

PERSUASIVE DESIGN TO ADDRESS SUSTAINABILITY IN ENGINEERING EDUCATION

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ABSTRACT

Sustainable design is becoming a common practice since there is a global interest in protecting the environment and enhancing the health and well-being of human beings. However, sustainability is a complex issue. The relationship and balance between environmental, economic, and social demands during the design process require an understating of systems, environment and human behaviour, and business perspective. Consequently, there is a need to provide engineering students with design knowledge and tools for sustainable design. One tool is persuasive design since this approach influences the users' behaviours and decisions. The change of behaviour of consumers might have a significant impact on waste, contamination, energy and materials consumption, and other sustainability indicators. This paper presents a list of strategies for persuasive design and a pedagogical model to introduce them to engineering design education. The pedagogical model focuses on applying persuasive design for sustainable design and its ethical dimension.

Keywords: Persuasive design, sustainability, engineering education, behaviours, pedagogical model

1 INTRODUCTION

Sustainability issues like resource scarcity, contamination, and global warming have become more relevant in recent years. Especially when those issues threaten all human activities and compromise the sustainability of societies as we know them today [1]. As main actors, academics, industry, and governments have proposed many approaches, including methodologies, design rules, new manufacturing processes and technologies, and manufacturing and supply chain policies, among others, to face such sustainability issues. However, it is common to find that none of those efforts have enough impact in the mid and long-term since consumption habits still follow a primarily throw-away culture. As an interesting approach, the persuasive design of a product can address issues that modify consumers' behaviour. This design method involves design principles that promote more sustainable lifecycle management of products by users. Nevertheless, persuasion is commonly more related to marketing strategies, and awareness campaigns about products and services and rarely is covered by engineering curriculum.

This article proposes a list of persuasion strategies arranged in a pedagogical model oriented to address two main issues: the first one relates to the inclusion of self-awareness and sustainable behaviour in engineering design courses. And the second one aims to prepare future engineers to implement persuasion into their product designs to promote more sustainable product consumption and use patterns.

2 PERSUASIVE DESIGN

Persuasive design is a strategy to shape human behaviour by incorporating specific features in products or services. This concept is highly related to psychology, communication, and marketing to create designs that appeal to users' emotions, desires, and motivations. Commonly, it is employed to design elements, such as colour, functionality, shapes, layout, and intractability, to persuade users toward a specific behaviour or goal. As stated by Fogg [2, 3], the primary purpose of persuasive design is to enhance consumer motivation, abilities, and behaviour triggers. These can be achieved by creating user experiences that are engaging, easy to use, and emotionally appealing.

2.1 Persuasion principles for engineering design

According to the existing literature, more than 30 principles of persuasion can be used in both products and services to influence consumer behaviour [4, 3]. However, many of those principles are primarily geared toward the use of technology or services and do not apply to products. Therefore, a list of the most applicable principles of persuasion for engineering design is proposed and summarized in Table 1

These principles were selected considering the FEEL-THINK-DO model around sustainability and how to implement them during engineering courses and prepare students to apply them in future product designs. Thus, persuasion principles in Table 1 provide easiness to being included in an academic context (e.g., big names, logos, research, tailoring) to support data and facts and their relationship with current sustainability issues. Emotionality was also considered to promote motivation and awareness. (e.g., pathos, Kairos). Nevertheless, it is possible to include other principles according to the requirements of the pedagogical goals.

