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A COMPREHENSIVE REVIEW OF DESIGN EDUCATION FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

This study analyses the recent spike in interest in incorporating sustainability into design education, recognizing its crucial role in tackling critical global issues. It provides a complete overview of design education for sustainable development by reviewing academic literature, design curriculum, and successful sustainable design initiatives. Additionally, this study examines novel teaching methodologies and successful sustainability strategies for design education. It objectively assesses potential issues and impediments and offers solutions. The study seeks to promote design education for sustainability by giving a detailed overview of the research landscape. This article encourages educators and institutions to include sustainability into design curricula by presenting successful and innovative methods. This research equips future designers with the knowledge, skills, and mindset to solve complex environmental and societal problems to promote sustainable design.

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1. INTRODUCTION

Design and designers have the power to create innovative solutions that minimize resource consumption, reduce waste, and promote social and environmental responsibility. By integrating sustainable practices into their work, designers can contribute to the development of products, systems, and environments that are not only aesthetically pleasing but also environmentally friendly and socially equitable. Furthermore, by raising awareness about sustainability through their designs, designers can inspire individuals and communities to adopt more sustainable lifestyles and behaviours. Industrial design, graphic design, architecture, urban planning, fashion, and other kinds of design all play important roles in producing products, systems, and settings that influence human behaviour, consumption patterns, and resource utilization. Designers have the ability to either contribute to unsustainable behaviours or to become good

change agents. Recognizing this potential, the incorporation of sustainability concepts into design education has become critical in order to develop a new generation of designers who are equipped with the knowledge and skills required to confront these difficult challenges.

1.1 RESEARCH OBJECTIVES

This research paper aims to explore and investigate the state of design education for sustainability, highlighting its importance in the context of the current global challenges. The objectives are as follows:

- To Understand the concept of design sustainability and its application to a broader societal and environmental context.
- To evaluate how sustainability ideas are implemented into curricula to assess the present level of design education in various fields.
- To identify best practices and effective case studies of design programs that prioritizes sustainability, and analyzes the effects on student learning and the larger design community.
- To develop effective solutions for improving sustainability in design education, taking into accounts the problems and barriers that may impede its implementation.
- To advocate for the inclusion of sustainability as a core component in design education, emphasizing designers' responsibility as agents of positive change in building a more sustainable world.

1.2 SCOPE AND STRUCTURE

This study paper will provide a thorough examination of design education for sustainability, encompassing numerous design disciplines and educational levels. The study's scope will include a review of academic literature, current design curriculum, and case studies of sustainable design initiatives. It will also look at new pedagogical approaches and effective efforts for incorporating sustainability ideas into design education.

The purpose of this study work is to add to the continuing discussion about design education for sustainability. We can collaboratively contribute towards a more sustainable and fair society by developing sustainable ideas and practices among designers.

2. RELATED WORK

2.1 LITERATURE REVIEW

The literature review is conducted on sustainable product design, and the following papers are reviewed.

Fabrizio Ceschin [1] highlights the educational value of a design framework that communicates the complexity and richness of Design for Sustainability (DfS) to students. This research explores the evolution of sustainable design, transitioning from product-level improvements to system-wide innovations. Through a literature review, Ceschin emphasizes the shift from incremental changes to transformative design approaches that address social needs holistically. He also identifies challenges in integrating DfS within organizations and suggests the need for systemic initiatives to foster sustainable design practices [1].

Maher et al. [2] emphasize the importance of university graduates being ecologically responsible citizens. Their study uses a Research through Design (RtD) approach to integrate design thinking with sustainability science, focusing on addressing sustainability challenges in complex social-ecological systems. The research introduces Meta MAP and Workflow design methods to promote interdisciplinary collaboration. However, the lack of clarity in project briefs and objectives limits the study's practical impact, suggesting the need for clearer design briefs to enhance outcomes and stakeholder collaboration (Maher et al., 2010) [2].

Rampasso [3] explores institutional barriers to social sustainability within companies, using design thinking to identify key challenges to sustainable development. The article suggests that further analysis of supply chains, environmental disclosure, and management systems could enhance understanding of these issues. Rampasso also recommends examining the human-nature relationship to encourage deeper reflection on environmental impacts. Addressing these aspects can assist scholars and policymakers in designing more effective institutional measures for social sustainability (Rampasso, 2022) [3].

Rampasso, I.S. (2022) [3] Company-focused concept of social sustainability: Examining institutional social sustainability barriers.

