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An Analysis of Sustainable Design Concept Implementation in Product Design Final Projects

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ABSTRACT

In support of the Sustainable Development Goals (SDGs), sustainable design has become one of the main focuses in undergraduate design education. Sustainable design refers to a design process that considers environmental, social, and economic impacts throughout the product lifecycle. This study aims to analyze the implementation of sustainable design in the final projects of Product Design students at Telkom University, as a case study from 2021 to 2023. Using qualitative methods and content analysis, 33 final project samples were evaluated using a sustainable design matrix. The analysis results show that although there is a decline in the quality of certain metrics, such as Biodegradable Materials, there is a positive trend in the use of environmentally friendly materials, material recycling, and efficient, multifunctional design. These findings indicate that students are increasingly aware of the importance of integrating sustainability principles into design, not only as an ethical responsibility but also as an innovative strategy. With a focus on sustainable materials and product durability, students demonstrate their commitment to reducing environmental impact and enhancing the quality of sustainable design.

KEYWORDS

Sustainable Design
Design Product
Department
Final Projects

INTRODUCTION

In order to support the Sustainable Development Goals (SDGs), it is essential to address Sustainable Design within the context of undergraduate design education (Watkins et al., 2021). Sustainable design is a design approach that takes environmental considerations into account during the design process, as well as the social impact of the resulting product (Bhamra & Lofthouse, 2007). Furthermore, sustainable design is a design process that considers environmental, economic, and social sustainability throughout the entire product life cycle (He et al., 2019). The primary objective of sustainable design is to create products and services in a manner that reduces the use of non-renewable resources, minimizes environmental impact, and connects humans with nature (Kazamia & Kafaridou, 2010). The design field is one of the factors contributing to environmental degradation. Specifically, 80% of the environmental impact occurs during the design process of a product (Murray, 2013). This is particularly significant for product designers, who play a vital role in developing products used by society. Product designers can pose environmental risks by creating unsafe products, generating waste that is difficult to recycle, and selecting materials and processes that pollute the air (Papanek, 1973). This is why there is an increasing push for designers to adopt

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more environmentally friendly practices and to reduce the environmental impact of the products and services they offer.

Sustainable implementation can significantly impact creativity and responsibility regarding the products created. For designers, this represents a positive interaction between social innovation—particularly within creative communities—and their revolutionary ideas with technological innovation (Manzini & Vezzoli, 2008). Creativity in product design can also arise from concern over existing environmental and social issues (Muttaqien & Adiluhung, 2021). Therefore, sustainable concepts, including the Sustainable Development Goals (SDGs) and sustainable design, can be implemented as foundational topics in final projects. Such projects can serve as a platform for students to apply the knowledge and skills acquired during their studies and to develop innovative solutions that consider environmental, social, and economic aspects.

On the other hand, the growing trend of interest in sustainable consumption has encouraged society to embrace new environmentally friendly products (Olsen et al., 2014). This trend, often referred to as ecological living, is a response to global environmental issues, aimed at restoring nature to its original state and reducing pollution (Pambudi et al., 2022). This factor has motivated product design students to implement sustainable design concepts in their projects, particularly in their final works.

There is a diverse range of interests among product design students concerning final project topics. For instance, there is a trend among students to emphasize environmental sustainability from the material aspect, as it is perceived to undergo less transformation (Spreafico & Landi, 2022). Some students focus their interests solely on specific themes, such as new materials or efficiency in industrial processes (Vezzoli, 2002). Currently, the concepts of sustainable design and good design are interconnected, where good design ensures that products utilize quality materials and components while considering consumer health and safety with effective and clear functionality (Bhamra & Lofthouse, 2007). Thus, good design inherently supports the principles of sustainable design and vice versa, facilitating the realization of product works in final projects that embody more environmentally friendly and sustainable concepts.

In the design process, students often create products with various considerations, including user needs and production factors, which indirectly incorporate sustainability matrices. Students should already understand or possess knowledge about the environmental impacts generated from the production processes of the products they design (Rahmawati & Suci, 2024). Integrating sustainability matrices at every phase of the design process is not only a requirement but also a shared responsibility (2050 Materials, 2023). Incorporating sustainability matrices can be achieved throughout the entire product life cycle by combining product design information from various stages and systematically analyzing the relationships between this information to form a comprehensive design framework (Kong et al., 2022). It is unjustifiable to design without considering sustainability, just as it is unacceptable to design hazardous or unsafe products (Sherwin, 2012). This highlights that sustainability in product creation is an embedded aspect, where graduates in design need to develop the ability to implement sustainable practices (Kuys et al., 2012).

