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## Article

# Stimulating Engineering Students' Potential for Sustainable Development

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**Abstract:** Engineers can play a critical role in achieving sustainable development (SD). Despite this, there is a lack of specialized courses delivered in the undergraduate engineering curricula in Lebanon. The purpose of this study is to assess the outcomes of a newly developed core course on sustainability for engineering students integrated into the undergraduate engineering curriculum at one university in Lebanon. The study makes an original contribution as no similar course, in its current structure, has been found in the existing literature. A quantitative methodology was employed through a survey administered to the students both before and after course delivery. The survey aimed to assess the effectiveness of the course in changing students' awareness, perceptions, practices, and views on the engineering profession and how it relates to sustainability. The findings indicate that the course has significantly enhanced the understanding and awareness of the engineering students regarding sustainable development. This enhancement impacted positively on their perceptions, practices, and views regarding the importance of sustainable development in engineering education. This study presents an interdisciplinary course integrated into the engineering curriculum and augmented the students' awareness and knowledge on how to incorporate sustainable development into their design processes.

**Keywords:** sustainability; engineering education; higher education; course; curriculum; Lebanon



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## 1. Introduction

Societies around the world are facing various challenges in terms of sustaining quality of life with the exponential increase in the population worldwide. Sometimes, a lack of common sense engulfs thinking, with selfishness presiding over the main resources available and the needs of future generations being ignored. Hence, higher education in countries facing economic, social, and political crises is, like elsewhere in the world, confronted with the challenges of sustainable development (SD). However, the case of economically developing countries differs from the long-industrialized countries of Europe, North America, and elsewhere, by facing even more complex social, economic, and environmental issues. The population aspires to a better quality of life, access to personal transportation, housing, and a more stable economic situation. In this context, environmental, social, and economic issues compete with each other and sometimes even contradict one another. This makes the challenge of education on SD issues even more complex and difficult, but no less urgent. As such, the United Nations (UN) introduced in 2015 a set of 17 Sustainable Development

Goals (SDGs) to ensure a sustainable world by 2030. These SDGs intend to hopefully offer a path forward for present and future generations to reduce poverty and improve the lives of people globally (UN-SDGs Agenda) with higher education institutes playing a major part in raising awareness and knowledge [1]. Given that Lebanon is confronted with significant political challenges due to its geographical location, surrounded by hostile countries affecting its economic growth, as well as its aspirations to enhance environmental and social aspects, research on education for societal transitions deserve particular attention.

Amongst all the 17 SDGs, SDG4, which focusses on education, is probably the core SDG that should enable the promotion and achievement of all other 16 goals [2]. UNESCO advocated that “Education for Sustainable Development” has to be integrated into all curricula of formal education, including early childhood care and education at primary and secondary education through technical and vocational education and higher education [3]. The latter emphasizes the Accreditation Board for Engineering and Technology (ABET) requirements that were published in 2010 for the inclusion of sustainability in engineering education. According to the ABET standards, engineering students should be capable of designing “a system, component, or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability” [4]. Whilst ABET is considered the accreditation board of interest in our university due to our curriculum structure, all other accreditation for engineering education boards equally encourage the same approach; for example, the European Network for Accreditation of Engineering Education (ENAE) [5]. As such, accreditation agencies have a major role in pushing and encouraging SD integration into curricula.

Given that the field of engineering is always evolving due to the rapid advances in technology, there is, therefore, an increasing need for universities to prepare their engineering students to contribute to SD [6]. The latter is critical due to the increasing demands on the Earth’s resources from a growing global population, which makes the role of engineers more fundamental to help meet the UN SDG targets as engineers are educated and trained to solve problems with innovative designs. Engineers can significantly impact people and the planet, and hence, it is crucial to integrate sustainability into the engineering curriculum. As such, engineering education is key to train cohorts of professionals to meet the needs of businesses and industries through their leading roles as innovators and their ability to think outside the box. Educators have an enormous task to revise courses and curricula to ensure that engineering graduates are well prepared and equipped to tackle these new challenges as practicing engineers [2,7].

