International Journal of Engineering Research & Technology (IJERT)

Teaching Sustainable Spatial Strategies Through Active Learning

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Abstract— **The furniture industry generates 10-15% of global waste annually, with India experiencing 7-10% yearly growth in metropolitan furniture waste. Despite reusing existing furniture being cost-effective for clients and socially responsible for designers, this approach remains underutilized. Designers typically favour creating new furniture over exploring reuse options, largely due to insufficient sustainable design training. This paper presents findings from "From Discard to Design: Sustainable Spatial Strategies for the Interior of a Community Library," a workshop conducted with 23 third-year architecture students. Participants learned to transform waste into functional furniture using recycling, upcycling, downcycling, and repurposing strategies. They learnt to differentiate between sustainable approaches, utilize digital scaffolds, and evaluate designs using verified criteria. They engaged in collaborative activities enhanced by digital design tools, and logged their navigation using a structured progress tracker provided. The active learning approach sustained engagement while developing consciousness about the possibility of transforming "kabaad" (waste) into creative design opportunities.**

Keywords— ***Sustainable Design Education, Furniture Upcycling, Interior Architecture, Repurposing, Recycling***

I. INTRODUCTION

Historically, spatial design practices across diverse civilizations were built upon intrinsic sustainability principles. Traditional societies followed design approaches characterized by minimal waste, local material utilization, and adaptive reuse of spatial elements. Indigenous architectural practices in regions like India, Africa, and pre-industrial Europe showcased material conservation strategies, where furniture and spatial components were meticulously maintained, repaired, and transformed across generations. However, the Industrial Revolution and subsequent mass production disrupted these sustainable traditions, establishing a model prioritizing disposability over longevity.

The furniture industry generates around 10-15% of total global waste, translating to approximately 300-450 million tonnes of furniture waste annually [10]. In India, the situation is particularly concerning, with the Centre for Science and Environment documenting furniture waste growing at 7-10% annually in metropolitan cities. The Indian Green Building Council estimates 10-15 million tonnes of annual waste from the construction and demolition sector, including furniture [9]. ASSOCHAM reports that urban households discard 20-25% of their furniture within 5-7 years, contributing to a 40% increase in furniture waste over the past decade, with only 5-8% being effectively recycled or repurposed [3].

Despite the clear economic advantages for clients and social responsibility benefits for designers, furniture reuse strategies remain severely underutilized in architectural practice. While architectural curricula increasingly incorporate sustainability modules, they frequently treat waste management as a peripheral concern rather than a central design opportunity. Existing pedagogical models have demonstrated limited success in changing deeply ingrained design behaviours that favour creating new over reimagining existing materials. This educational deficiency translates directly to professional practice, where designers consistently favour creating new furniture over exploring reuse options—not from lack of concern but from insufficient practical training in sustainable approaches. The "From Discard to Design" workshop was developed to directly confront this problem by providing hands-on experience with transformation strategies that convert waste materials into functional design elements for community spaces. This paper documents this structured active learning workshop, supported by digital tools, that aims to introduce students to waste materials as design resources beyond conventional boundaries. It seeks to describe the workshop structure and pedagogical approach used to engage students with waste material transformation.

II. LITERATURE REVIEW

As with any other product, every piece of furniture has a certain lifespan. As soon as it is no longer needed or its aesthetics are no longer appealing, the piece of furniture is disposed of. Such pieces of furniture often end up as waste and are eventually

disposed of in landfills. Landfills have a negative impact on the environment. In 2017, approximately 80% of the 12.2 million tonnes of furniture thrown away by people in the US ended up in landfills, with only 0.3% of the waste being recyclable [6]. One of the ways to address the problem of increasing waste is to develop repurposable products. Using the concept of repurposability in product design can extend the life of a product and reduce waste by transforming or repurposing the product for another function after its effective life has expired. Combining and repurposing product functions not only extends the life of the product but also saves costs and materials [11]. Al-Saud et al.[1] explores the economic benefits of investing in waste recycling and environmental sustainability, highlighting the potential for positive returns while engaging students in creative design practices and leveraging environmental raw materials. It seeks to promote the adoption of best environmental practices in the field and generate actionable insights to inform future strategies. Recent research by Gamal et al. [7] highlights the growing market emphasis on eco-friendly design solutions, positioning repurposing as both an environmental imperative and strategic design approach.