The final project represents the culmination of the students' learning process, reflecting their ability to apply the theories and concepts acquired during their studies. The application of sustainable design in the final project serves as a benchmark to assess the extent to which students can integrate sustainability aspects into their work, ensuring that graduates in this field possess sustainability considerations embedded in their expertise. Analyzing the application of sustainable design in the implementation of final projects by product design students is crucial for understanding how sustainable design is integrated into their final works. The results of this research are expected to provide insights into the implementation of sustainable design at the higher education level for product design. Furthermore, these findings can serve as a reference for educators, practitioners, and students to enhance the quality of sustainable product design in the future.

METHOD

This study employed a qualitative method with a content analysis approach to identify the

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implementation of sustainable design in the final projects of Product Design students at Telkom University. Content analysis is used to determine the presence of certain themes or concepts in qualitative data (Columbia University, n.d.). The researcher categorized and detailed the information within the data to measure and analyze the sustainable design approaches used by Product Design students. The research sample consisted of 33 final projects, with 11 samples per year from 2021 to 2023, selected using purposive sampling based on keywords related to sustainable design.

The assessment utilized the sustainable design matrix categories from the book *"Design for Sustainability: A Practical Approach"* by (Bhamra & Lofthouse, 2007). Each matrix category was aligned with the design practices outlined in the literature review. Each sample was evaluated on a scale of 1 to 5 points. The total score was 55 for the 11 samples each year, and the scores were grouped into five categories of implementation quality: very low (0-10), low (11-22), moderate (23-33), high (34-44), and very high (45-55). This categorization was applied to facilitate data analysis and interpretation. The obtained data were then analyzed to identify trends and patterns in sustainable design implementation. The analysis results provide an overview of how sustainability principles are applied in the final projects of Product Design students.

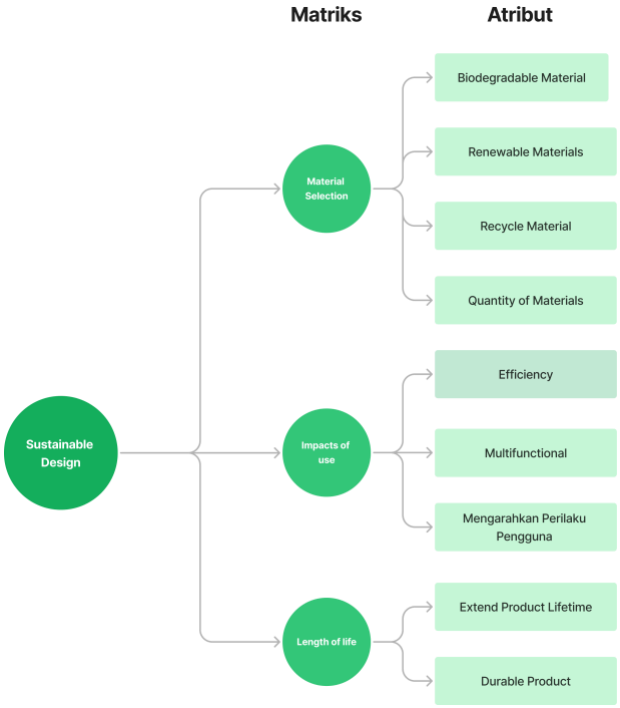

Figure 1. Sustainable Design Parameters.

RESULT AND DISCUSSION

1. Assessment of Sustainable Design Matrix Implementation

Figure 2. The Assessment Results of Sustainable Design Matrix Implementation

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In general, a product design project can implement several sustainable design matrices within its development, either by embedding them or making them the primary focus or topic of the final design project. There is a trend indicating a decline in the quality of sustainable design principle implementation. However, some aspects showed improvement in 2022 but declined again in 2023, such as the implementation of recycled materials and material quantity. Additionally, there was a decrease in quality in 2022 followed by an increase in 2023 for multifunctional matrices and user behavior guidance.