Unfortunately, despite the many attempts to introduce a change into engineering curricula to integrate SD, the implementation seems to have been challenging. Nevertheless, several engineering schools have made substantial updates to their courses and curricula over the past few decades, as highlighted by Nakad et al., who demonstrated considerable dynamism for change, at least in terms of ambition within engineering education institutions. However, the realization of these changes is often slow and difficult to establish [2]. This movement reflects a forward-thinking effort by these institutions to inspire others to follow suit. As such, colleges and universities have recently started to include topics of sustainable engineering, such as life cycle assessment, renewable energy concepts, and waste minimization methods, into their course material. The need for change is urgent if the SDGs’ objectives are to be met. Graduating engineers may not fully grasp the constraints of limited resources and waste management [7] or even recognize that sustainability is based on three pillars: environmental, economic, and social.

In order to make this change, a constructive approach is needed. Following Kolmos et al.’s review [8], following in Sterling’s 2001 footsteps, who is considered to be one of

the pioneers in the literature on education for SD (ESD) and engineering education for SD (EESD), three different strategies of educational approaches to sustainability could be implemented:

1. Add-on strategy: Education about sustainability is an assimilation strategy where sustainability subjects are included in the formal curriculum. There is no change in the educational paradigm.
2. Integration strategy: Education for sustainability includes content and values, and will involve some modifications of the program, but the educational paradigm remains intact.
3. Rebuild strategy: Education as sustainability is a transformative, epistemic learning response and will involve an educational paradigm shift involving the whole learning person and the entire institution (or at least a whole faculty or school).

A recent study was conducted at the University of Balamand in Lebanon to assess engineering students' awareness of sustainability. The study found that while there are good levels of sustainability awareness, knowledge of the Sustainable Development Goals (SDGs) is lower among their engineering students when compared to their European counterparts [9,10]. Despite facing challenging lifestyles due to decades of civil unrest and economic meltdown, the engineering students demonstrated motivation and a strong positive attitude towards addressing sustainability issues in their country. The results also indicated that students perceive the university as not sufficiently promoting the principles of SD, even though there are many ongoing successful funded projects on SD. Most participants expressed a strong interest and positive attitude towards contributing to making their university more sustainable. Therefore, the study concluded that significant improvement could be achieved by integrating SD into the engineering curriculum in a clear and constructive manner, preparing students to become responsible and active citizens capable of building a more sustainable world.

As such, there was an urgent need to act, and the add-on strategy was adopted by adding a new course "SD for Engineers" to the undergraduate engineering curriculum. The purpose of this paper is to assess the effectiveness of the course in changing students' awareness, perceptions, practices, and views on the engineering profession and how it relates to sustainability before and after the course delivery. Our hypothesis is that the course will improve the engineering students' understanding of the importance of sustainability.

## 2. Incorporating Sustainability Courses into Engineering Curriculum

In order to integrate sustainability into the engineering curriculum, the approach of the add-on strategy, which is adding a sustainability-related course, has been adopted by many universities. Ashraf and Alanezi encouraged the adoption of a new strategy, the micro curriculum strategy, and the introduction of a standalone course in order to integrate sustainability into the engineering curriculum [11]. However, based on their study, they found out that it is more effective to develop and integrate a standalone course that familiarizes students with the concept and principles of sustainability. The literature indicates that this approach had been widely adopted even before the launch of the SDGs in 2015. At the Technical University of Denmark, Olsen et al. introduced the course "Sustainability in Engineering Solutions" which aimed to provide engineering students with the basic concept of sustainability and its three dimensions [12]. It had equally provided them with an overview of a number of tools for the analysis of problems and the synthesis of solutions that are sustainable throughout their life cycle. The course encouraged critical thinking in the students' projects. Project-based learning was used, but identifying suitable projects was challenging due to the diversity of the technical fields.