However, the gap exists that these studies do not focus or emphasize on making the training of such specialized skills an important component of the curricula of architecture and design schools, specifically in the Indian context. Basar & Cartier [4] conducted a study to demonstrate educational strategies applications of repurposing design with the scope of sustainability. During this practice, the students learned the principles of sustainable design and the relationship of the term sustainability with different disciplines in the 15-week lecture time. In the final application work, the students created a second chance to dispose of products that were considered as waste materials and designed new products from them. The study was well structured, but it only focused on one aspect. The benefits of teaching the concepts of recycling, upcycling, downcycling and repurposing to students as sustainable spatial strategies is a very useful approach, as then they can have a holistic perspective of the diverse applicative concepts and develop the capability to select the most appropriate strategy which is tailored to a certain context. This is triangulated by Gürel [8] as she mentions that it is necessary to highlight the "environmental contextualization" of constitutive interior components.

III. METHODOLOGY

A. Workshop Design and Setting

The "From Discard to Design: Sustainable Spatial Strategies for the Interior of a Community Library" workshop was designed as a hands-on learning experience for third-year B.Arch students and was conducted over a period of 6 hours. The physical space was arranged to facilitate lecture time, collaborative group work, and individual design activities. Twenty-three students participated in the workshop. These students had completed foundational courses in design principles and interior architecture but had limited prior exposure to sustainable design methodologies. The workshop was integrated as a component of their formal curriculum subject—Architectural Design V—rather than as an optional activity.

B. Structure of the Workshop

The workshop was conducted halfway through the semester, at which point students had already designed a community library with certain requirements that contained implicit suggestions for sustainable strategies without explicit mention. For example, the rural setting of the project could naturally encourage the use of local materials. By the time of the workshop, students had preliminary design drawings of their library projects ready.

TABLE I. WORKSHOP PHASES AND LEARNING OBJECTIVES

Workshop Phase	Key Activities	Learning Objectives
Pre-Workshop	• Questionnaire completion • Library design review • Group formation	• Establish baseline knowledge • Create awareness of sustainability gaps Prepare for collaborative learning
Lecture and Discussion	• Sustainability discussion • SDG connections • Introduction to the strategies • Mini-exercises on each strategy	• Differentiate between recycling, upcycling, downcycling, and repurposing • Connect theoretical concepts to global sustainability frameworks • Recognize furniture waste as a design opportunity
DESIGN CHALLENGE **Phase 1: Exploration**	• Campus furniture survey • Photographic documentation • Measurement recording • Component identification	• Develop observation skills for identifying reuse potential • Recognize value in discarded items • Practice systematic documentation • Identify structural and material properties
DESIGN CHALLENGE **Phase 2: User Analysis**	• User selection • Flow chart completion • User-activity-requirement-function mapping	• Connect user needs to design requirements • Translate user activities into functional criteria • Prioritize user experience in sustainable design • Develop systematic user analysis skills
DESIGN CHALLENGE **Phase 3: Furniture Analysis**	• Furniture analyzer tool application • Material evaluation • Structural assessment • Transformation potential identification	• Apply systematic analysis to physical objects • Assess materials for reuse suitability Identify structural constraints and opportunities • Match furniture characteristics to appropriate strategies
DESIGN CHALLENGE **Phase 4: Design Development**	• Strategy selection • Conceptual sketching • Iterative refinement	• Apply sustainable strategies to concrete design problems • Translate analysis into design decisions • Develop iterative design thinking
DESIGN CHALLENGE **Phase 5: Strategy Evaluation**	• Peer assessment • Criteria-based evaluation • Title assignment • Score determination	• Develop critical evaluation skills • Recognize effective strategy implementation

C. Pre-Workshop

Prior to the workshop, students were asked to complete a short questionnaire designed to gauge their understanding of sustainable strategies. This provided baseline data on their knowledge and preconceptions about sustainable design approaches.