The material quantity matrix in 2022 had the highest implementation score over the three years, with 43 points (categorized as high). This high score was influenced by the tendency of students to design their final projects using non-varied materials. For example, the design of a handbag made from textile waste, which, despite using various colors of leftover fabric, used the same type of material. Similarly, several household equipment designs were predominantly created using a single material, such as wood, as the primary material. This was due to considerations of production efficiency given time and budget constraints, as well as a desire to highlight the material's characteristics.

From 2021 to 2023, the sustainable design matrix for biodegradable materials had the lowest quality implementation score among others, never exceeding 6 points (categorized as very low) in 2021 over the three-year period. For example, in 2021, the "laptop bag design made from mushroom leather" scored an implementation value of 5, and in 2022, the "boots design made from coffee leather" also received the same score of 5. Although both samples achieved the maximum score within the Biodegradable Materials category, only these two samples were found in the last three years. This was due to long experimental times, a lack of technical support and infrastructure, and challenges in the production process when creating final design projects.

Overall, this trend shows a decline in the implementation and quality of sustainable design aspects in final projects. However, there is also inconsistency in the trends of sustainable design matrix implementation, reflecting shifting priorities and interests in sustainable design implementation among students. This offers insight into how sustainable design matrices are integrated into student final projects and highlights the matrices that require further attention to enhance implementation and sustainability quality in product design.

2. Distribution of Topics Based on Sustainable Design Matrix

Table 1. Distribution of Topics Based on the Sustainable Design Matrix

Sustainable Design Matrix	Number of Academic Years		
	2021	2022	2023
Biodegradable Material	1	1	
Renewable Material	2	3	
Recycle Material	4	5	6
Quantity of Materials	1		
Efficiency	3		5
Multifunctional		2	
Behaviour steering			
Extend Product Lifetime			
Durable Product			

Based on the data from the final projects of product design students at Telkom University during the period of 2021-2023, it can be concluded that the most common sustainable design matrices as final project topics are recycled materials and efficiency. The majority of design topics related to recycled materials over the past three years are associated with the design of household and lifestyle

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products, such as watches made from recycled skateboards, eyeglass frames from furniture waste, and furniture made from plastic waste.

In contrast, there were no final projects addressing the efficiency matrix in 2022. However, in 2021 and 2023, the product design topics presented were more varied, ranging from "redesigning medical mask waste processing facilities in terms of dimensions and operations" to "designing courier motorcycle bags to enhance efficiency." This indicates a growing awareness of the importance of utilizing recycled materials and improving efficiency in product design. In undergraduate practice, the implementation of recycled materials and efficiency is highly relevant. Both aspects are the most accessible and implementable practices for students to achieve tangible results in evaluating the environmental, social, and economic impacts of the designed products.

In addition, the topic of the renewable materials matrix has also been adopted relatively frequently, although its occurrence is slightly lower. In 2023, there were no final project topics related to this matrix. The implementation of renewable materials is associated with household products, such as the design of vanity tables and desk organizers made from bamboo. The implementation of renewable materials in the final project designs indicates a drive towards innovation in sustainable product design, focusing on renewable materials as alternatives to conventional materials.

Furthermore, there is a low incidence of final project topics addressing biodegradable materials, material quantity, and multifunctionality. Additionally, the absence of topics related to matrices that guide user behavior, extend product lifespan, and enhance durability highlights the need for further efforts to raise awareness and implementation of these aspects. Overall, the data in Table 1 indicate a growing trend in the implementation of sustainable design matrices as final project topics within the academic environment, particularly among product design students.

3. The Tendency of Implementing the Sustainable Design Matrix

Based on Figure 2, there is a discernible trend in the implementation of the sustainable design matrix. To facilitate further analysis, matrices with low implementation quality scores can be eliminated. The following presents the trends in the implementation of various sustainable design matrices from 2021 to 2023.