Table 1. List of persuasive principles for engineering design. Based on [2, 3, 4]

N	Principle	Definition
1	Big Names	Use experts and important people to support your argument
2	Logos	Use logic, number, facts, and data to support your argument
3	Pathos	Appeal to the user's emotions
4	Kairos	Build a sense of urgency for the cause
5	Research	Use studies and information to make your argument seem more convincing. Use words, graphs, tables, illustrations
6	Tunnelling	To lead users through a pre-determined sequence of actions or events, step by step.
7	Tailoring	To provide features that are specific to the individual to enable better a particular behaviour (customize)
8	Suggestion	People are more likely to engage in an activity when it is closely related to what they are currently doing.
9	Conditioning	To reward a target behaviour

3 PEDAGOGICAL MODEL FOR PERSUASIVE DESIGN

This article presents a pedagogical model that outlines the principles and methods based on persuasive design to facilitate learning experiences in engineering students around sustainability issues and provides a structured approach for designing, delivering, and assessing educational activities to measure and make decisions on the learning-teaching process.

The pedagogical model aims to motivate and engage students in actively addressing sustainability challenges during their undergraduate studies and, therefore, future engineering work. By incorporating sustainability into engineering design education, students can better understand the importance of sustainable practices and their impact on society and the environment. In addition, the pedagogical model seeks to empower future engineers to apply their knowledge and skills to create innovative and sustainable solutions, fostering a culture of responsibility, awareness, and stewardship within different engineering fields.

The methodological approach proposed covers the FEEL-THINK-DO model and the different levels of Bloom's taxonomy to ensure a robust response from students regarding the factor or persuasion. As a novel element, this approach considers persuasion applied to students and by students implementing sustainability aspects. Table 2 synthesizes the main components of the proposed pedagogical model.

3.1 Implementation approach ON STUDENTS

The first approach of the pedagogical model is centred on students. Persuasion principles are included in pedagogical activities following the FEEL-THINK-DO model and progressively considering Bloom's taxonomy to create an incremental development of competencies during the courses or modules. Figure 1 shows the approach for persuasive design ON STUDENTS, and Table 3 maps the FEEL-THINK-DO model to the engineering topics, learning resources, and principles of persuasion.

Table 2. Summary of main components of the proposed pedagogical model based on persuasive design

Component	Description	For the proposed model
Learning Objectives	Goals that students are expected to achieve	<ul style="list-style-type: none"> To increase self-awareness about sustainability issues To identify and implement sustainability indicators to measure the environmental impact To apply design tools to reduce or improve sustainability indicators in design projects. To implement persuasive principles in their design projects to persuade others
Instructional Methods	Approaches used to deliver the content and teach students	<ul style="list-style-type: none"> Lectures Case studies Design projects Role-play activities
Assessment Methods	Tools and techniques used to measure student's learning and progress	<ul style="list-style-type: none"> Project presentations assessed through rubrics. Surveys about persuasion impact on students Surveys about persuasion impact on others
Learning Resources	Materials and tools used to support the educational activities	<ul style="list-style-type: none"> Documentaries Sustainability reports, including indicators. Online learning platforms
Learning Environment	The physical and social context in which learning occurs	<ul style="list-style-type: none"> Classroom design oriented to collaborative work. Design thinking-based approach
Feedback and Evaluation	Feedback activities aimed to improve the learning and assess the effectiveness of the pedagogical model itself	<ul style="list-style-type: none"> Group-based feedback Co-evaluation and self-evaluation during the presentation of projects