D. Lecture and Discussion

The workshop began with students forming groups of three. The facilitator initiated a discussion on furniture waste issues, both globally and in the Indian context, encouraging students to reflect on why this constitutes a genuine problem. The discussion extended to Sustainable Development Goals (SDGs) and how the workshop's learning objectives aligned with these global aims.

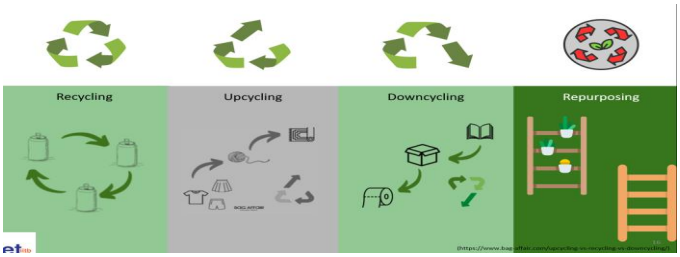

Fig. 1. The Concepts explained

The interaction progressed toward the four key sustainable strategies that formed the workshop's focus as shown in Fig 1. For each concept, the facilitator provided explanations followed by brief 5-minute practical exercises, one of which is shown in Fig 2.

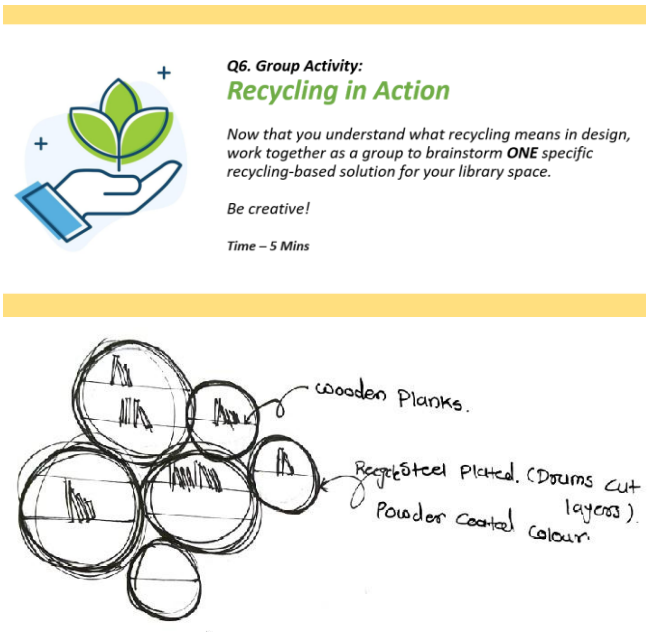

Fig. 2. 5-minute Practical Exercise and Sample Student Work

This theoretical and conceptual discussion with activities occupied approximately 1.5 hours of the workshop. Following the conceptual foundation, students were presented with a hypothetical design context as shown in Fig.3. The design challenge comprised of five phases – exploration, user analysis, furniture analysis, design development and strategy evaluation.

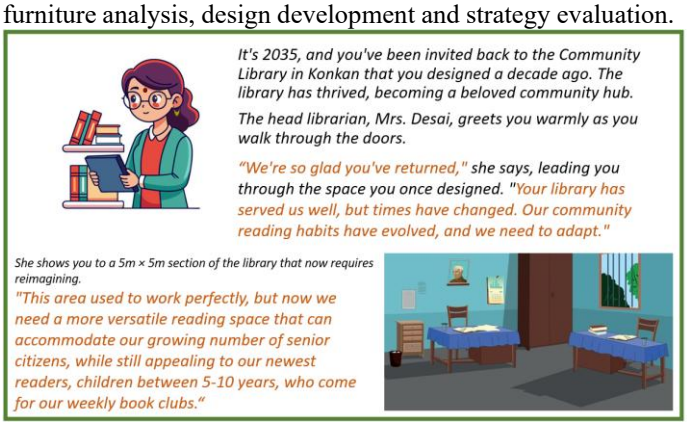

Fig. 3. Context of the Design Challenge

E. The Design Challenge

1) ***Exploration:*** Students then engaged in a structured exploration activity to identify existing furniture:

a) **Survey the Campus:** Students explored learning spaces on campus to select four pieces of furniture that could potentially be repurposed for their library project, assuming these furniture pieces were found in or around the library premises.