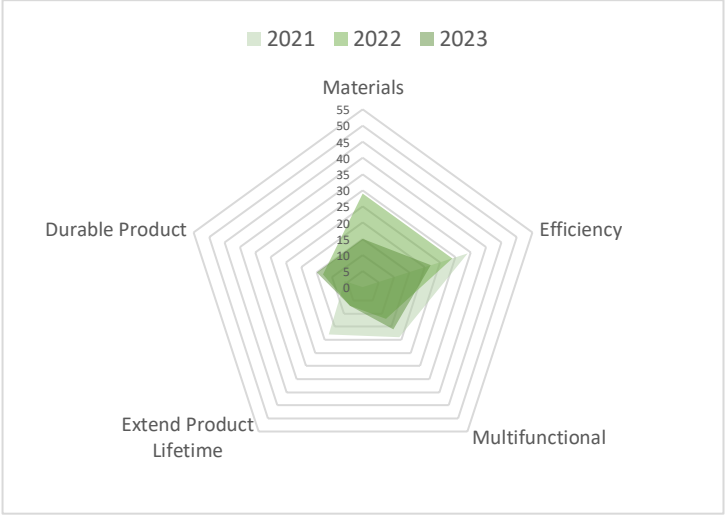

Figure 3. The Tendency of Implementing the Sustainable Design Matrix

a. Materials

Considerations of materials in sustainable design, based on the matrix commonly implemented by product design students, encompass aspects of renewable materials, recycled materials, and the quantity of materials used. Students have extensively explored these three aspects in their final projects, demonstrating that the appropriate use of materials can yield products that are not only

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environmentally friendly but also take into account social and economic factors. This can be elaborated in further detail as follows:

1) Renewable Materials

Students tend to explore and implement renewable materials in their final projects as an alternative to conventional materials. For instance, bamboo has been utilized in household products in three final projects during 2021 and 2022. The use of renewable materials opens opportunities for innovation in product design, making this matrix particularly relevant when applied to final projects. Products made from renewable materials not only support sustainability but also offer unique market value in an increasingly environmentally conscious marketplace, appealing to a market segment that prioritizes ecological concerns. However, it is essential to note that a crucial criterion for renewable materials is the ability to be produced at a sufficient speed to meet demand, both in terms of time and quantity.

2) Recycle Material

In addition to the tendency to implement renewable materials, recycled materials are also widely incorporated into Final Projects, even surpassing the trend of using renewable materials. This indicates that solutions for designing sustainable products almost always involve recycling. (Spreafico & Landi, 2022). The increasing number of Final Projects utilizing recycled materials, particularly in the use of production waste and plastic waste processing, reflects students' awareness of environmental issues around them and their desire to reduce waste. Additionally, recycled materials are more affordable and accessible, making them an economical choice for design projects. The use of recycled materials also fosters innovation and creativity, allowing for the exploration of new ways to transform discarded materials into functional and aesthetically pleasing products. The utilization of production waste materials can still be enhanced by incorporating other materials sourced from production leftovers, thereby allowing for greater design exploration (Muttaqien & Adiluhung, 2021). By utilizing recycled materials, students can create products that possess compelling narratives and added value for consumers, while also supporting the circular economy and mitigating environmental impact.

3) Quantity of Materials

There is a trend among students to design their Final Projects using non-varied materials. This choice is based on considerations of production process efficiency due to time and budget constraints, as well as the intention to highlight the characteristics of the materials used. Reducing the amount of material used in product design can significantly decrease environmental impact. This reduction in material usage can be achieved through smart and efficient design practices (Bhamra & Lofthouse, 2007). The implementation of using non-varied materials in Final Projects is one of the easiest and most relevant sustainable design practices. In the sample works of students' Final Projects, there is a tendency to produce products with minimalist designs that highlight the primary material, such as in the designs of a multifunctional wardrobe and a makeup organizer, both of which are entirely made of wood. This approach serves as a response to the amount of production waste that negatively impacts the environment (Rahmawati & Suci, 2024)

b. Efficiency

From the data sample of Final Projects, creating or enhancing the efficiency of a designed product is one of the trends in implementing sustainable design matrices and a common practice among Product Design students in their Final Projects. For example, the designs of a "motorcycle bag for couriers" and the "redesign of a mask waste processing facility" focus on simple yet efficient designs. Both projects prioritize functionality and good ergonomics, allowing them to optimally meet user needs. These examples demonstrate how sustainable design, with an emphasis on efficiency, can be applied to create products that not only fulfill users' functional and ergonomic requirements but also minimize negative environmental impacts. By designing comfortable and efficient products, the need to replace items with new ones can be reduced, thereby extending product lifespan and decreasing waste. The implementation of efficiency matrices in Final Project designs is a relevant

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practice that students can adopt, particularly by creating ergonomic products focused on user needs as a solution.