Jawahir et al. (2006) [4] emphasize the need for collaboration among legislators, designers, manufacturers, and researchers to standardize sustainability scoring and subgroup elements. Their study introduces a life-cycle-based approach to product sustainability, using the Product Sustainability Index (PSI) to assess sustainability from creation to disposal. The research highlights cost reduction, efficient material use, and minimizing industrial waste while promoting repair, reuse, recovery, and recycling. Although the study underscores the importance of these elements for sustainable design, it does not address pre-manufacturing processes or broader environmental, economic, and social impacts, suggesting that future research should explore these areas to develop a more comprehensive evaluation system [4].

McAloone and Andreasen **[5]** highlight the shift from traditional product design to a Product Service Systems (PSS) approach as a sustainable design method. PSS[5] focuses on the entire product life cycle, from creation to usage and maintenance, encouraging designers to adopt holistic strategies for sustainability. However, the study also notes the challenges designers face, such as managing complex life cycles, catering to diverse customer groups, and addressing social responsibility concerns. To effectively implement PSS, future research must involve all stakeholders and address user needs and responsibility issues [5].

Seay [6] emphasizes the growing importance of design for sustainability in engineering education and professional practice. His research focuses on developing eco-friendly design principles to ensure that future generations have the resources they need. While Seay stresses designing sustainable processes and products, he identifies a gap: design engineers are not adequately involved. Future studies should explore the role of design engineers to ensure that sustainability principles reflect all necessary skills and perspectives.

Conway et al. [8] highlight that design education often emphasizes "why things should change" rather than "how to effect change." Their research on Irish post-primary design education aims to integrate sustainability by aligning with the Sustainable Development Goals (SDGs). The study prioritizes hands-on projects and acknowledges the challenges of assessing design education's impact & suggests collaboration between researchers and educators to incorporate sustainability into both theoretical and practical aspects of design education [8].

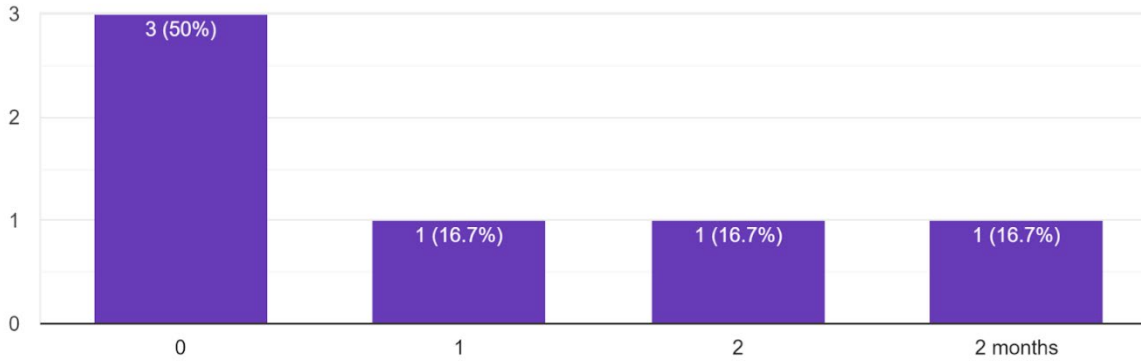
Fletcher, Kate, and Emma Dewberry [9] argue that sustainability should encompass more than environmental issues, emphasizing its societal benefits. Their study focuses on making education greener by promoting sustainable design, raising public awareness, and encouraging eco-friendly behavior. They emphasize the importance of considering environmental factors, such as energy savings and using recycled materials, in product construction. However, the research highlights a lack of public awareness about sustainability initiatives, suggesting a need for more education on eco-friendly design in courses to equip students with the necessary.

Tomasowa [10] examines how people develop awareness of sustainable design across fields like architecture, engineering, and product design. The research highlights efforts to make industrial practices more eco-friendly through workshops at the Centre for Sustainable Engineering (CSE), stressing the importance of minimizing environmental impact, efficient resource use, cost control, and waste management. However, the study overlooks the critical 6R techniques—Reduce, Reuse, Recycle, Recover, Rethink, and Redesign—which are essential for reducing ecological footprints. Future research could integrate these strategies for a more comprehensive approach to sustainable design [10].

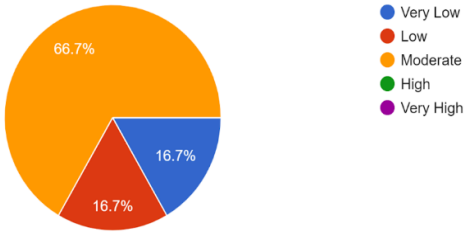
2.2 PRIMARY RESEARCH

We have performed primary research after literature review. This section discusses the outcome of the interview and survey conducted. This research includes users from academecian, students and industry practitioners.