Additionally, the School of Engineering of the Polytechnic Institute of Porto proposed an E4SD 2014 Summer Course under the framework of sustainability [13]. The main objectives of the course were to assess the institutional ability to host international teaching initiatives, even from countries with substantially different cultures. The results achieved were encouraging, as the experimentation of teaching at an international and intensive level was challenging and motivating, and the inclusion of multiple cultures allowed the analysis of different perspectives. The experience showed that it should be replicated, possibly with students coming from other cultures, and was the seed for establishing a formal offer of graduation courses. It proved that the Problem-Based Learning approach is a way of promoting the integration and inclusion of multiple cultures.

Svanström described a new course that had been added in Spring 2015 for first-year students at Chalmers University of Technology in Göteborg, Sweden [14]. It fell under chemical engineering and focused on the professional role of engineers in order to develop more changes towards SD. Students were asked to complete two projects: an individual one in which they had to change then assess a sustainable action in their daily lives, and the second one was a teamwork approach to making a considered sustainability-motivated change in the chemical industry.

Gröndahl and Franzen introduced the “Applied Ecology” course to first- and second-year master’s students enrolled in the sustainable technology program at the division of industrial ecology at KTH-Royal Institute of Technology in Stockholm, Sweden [15]. The primary objective of this course was to enhance students’ understanding of ecological methods and demonstrate how ecological knowledge can be effectively applied to address real sustainability challenges in society. Similarly to project- and problem-based learning courses, their program emphasized real sustainability issues and adopted a student-centered learning approach, offering practical insights into complex societal challenges. To further enhance the course, increased communication was recommended before, during, and after fieldwork among students, teachers, and stakeholders.

In their 2016 study, Barrella and Watson examined the conceptual sustainability knowledge of students from the Georgia Institute of Technology and James Madison University [16]. These institutions employed distinct approaches to incorporating sustainability into their curricula. The former adopted a vertical integration approach by introducing a dedicated sustainability course, while the latter opted for horizontal integration by integrating sustainability concepts into existing courses. The researchers utilized concept maps to explore the question, “What is sustainability?” The findings revealed that students exposed to the horizontally integrated curriculum exhibited more extensive, profound, and interconnected knowledge compared to their counterparts in the vertically integrated curriculum.

Hsiao and Elshafei shared a case study about an international collaboration of an introductory engineering course called “sustainability in engineering design” between the University of Prince Edward Island and the Universities of Canada in Cairo, Egypt [17]. Their course covered sustainability concepts which are related to the interactions among humans, living systems, the natural environment, and the engineered world. Physical, chemical, biological, ecological, social, economic, and life-cycle principles were introduced, as was how they related to sustainable engineering design. The course focused also on professional ethics, environmental stewardship, and health and safety in Canada and Egypt, highlighting cultural and contextual aspects. Simson and Davis introduced a new interdisciplinary course on sustainability and alternative energy at The Cooper Union, a small, primarily undergraduate institution [18]. The course aimed to introduce students to SD to optimize energy system design towards a near-zero-carbon world. It also covers life cycle assessment and interdisciplinary issues. Designed to be interactive, the course

includes in-class discussions and group projects. The authors' assessments found that, despite the limitations of a remote format, students from various disciplines successfully met the course learning objectives.

The approach of the add-on strategy continues to be adopted to this day. Molina-Solís et al. discussed in their study the integration of SDGs into the Biomimetics and Sustainability course at Tecnológico de Monterrey, involving 194 students [19]. The students were asked to create a proposal using wind or solar resources to generate electricity in their region and select three or more SDGs aligning with their proposal. The study found that including SDGs in class assignments made learning more meaningful, and the authors hoped this will inspire more teachers to incorporate the SDGs into their students' projects. Gerosa also presented a work in progress on developing a course aimed at enhancing systems thinking skills in engineering students while promoting sustainability and ethics [20]. The course is aimed at encouraging engineers to consider non-technical aspects and environmental and social impact in their designs. Introduced as a 6 h teaching unit at the University of Padova, it aimed to familiarize students with systems thinking, sustainability, and ethical issues. Student feedback was encouraging, and future developments will focus on course implementation and assessing learning outcomes. The author plans to design a full 24 h course and develop a procedure to assess the skills acquired.

