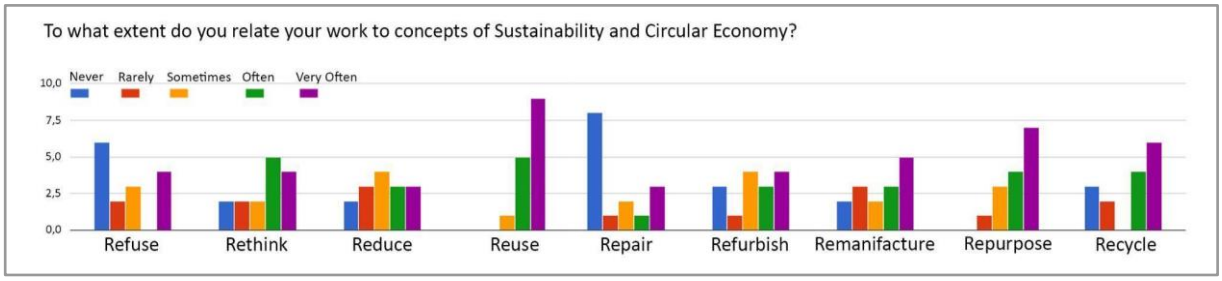

Figure 7. Student comments on the relationship between workshop practice and the 9R principles (Yılmaz Barış, 2024)

4. Conclusion and Suggestions

The interactive and engaging learning methods considerably improved students' understanding and retention of sustainability principles, as evidenced by the shift from limited to comprehensive knowledge. Students not only developed a deeper appreciation for the 9R principles but also expressed a strong willingness to apply these concepts in their professional lives. While earlier studies highlighted that students were often skeptical about the feasibility of transitioning to a circular economy and initially struggled to integrate such approaches into real-world scenarios, they also emphasized that confronting these challenges within educational settings provided critical learning experiences (Kopnina, 2018). In our study, students were exposed to the 9R concept at the beginning of their educational life, effectively reused waste materials, and demonstrated how art can actively contribute to environmental sustainability. This hands-on approach, from an artistic perspective, conceptually similar to the way artists use discarded objects through the accumulation technique (Toluyağ, 2021), not only highlights the potential of art to address environmental challenges but also deepens students' understanding of sustainable practices. From a design perspective, sustainable products should be designed with recyclability and reusability in mind or made suitable for second use (Günal Ertaş, 2023). Aligning with the idea that sustainable design is integral to creating a circular economy through the workshop, the students embraced the principles and were eager to apply their newly acquired skills and insights to future projects.

They utilized artistic methods that challenged them to engage with the 9R principles, addressing the challenging issue of waste management while illustrating the potential for creative solutions to drive positive environmental change. Their projects explored a wide range of themes, from tough environmental issues like recycling and climate change to more abstract concepts such as chaos and capitalism. This thematic diversity reflects their interest in using their creations to convey meaningful messages about sustainability. This approach to art-making underscores the importance of exploring different perspectives and ideas to produce thought-provoking and impactful pieces that embody the aesthetics of sustainability. The works produced by the students during the workshop process have demonstrated that they have understood the 9R concepts or gained awareness on this matter. The

students not only transformed materials but also produced conceptual works related to sustainability and social issues. These findings have been supported by the survey results and the observations of the workshop coordinators.

Reflecting on these projects invites a conversation about how artistic education can incorporate sustainable materials, processes, and themes to promote environmental consciousness and responsibility. By focusing on the principles of reuse, repurpose, and recycle, students align their work with practices that support a circular economy and long-term waste reduction. Ensuring the life cycle of waste materials not only provides significant advantages but also offers designers the opportunity to create unique products with a wide range of potential applications (Yalçınkaya & Karadeniz, 2022). Designers who, during their student years, experiment with prioritizing flexibility, adaptability and upgradability in their designs by utilizing waste materials can leverage this experience to maximize the personalization potential of products, thereby strengthening users' emotional connection with them (Agost & Vergara, 2020; Haines –Gadd et al., 2018). This empowers them not only to create sustainable designs and artworks but also to advocate for environmentally conscious design and artmaking. A key observation from the study is that reused materials appeared as new in the final artworks, showing that their quality was not diminished. Instead, these materials challenged students to think more creatively about their use, which became a valuable aspect of the study's outcome. To build on these findings, future studies should consider incorporating more interactive activities, such as waste audits and upcycling projects, into the curriculum. These activities can encourage students to think more creatively about waste. Moving forward, incorporating additional hands-on activities and real-world examples can further reinforce these concepts, fostering positive behavioral changes and environmental consciousness through experiential learning.

While implementing the basic design studio curricula and lesson plans in both departments, it was noted that the waste materials left from studio activities could be utilized in a workshop event. The aim of this workshop was to introduce first-year students to the action hierarchies that support the circular economy. Within the framework of the "refuse" concept, which holds the highest priority in the circular economy hierarchy, it was also considered that the teaching materials used in the basic design studio could be re-evaluated along with the workshop content. For example, future projects are planned to explore topics such as producing paper-based work in digital environments, further aligning the curriculum with sustainable practices. There are also studies that present similar perspectives regarding this approach. Dilmaç and Karabacak (2023) used free mobile digital drawing applications called *SketchBook* and *3D Modeling* instead of traditional methods in Visual Arts classes at the secondary education level and investigated their impact on students' environmental attitudes. The study included student opinions indicating that using digital programs prevented the generation of unnecessary waste. Another field where traditional and digital methods are compared, particularly in terms of future use of digital environments, is graphic design—a field that generates significant amounts of paper waste during design and production processes. A study in this field addressed the question, "Paper or digital in design and production?" The study suggested that digital platforms might replace paper due to the faster and more convenient design and reproduction of graphic products in digital environments. However, it also highlighted the increase in the production of electronic devices such as computers, televisions, mobile phones, video players, and electronic billboards. This shift poses a risk of escalating electronic waste. Furthermore, it emphasized that paper waste decomposes more easily in nature compared to electronic waste (Kınık, 2022). Although some waste was generated during our workshop process, it was observed that efforts to repurpose materials, particularly paper, fostered an introduction to and awareness of circular economy principles among first-year students, as confirmed by survey results. This observation aligns with the outcomes of a workshop that examined students' awareness and development regarding reuse. The study by Bekar, Lüleci, and Çakır (2023) reported notable findings, including increased student awareness of reuse and its relationship to sustainability. It also highlighted the recognition of waste as a resource and the creative potential of material limitations in addressing functional, technical, and aesthetic challenges. Similarly, despite some waste generation during our workshop, efforts to recycle materials, particularly paper, proved effective in introducing first-year students to circular economy principles, as evidenced by survey

results. This congruence between the study and our workshop underscores the shared emphasis on sustainability and the educational value of reuse.

In design fields, adaptable and reusable materials are increasingly valued for their sustainability and efficient use of resources, offering flexibility throughout their lifecycle and supporting diverse user needs (Akçaova, 2024). Building on these concepts, this process provided students with the opportunity to experience sustainable design approaches both theoretically and practically. While the findings provide valuable insights within the given context, one limitation of this study is the relatively small sample size of 15 participants. Future studies with larger participant groups would enhance the generalizability of the results. In conclusion, the value of this topic lies in raising awareness about sustainability issues within the field of design, particularly from the early stages of education, which is of great importance. The study aimed to encourage educators in design fields to reflect on collective teaching practices and inspire them to explore ways to incorporate sustainability concepts into their exercises. By doing so, the goal was to lay a foundation that contributes to the broader culture of innovation in design education.

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All authors contributed equally to the article. There is no conflict of interest.

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