b) **Documentation:** Students captured clear, high-quality photographs of each furniture piece from multiple angles.

c) **Measurement and Recording:** The Dimensions of each item were noted.

d) **Component Analysis:** Students listed materials, parts, and structural details relevant for the redesign process.

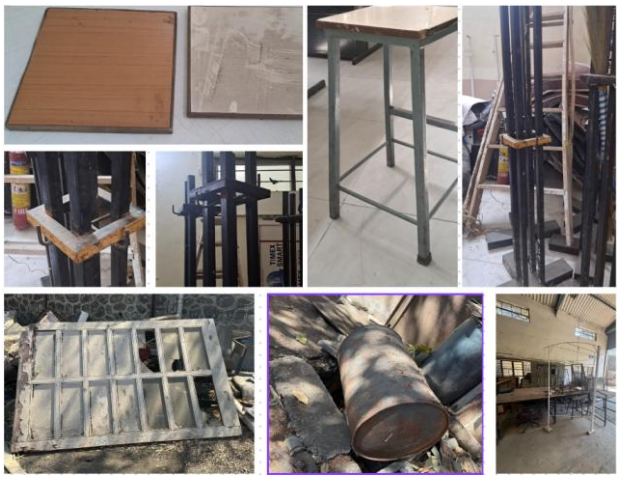

Fig. 4. Documentation from Campus Survey for the Exercise

2) ***User Analysis:*** Upon returning from their exploration, students were asked to select two different types of users from their library design and complete a flow chart on user-activity-requirment-function mapping for each as shown in Fig 5. This exercise helped them consider user needs and experiences when repurposing furniture.

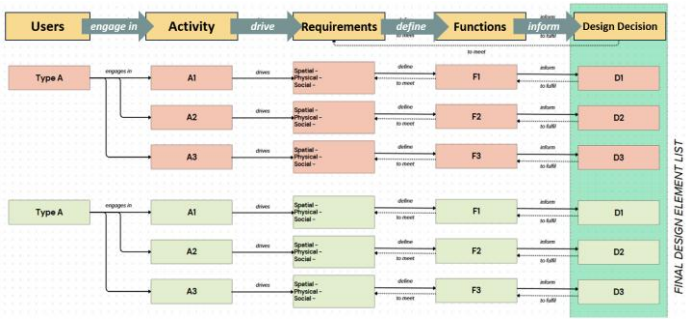

Fig. 5. Flow Chart for the user-activity-requirement-function mapping

3) ***Furniture Analysis:*** The furniture analysis phase represented a critical step in the workshop, providing students with a structured analytical framework to evaluate salvaged furniture systematically.

After collecting potential furniture items during campus exploration, students employed the furniture analyzer tool—an evaluation matrix that guided their assessment process. This tool prompted students to move to a comprehensive analysis across multiple dimensions: material composition, structural integrity, component modularity, and transformation potential.

The analysis process required students to document physical attributes (dimensions, weight, materials), evaluate structural elements (joints, load-bearing capacity, stability), assess material condition (wear patterns, degradation), and identify transformation opportunities (separable components, material adaptability, functional flexibility). This approach facilitated evidence-based decision-making regarding appropriate sustainable strategies.

4) ***Design Development:*** Based on their analysis of recovered furniture items, student groups started designing solutions using one of the sustainable strategies: repurposing, recycling, upcycling, or downcycling. The design development process followed an iterative approach where teams engaged in multiple rounds of internal discussions and rapid ideation.