### 3. The Course Background

A collaborative research project commenced in 2022 including our Lebanese University and an engineering institute in France, ENSTA, in its Brest campus, by conducting a survey amongst the engineering students to evaluate their awareness and perception of sustainability. The survey revealed a serious lack of understanding and awareness of sustainability amongst the Lebanese students despite the numerous funded projects being conducted at the university and underlined an urgent need to develop a new course focusing on sustainability. To address this, a new course entitled "Sustainable Development for Engineers" was designed by the corresponding author between June and August 2023. It was approved by the Faculty Council in August 2023, integrated into the engineering curriculum at the University of Balamand in Lebanon in September 2023, and has been delivered by the corresponding author since then.

When the proposal was submitted to the Dean of the Faculty of Engineering in May 2023, the Dean responded very positively, especially after recognizing the significant gap in the curriculum regarding sustainability. Despite facing many challenges, the Dean decided to replace a core civilization course with the newly developed course, SD for Engineers. This change marked a turning point for the Faculty of Engineering, and the course became a core course, requiring all undergraduate engineering students to study as a prerequisite before they embark on their senior design projects to address a significant gap in the curriculum required for ABET re-accreditation, which our university is required to achieve for its engineering degrees to be accepted in Lebanon and globally due to its American curriculum model. The course was given a General Engineering code, GENG222. This code has now been revised to SUST229, to give sustainability a more prominent stance in the curriculum, which has equally paved the way to introduce a new series of courses at the university offered to non-engineering students related to sustainability principles.

The course is structured to introduce the fundamental and advanced concepts of SD. It transitions students' understanding of the SDGs to focus specifically on the critical role engineers play in achieving these SDGs. Students should then be able to resolve problems by adopting sustainability principles, which should in turn reflect on the students' multidisciplinary design ability to ensure a proper sustainable design process to improve and preserve the quality of life of future generations. It is worth noting that students have

to have completed an Introduction to Design course before they are allowed to register on the new SD for Engineers course.

The course is divided into two parts. The first part ensures that students become familiar with the concept of sustainability and SD, its definition and history, the SDGs, the role of engineers in each SDG, the interactions among the SDGs, and methods for assessing sustainability. Assessment for this part includes an exam and an individual oral presentation. Given that engineers design projects with lasting economic, environmental, and social impacts, it is crucial that students become equipped with the necessary conceptual knowledge to engage in sustainable design. In the second part, the engineering students learn the steps to create sustainable designs through a set of instructions. They work in groups of 3–5 students to submit a final report and a presentation of their interdisciplinary design. Students are strongly encouraged to build their teams with members from other disciplines and to choose their own projects' ideas reflecting multidisciplinary. The latter meant that engineering students were exposed to engineering disciplines other than their own and able to collaborate crossing boundaries for the first time.

Upon successful completion of this course, the engineering students are expected to:

1. Define the concept of SD for its global impact on engineering solutions.
2. Integrate the principles of SD, along with its three main pillars, into the engineering design process.
3. Demonstrate effective teamwork skills by collaborating with peers from different disciplines on engineering projects related to SD.
4. Recognize the essential role that engineers play in achieving SDGs.
5. Communicate with audiences through professional presentations.
6. Demonstrate innovative thinking by designing sustainable solutions, and become agents of change.

The course's design was pivotal, yielding instant positive outcomes for students' SD education, allowing them to choose topics aligned with their interests, thereby fostering commitment to sustainability. Through numerous examples of engineering achievements across all SDGs, students gained confidence and understanding of their pivotal role in advancing sustainability, particularly its societal aspects. For the first time, students embraced interdisciplinary collaboration, fostering teamwork with peers from other engineering disciplines.

The course was presented at the Qatar 2023 Expo, raising the profile of the Faculty of Engineering through its new initiative, and serving as a catalyst for promoting sustainable practices within an institution that is situated in Lebanon, a country urgently in need of long-lasting sustainable solutions.

#### **4. Methodological Procedures**

To effectively introduce sustainability into the Faculty of Engineering curriculum, a new course was designed and integrated. To evaluate the effectiveness of this course, a survey was conducted before and after course delivery. In total, 31 students were enrolled in the 2023/2024 fall semester, with 28 students completing the survey before the start of the course and 27 students completing the same survey at the end of the semester after the course ended. The survey was composed of 5 sections:

1. SD understanding and awareness;
2. SD perceptions and interests;
3. SD practices and strategies;
4. SD and engineering profession;
5. Demographic data.