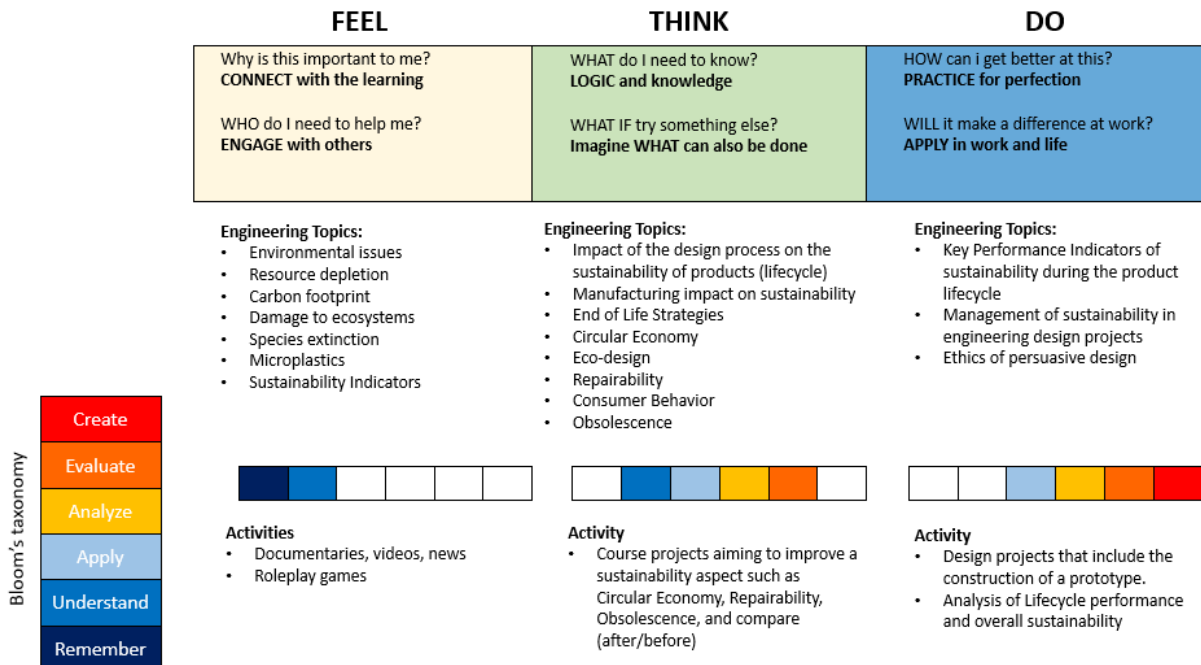


Figure 1. Approach for persuasive design ON STUDENTS

Table 3. Persuasion principles recommended for each engineering topic of the proposed model

Main Process	Engineering Topic	Learning resources recommended	Persuasion Principles from Table 1
FEEL	Environmental issues	Videos, Video	1,2,3,4,6
	Resource depletion	Documentaries,	1,2,3,6
	Raise of Carbon Footprint	Sustainability reports	1,2,4,6
	Damage to ecosystems	about resource depletion,	1,2,3,4,6
	Species extinction	species extinction, global	1,2,3,4,6
	Microplastics	warming, interviews to	1,2,3,4,6
	Sustainability indicators	experts, news	1,2,6
THINK	Design impact on product sustainability	Lectures, documentaries, sustainability reports,	1,2,5,6
	Manufacturing impact product sustainability	scientific articles, self-diagnostics about the	1,2,5,6
	End of life strategies	environmental footprint	2,5,6
	Circular Economy		2,5,6,8
	Eco-design		2,5,6
	Repairability		2,5,6
	Consumer behaviour		1,2,4,5,6,8
	Obsolescence		1,2,4,5,6,8
DO	KPI of sustainability during the product lifecycle	Lectures and group activities, design	5,6,7,8
	Management of sustainability in engineering design projects	workshops and presentations	6,7,8
	Ethics of persuasive design		1,2,5,6,7

3.2 Implementation approach BY STUDENTS

Once students fulfil the different levels of the pedagogical model, the next step is to generate awareness about how persuasion can be involved in product design for others. For this approach, seven persuasion elements are proposed to be included across the product design process to influence the behaviour of final users.

The seven persuasion elements proposed in this section were selected based on product design approaches related to sustainability and lifecycle [5], emotional product attachment [6], and product lifetime extension practices [7], which are useful strategies to battle product obsolescence, rapid product replacement, and unsustainable consumption patterns. However, the success of the persuasive design, also largely depends on the self-consciousness about sustainability issues, cultural background, and consumption behaviour of the user of the product.

Figure 2 maps the persuasion elements to the product design steps and the persuasion principles from Table 1.