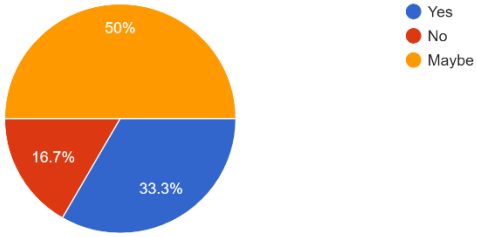
How many years of experience do you have in design education ?



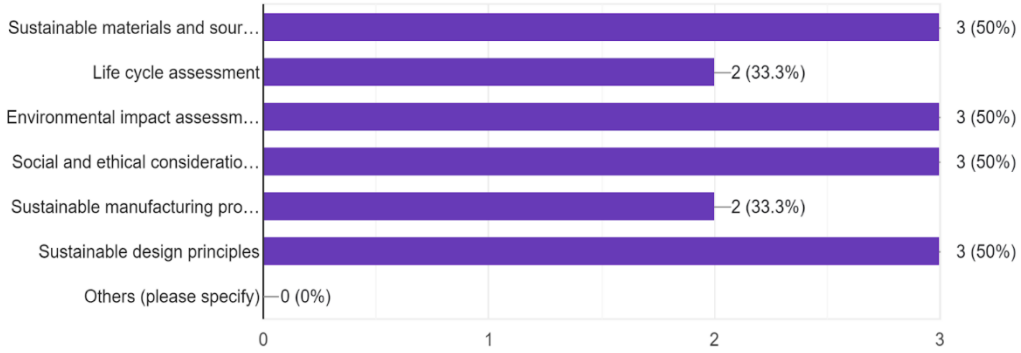
Knowledge of sustainability practices in design education?



Does your design education program incorporate sustainability principles in its curriculum?



Which sustainability topics are covered in your design education?



How are sustainability principles integrated into the curriculum?

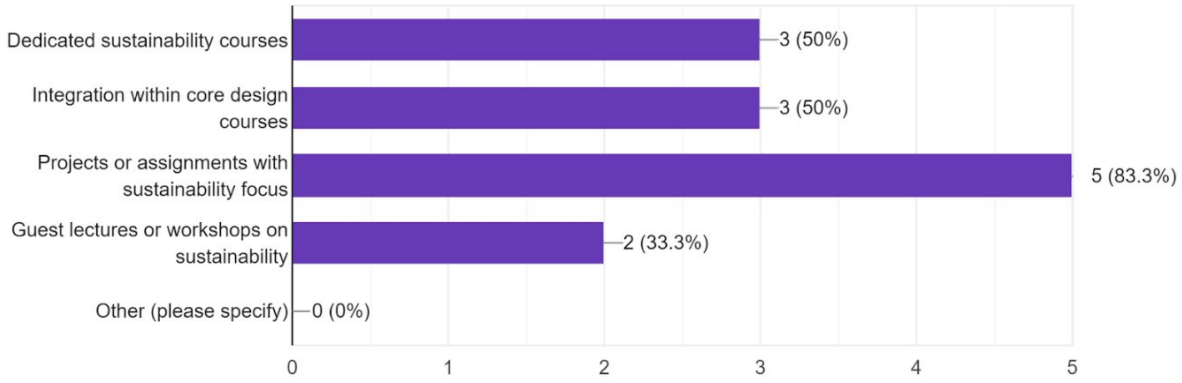


Figure 1. Primary research insights

2.3 FIELD STUDY

The field study has been performed considering various sectors production companies.The field study is done to understand which sustainable practices they are following or not. Also, where they are facing the issues during the production. The sectors are mentioned below.

- Sheetmetal Company
- Casting Company
- Plastic moulding Company
- Cement Brick Company

2.3.1 ISSUES

- Production line: Production line issues in the plastic molding industry often involve equipment malfunctions, process inefficiencies, and quality control challenges that can lead to delays, increased costs, and subpar product quality.
- Material waste: The excess raw materials discarded during production, which can arise from inefficient processes, improper machine settings, or design flaws, leading to increased costs and environmental impact.
- Time taken process: It encompasses the total duration required for production cycles, including setup, moulding, cooling, and finishing, which directly affects productivity and efficiency.
- Design problem: It often includes challenges related to optimizing mold design for efficiency, ensuring material compatibility, addressing design for manufacturability (DFM), and minimizing defects while balancing cost and performance requirements.
- Batch production problem: It typically involve managing inconsistent production schedules, variability in batch quality, inefficient use of resources, and difficulties in coordinating machine setups, all of which can lead to increased costs and delays in meeting customer demands.