The students completed a Google Forms survey, which included detailed ethical considerations, outlining the study’s objectives, confidentiality policy, participant anonymity, and data storage and handling procedures. Initially, a pilot survey with 15 students was conducted to gather feedback, which was used to refine the final survey. The survey link was distributed to students during the first and last sessions of the course.

## 5. Results

### 5.1. SD Understanding and Awareness

Before the course started, 57.1% of students indicated that they understood the concept of sustainability, but only 7.1% felt confident enough to explain it, and just 35.7% were aware of the 17 SDGs. After the course ended, 96.2% reported that they understood the concept of sustainability, felt confident in explaining it, and were aware of the SDGs (Figure 1).

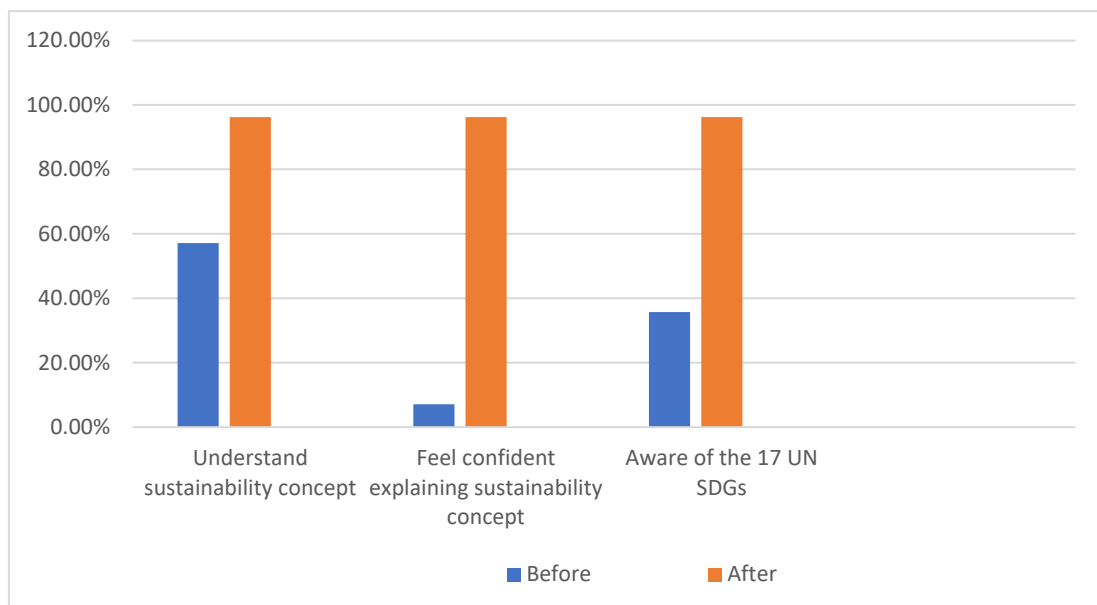


Figure 1. Concept awareness before and after the course.

The number of students who identified schools or universities as their primary source of sustainability knowledge increased from 15 to 26, post course delivery (Figures 2 and 3). Additionally, the number of students who recognized books, documentaries, or personal interests as sources of their sustainability knowledge rose from 8 to 14. Notably, no students reported having no knowledge of sustainability after completing the course.