3.3 Assessment of persuasion effectiveness

Since the proposed pedagogical model can be applied to both ON STUDENTS and BY STUDENTS, it is necessary to formulate a proper set of assessment activities to evaluate the effectiveness of the persuasive design approach to students and others after implementing the model. Table 4 summarizes the main structure of assessment activities for students and others.

Persuasion elements	Def of requirements	Conceptual Design	Basic Design	Detailed Design	Persuasion Principles Involved
Personalization / Exclusiveness	✓	✓	✓		6,7
Product simplification	✓	✓	✓		9
Open Architecture of Products	✓	✓			6,7
Materials with low environ. impact	✓	✓	✓		5,6,7
Lifetime Extension	✓	✓	✓		7,9
Measurement and display of environmental impact during the lifecycle				✓	2,3,4,5
Display of all persuasion elements				✓	1,2,3,5

Figure 2. Persuasive elements to be included in product designs by students

Table 4. Assessment activities recommended for the proposed approaches

Approach	Assessment activities	Performance Indicators
ON STUDENTS (Subject: students)	<ul style="list-style-type: none"> Surveys about sustainability awareness (Likert Scale) Presentation of design projects assessed by rubrics. Co-evaluation, self-evaluation 	% of change (Likert scale) Position change of sustainability aspects in the hierarchy of product attributes
BY STUDENTS (Subject: others)	<ul style="list-style-type: none"> Surveys about sustainability awareness (Likert Scale) Surveys about purchasing motivation. 	Specific rate of Y/N responses (i.e., Would you buy this product or not?)

4 ETHICAL CONSIDERATIONS

Persuasive design influences people's behaviour by incorporating psychological techniques in the design process. While persuasive design can be used for positive purposes, such as encouraging healthy habits or sustainable behaviour's, it can also be used for manipulative or harmful purposes, such as exploiting users' vulnerabilities or promoting addictive behaviours [5]. As such, it is essential for engineering students to be aware of and consider the ethical implications of their design choices and to use persuasive design ethically and responsibly. The main ethical implications of persuasive design are mentioned as follows:

- **Deception and Manipulation:** users cannot be aware that they are being manipulated through persuasion, even using misleading or false information.
- **The exploitation of Vulnerabilities:** persuasive design can take advantage of people's vulnerabilities, fears, desires, and insecurities to persuade them to take specific actions. This negative reinforcement can lead to anxiety and depression.
- **Privacy Interests:** persuasion facilitates the collection and use of personal information (i.e., purchasing history, social media activity, location, among others) to create more effective persuasive tactics. This situation enables privacy concerns, especially when users are unaware of how their personal information is used.
- **Harmful Behaviour:** through persuasion is possible to promote addictive behaviours, such as excessive shopping, use of social media, gambling, or consuming food products. This leads to mid and long-term negative consequences, such as addiction, financial problems, and mental health issues.
- **Accountability and Responsibility:** persuasive design raises questions of responsibility and accountability, particularly when the design is used for harmful or unethical purposes. Future

product designers using persuasive design will be responsible for being transparent about their practices and ensuring that they are not causing harm to individuals and society.

5 CONCLUSIONS

This article presents a pedagogical framework to incorporate persuasive design in the engineering curriculum. The framework is based on the FEEL-THINK-DO that follows a progressive learning journey through Bloom's taxonomy. The pedagogical model has two main components. In the first one, students learn about persuasion principles and how they relate to engineering topics. In the second part, students identify the persuasion elements and how they relate to the design process and the persuasion principles. The idea is that students navigate from a personal learning experience about engineering and persuasion principles to a discipline-specific application of persuasive design. Since design impacts users' behaviour, it is imperative to educate students about the ethical implications of this design approach. Therefore, responsible, and ethical use of persuasive design must be part of the educational plan. The proposed framework will be implemented through the development of learning modules. The authors are socializing the framework with different stakeholders before moving to the implementation process.

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