2.3.2 EXPECTATIONS

- Fluid process line: A "fluid process line" in batch production of the moulding process refers to a flexible and adaptable manufacturing setup that allows for efficient transitions between different production stages or product variations, optimizing workflow and reducing downtime.
- Time costing: "Time costing" in batch production of the moulding process refers to the calculation of production costs based on the time required for each stage, ensuring optimal efficiency and accurate budgeting by minimizing delays and maximizing resource use.
- Reduce Waste: Helps to minimize excess material, energy, and time usage, optimizing resource efficiency, and improving overall sustainability and cost-effectiveness.
- Batch defects reduction: Refers to implementing strategies and quality control measures to decrease the occurrence of flaws in produced batches, thereby enhancing product quality and reducing rework costs.

3. OBSERVATIONS AND SUGGESTIONS

3.1 GAPS IN DESIGN EDUCATION AND SUSTAINABLE DESIGN

- **Lack of Emphasis on Sustainability:** Many design programs prioritize aesthetics, functionality, or market demands, but often overlook sustainability as a core component. Students may not fully understand the environmental and societal impact of their designs.
- **Insufficient Interdisciplinary Learning:** Sustainable design requires knowledge from various fields like environmental science, material sciences, and ethics. Design education often lacks interdisciplinary approaches, making it difficult for students to integrate sustainability into their projects effectively.
- **Limited Practical Exposure:** Sustainable design requires hands-on experience with sustainable materials, life-cycle assessment tools, and eco-friendly technologies. Many design programs don't offer enough practical learning opportunities for students to experiment with these tools.
- **Absence of Circular Economy Concepts:** Circular economy principles, such as designing for longevity, reuse, and recyclability, are not always integrated into the design curriculum, leaving students with a linear design mindset.
- **Short-Term Project Focus:** Design education often emphasizes quick project turnovers, which doesn't foster deep thinking about long-term sustainability. Students may develop a short-term view that overlooks the life cycle of a product or its broader environmental impacts.
- **Limited Industry Collaboration:** Partnerships between academia and industries working on sustainable products and processes are not always strong. As a result, students may not be exposed to real-world challenges or innovations in sustainable design.

3.2 SUGGESTIONS FOR TEACHING SUSTAINABLE DESIGN

- Incorporate sustainability into the curriculum: Make sustainability a foundational aspect of design education by including it in all stages of the design process. Courses should address environmental, social, and economic sustainability to foster holistic thinking.
- Interdisciplinary Learning: Collaborate with departments like environmental science, engineering, and business to create a multidisciplinary curriculum. This will provide students with a broader perspective on how sustainability can be integrated into design.
- Life Cycle Thinking: Introduce life cycle assessment (LCA) tools to help students evaluate the environmental impact of materials and products. By teaching students how to assess a product's entire life cycle, they can make more sustainable design decisions.
- Hands-on Experience with Sustainable Materials: Provide students with the opportunity to work with sustainable materials and eco-friendly production processes. Projects could focus on the use of recycled materials, designing for disassembly, or prototyping with biodegradable components.
- Circular Economy and Systems Thinking: Teach students about circular design principles, encouraging them to think beyond creating standalone products to systems where Products are reused, repaired, or recycled. This helps them consider how their designs fit into a broader ecosystem.
- Collaboration with Industry and Real-World Projects: Establish partnerships with companies that focus on sustainable design and technology. Collaborative projects with industry partners can give students real-world experience in tackling sustainability challenges.
- Long-Term Design Projects: Create projects that require students to think about long-term sustainability, encouraging deeper investigation into the life span, reuse, and end-of-life strategies for their designs.
- Promote Ethical and Responsible Design: Encourage students to consider ethical implications in their work, such as how their designs impact communities, labor practices, and resource consumption.

4. CONCLUSION

In conclusion, integrating sustainable design principles into education is essential for tackling modern environmental and societal challenges. The research identifies key gaps in current design education, such as the lack of interdisciplinary learning, practical exposure to sustainable tools, and the absence of circular economy concepts. A shift is needed to prioritize sustainability within the curriculum, fostering long-term thinking in students. By embedding sustainability in core courses, offering hands-on experience with eco-friendly materials, and collaborating with industry, design

education can better prepare future designers to create responsible solutions and advocate for sustainability in their careers.

CONFLICT OF INTERESTS

None

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