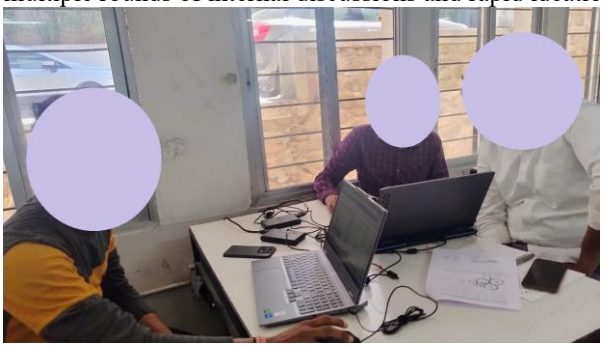

Fig. 6. Students working on Design Development

Students moved through conceptual sketching, refinement of ideas, and critical evaluation of feasibility within their groups. Given the time constraints of the workshop format, students were able to produce conceptual-level drawings that effectively communicated their design intent, transformation process, and anticipated outcomes.

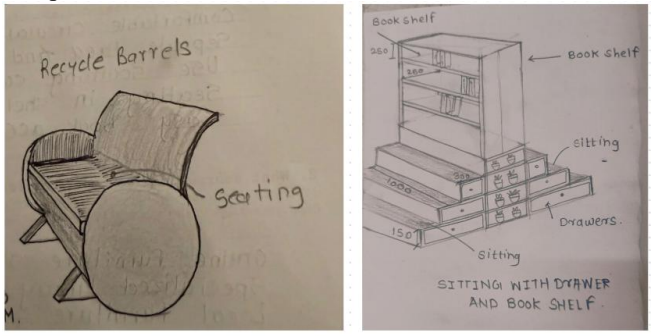

Fig. 7. Sample Outputs from the Workshop

*5) **Strategy Evaluation:*** The workshop concluded with a structured peer evaluation component, where groups assessed each other's designs based on an evaluation framework, focused primarily on how effectively each group had implemented their chosen sustainable strategy rather than subjective aesthetic qualities.

Feature	Recycling	Upcycling	Downcycling	Repurposing
Material Integrity	**Low** - Original material broken down	**Medium** - Partial preservation with modifications	**Low** - Material often degraded	**High** - Original form largely preserved
Value Change	Maintained or slightly decreased	Increased	Decreased	Maintained or repurposed
Processing Level	**High** - Industrial processes	**Medium** - Craftsman intervention	**Medium to Low** - Basic processing	**Low** - Minimal alteration
Output Uniqueness	Standardized products	Unique, one-of-a-kind pieces	Often generic, bulk materials	Distinctive, story-rich items
Visual Reference to Original	None or minimal	Partial - Some visible origins	Minimal or none	High - Clearly recognizable
Examples in Interior Design	Recycled glass countertops, reclaimed wood flooring	Wine barrel chairs, pipe shelving systems	Textile scrap insulation, mixed plastic outdoor furniture	Ladder bookshelves, suitcase tables
Environmental Benefit	**Medium** - Diverts waste but energy intensive	**High** - Adds value with less processing	**Medium** - Extends usable life but eventual disposal	**High** - Minimal processing, extends life significantly
Material Lifespan Extension	**Medium**	**High**	**Low to Medium**	**High**

Fig. 8. Sustainable Strategies Comparison Matrix

Assessment criteria have been shown in Fig 8. Based on the assessment matrix, the groups gave each other titles and scoring as shown in Fig 9.

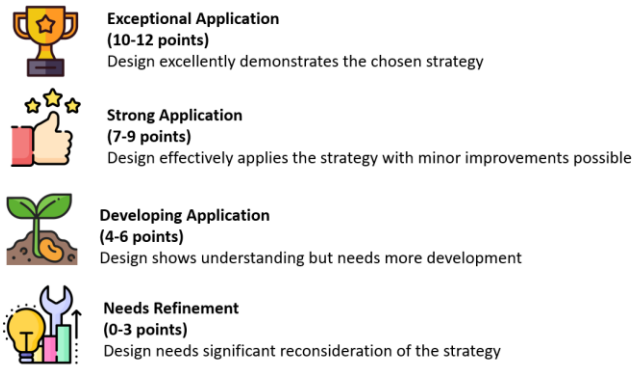

Fig. 9. Titles based on Peer Evaluation

IV. FINDINGS

The findings from the pre-workshop questionnaire show that sustainability remains a secondary consideration in students' design approaches. Only 13% of students prioritized sustainability in their initial approach to library design challenges, despite libraries being long-term community assets where sustainable design would provide significant operational, environmental, and user benefits.