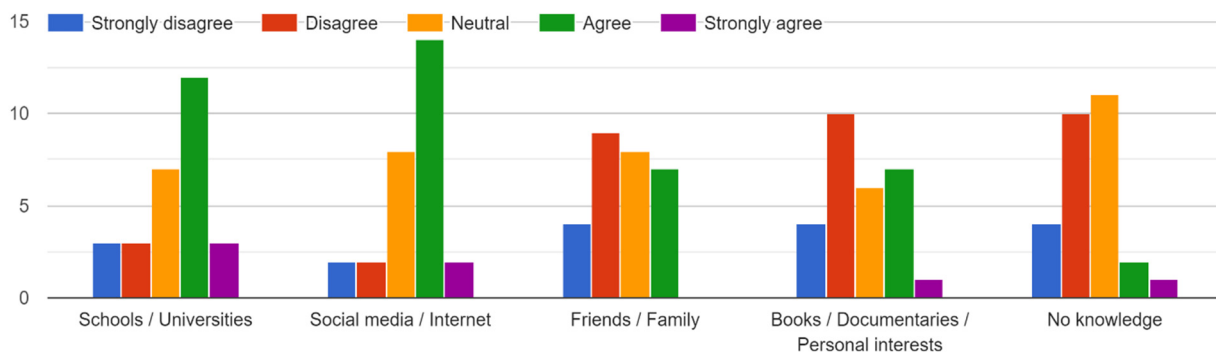


Figure 2. Sources of knowledge before the course.



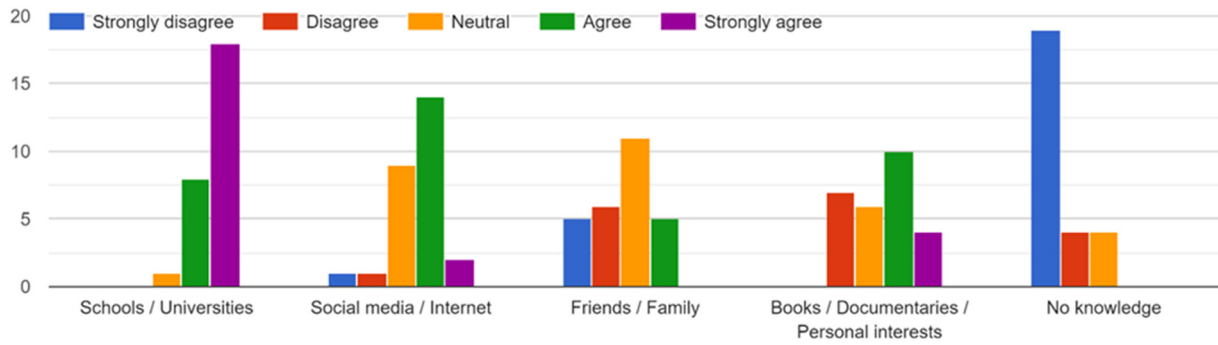


Figure 3. Sources of knowledge after the course.

Before the course, most students associated sustainability primarily with environmental preservation (Figure 4). However, after course delivery, 96.3% considered sustainability to be an approach to developing or growing by using resources in a way that allows for them to renew or continue to exist for others (Figure 5). They agreed that, in addition to its general definition, sustainability also involves creating a well-balanced society with equal rights. Only 14.3% of the students had chosen this perspective before the course, but this number increased to 40.7% after the course ended.

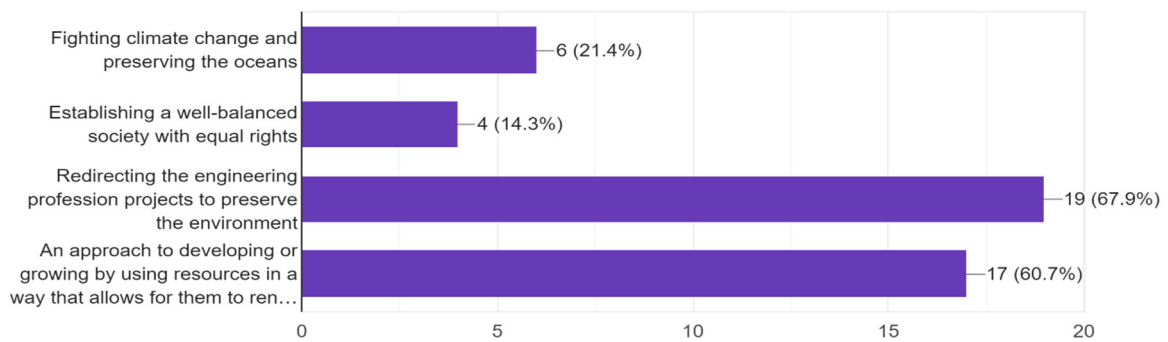


Figure 4. Sustainability definition before the course.