c. Multifunctional

In Final Project designs that implement multifunctional matrices, the aim is to enhance the quality of the resulting products. This practice is widely adopted by students as a solution to the problems they address or as an innovation they seek to introduce in their Final Projects. Examples include the design of a multifunctional wardrobe for limited spaces and the design of a shopping bag capable of carrying various items, such as vegetables, fruits, and meat. In multifunctional product designs, there is potential to reduce environmental impact by decreasing the number of products purchased by users (Bhamra & Lofthouse, 2007). By implementing this matrix, students can create products that allow a single item to fulfill multiple needs or functions, thereby reducing the need for separate products and ultimately lowering consumption.

d. Extend Product Lifetime

The implementation of extending product lifespan is a relevant practice in the design of Final Projects. This practice is commonly applied in student design projects, particularly through modular techniques that facilitate disassembly, especially for cases requiring high mobility. By designing products with a modular structure and ease of repair, the lifespan of a product can be significantly extended (Bhamra & Lofthouse, 2007). For example, in the design of a modular display rack for exhibitions, the modular system emphasizes ease of assembly and disassembly to facilitate mobility during exhibitions. The rack is also designed to be flexible, accommodating various types of products and display needs. Modular furniture systems offer convenience in terms of mobility, installation, and customization, supporting the optimization of limited space usage (Pambudi et al., 2024). Although such practices are relevant and relatively easy to implement, careful consideration and in-depth research are necessary to produce functional products that have a positive impact on both users and the environment.

e. Durable Product

In the implementation of product design with good durability in Final Projects, this is embedded through the use of high-quality materials, robust, and ergonomic designs. Such practices are relevant to Final Project designs, as seen in several samples, such as the "design of a table and chair set from used tires" and the "design of stools from plastic waste using weaving techniques," where the products are constructed using aluminum and iron frames, designed with strength in mind. The implementation of durable product matrices in student design projects is a fundamental practice, as the quality of a product is considered good when it possesses high durability. When a product has a longer lifespan, it helps reduce product waste and indirectly decreases resource consumption (Manzini & Vezzoli, 2008). By focusing on quality and durability, designers or students can create products that not only meet consumer needs but also contribute to long-term sustainability.

Overall, the tendency to implement sustainable design matrices in the final projects of product design students indicates that they are not only pursuing aesthetics and functionality but are also giving serious attention to environmental impact and long-term sustainability. The potential of sustainable design can result in products that provide essential value, leading to extended product lifespans (Kazamia & Kafaridou, 2010). This indicates that students are increasingly aware of the importance of integrating sustainability principles into their design processes, not only as an ethical responsibility but also as an innovative strategy. This approach also has a positive impact on the economic factors of a product, resulting from the creation of well-designed and high-quality outcomes (Muttaqien & Adiluhung, 2023). By selecting environmentally friendly materials, recycling resources, and designing products with efficiency and multifunctionality, students demonstrate their commitment to creating design solutions that not only meet consumer needs but also reduce environmental impact. The implementation of designs that emphasize durability and product longevity further reflects their understanding of the importance of minimizing waste and

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promoting the sustainable use of resources. This awareness and commitment represent positive steps toward more responsible and sustainable design practices.

CONCLUSIONS

The trends in the implementation of the sustainable design matrix in the final projects of Product Design students during the 2021-2023 period indicate that students are not only focusing on aesthetic and functional aspects but are also paying attention to environmental impact and sustainability. For example, designing with bamboo as an alternative to conventional materials aims to reduce environmental impact. Bamboo is chosen for its renewable and eco-friendly properties, making it suitable for household products.

The implementation of modular techniques in design allows for easy disassembly and assembly, enhancing design flexibility while supporting sustainability and facilitating maintenance and replacement of product components, thus providing an efficient solution for sustainable design. However, a decline in the quality of sustainable design implementation is observed in the biodegradable materials matrix, alongside variations in the implementation scores for the material quantity matrix and efficiency matrix, presenting challenges in integrating these principles.

Despite these challenges, there is a positive trend in the selection of materials categorized as renewable, recycled materials, and designs emphasizing efficiency and multifunctionality. This reflects an increasing awareness among students of the importance of sustainability in design as both an ethical responsibility and an innovative strategy. By adopting more sustainable materials and considering product durability and lifespan, students demonstrate their commitment to creating design solutions that not only meet consumer needs but also reduce environmental impact. This awareness and commitment represent a positive step towards more responsible and sustainable design, aligned with efforts to address environmental issues and ensure long-term sustainability.

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