When selecting furniture for library reading areas, student priorities were dominated by functional aspects. Sustainable and eco-friendly materials ranked only fourth in priority, tied with "durability and maintenance requirements" and "tactile qualities and material experience".

After classroom discussions on the Sustainable Development Goals (SDGs) and the four key sustainable strategies, a Slido quiz was administered to assess student learning. The results revealed that only 47% of students could correctly identify the appropriate sustainable strategy when presented with various scenarios. This modest success rate suggests that while students gained some theoretical knowledge about sustainable design approaches, many still struggle with accurately recognizing and categorizing specific strategies in practical contexts. The finding reinforces the knowledge-application gap identified in the research and highlights the need for more targeted educational interventions that help students translate theoretical sustainability concepts into practical design decisions.

Following the workshop, interviews were conducted with all seven student groups to gather insights about their experience. Students expressed strong positive engagement with the active learning approaches used during the session. They reported that the workshop imbibed a greater sense of environmental responsibility, particularly regarding waste reduction and sustainable practices. The practical tools provided were found useful by participants, who indicated their intention to incorporate these resources into future design projects. While students appreciated the workshop structure, they expressed dissatisfaction with its time constraints. Many suggested that extending the activities across multiple days would have allowed for deeper ideation and more thorough consideration of various sustainability factors in their design process.

V. CONCLUSION

The "From Discard to Design" workshop demonstrated a structured pedagogical attempt that had the ability to effectively shift students' perspectives on furniture waste from disposal challenges to design opportunities.

The findings revealed a significant gap between theoretical understanding and practical application of sustainable design principles among architecture students. Despite growing awareness of environmental concerns, sustainability considerations continue to rank lower in priority compared to functional and aesthetic aspects in students' initial design approaches. This gap highlights the necessity for educational

approaches that go beyond conceptual teaching to engage students in hands-on applications of sustainable strategies.

By structuring the learning experience through gradual phases—from exploration and analysis to design development and evaluation—students developed not only theoretical knowledge but practical skills in translating sustainability concepts into tangible design solutions. The hands-on nature of the workshop, combined with analytical tools and structured evaluation processes, ensured sustained engagement with sustainability principles. However, the limited time frame of the workshop emerged as a constraint, suggesting that extended engagement might yield more refined design outcomes and deeper integration of sustainable thinking.

Few important implications emerge from this research:

1) **Curricular Integration**: Sustainable design strategies should be embedded throughout architectural curricula rather than treated as isolated modules, allowing students to develop sustainable thinking as a fundamental design skill rather than an optional consideration.

2) **Active Learning Strategies**: The active learning framework implemented in this workshop provides a viable model for teaching different concepts in architectural education as the experiences become more hands-on.

3) **Assessment Innovation**: The peer evaluation component of the workshop introduces alternative assessment methods that emphasize process and strategic thinking over finished aesthetics, an approach that merits further exploration in design education.

4) **Design Challenge Model**: While this research focused specifically on furniture waste in library design contexts, the methodological approach has broader applications across architectural education. The systematic process of exploration, analysis, design, and evaluation could be adapted to address other sustainable design challenges, from building component reuse to adaptive repurposing of entire structures.

In conclusion, this workshop's structure presents a replicable model for architectural educators seeking to bridge the persistent gap between sustainability theory and practice. Future research directions might explore the longitudinal impacts of such workshops on students' subsequent design approaches, investigate more extensive documentation of the material transformation processes, and develop more sophisticated assessment metrics for peer learning, evaluation and sustainable strategy implementation.

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