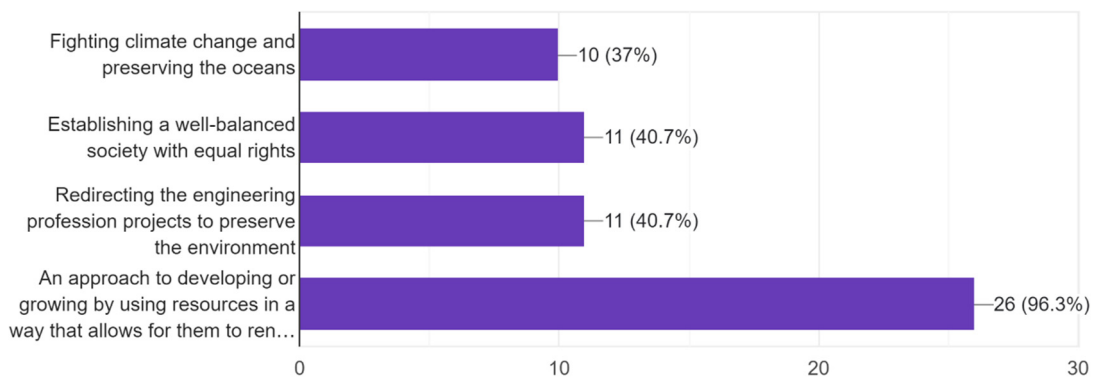


Figure 5. Sustainability definition after the course.

5.2. SD Perceptions and Interests

Before the course (Figure 6), 27 students believed that SD projects should primarily address environmental issues, 25 thought they should focus on economic issues, 19 on social issues, and 8 on political issues. However, after completing the course (Figure 7), all 27 students agreed that SD projects should encompass environmental, economic, and social issues, with 23 students also recognizing the importance of addressing political issues.

It is worth noting that students were asked to answer each issue by choosing one of the following options: Not related at all, Less related, Neutral, Related, Strongly related.

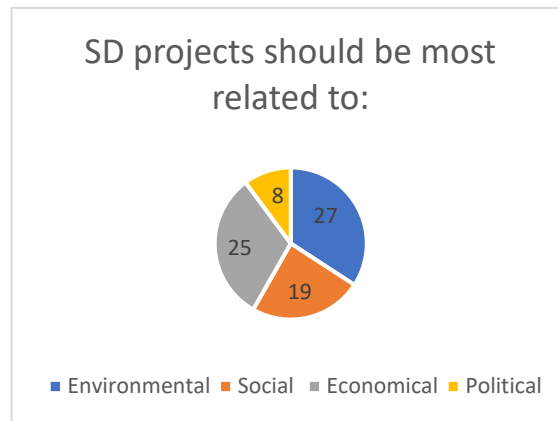


Figure 6. Before course.

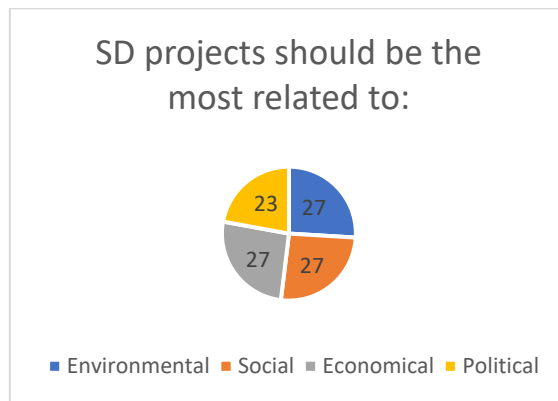


Figure 7. After course.

Students were given the same statements about SD before and after the course to check their points of view regarding sustainability. Before the course, a majority of 96.4% of the students believed once again that sustainability is related to environmental matters. After the course the majority, numbering 92.5% of the students, believed that SD is a much broader concept that improves people’s quality of life (Figures 7 and 8).

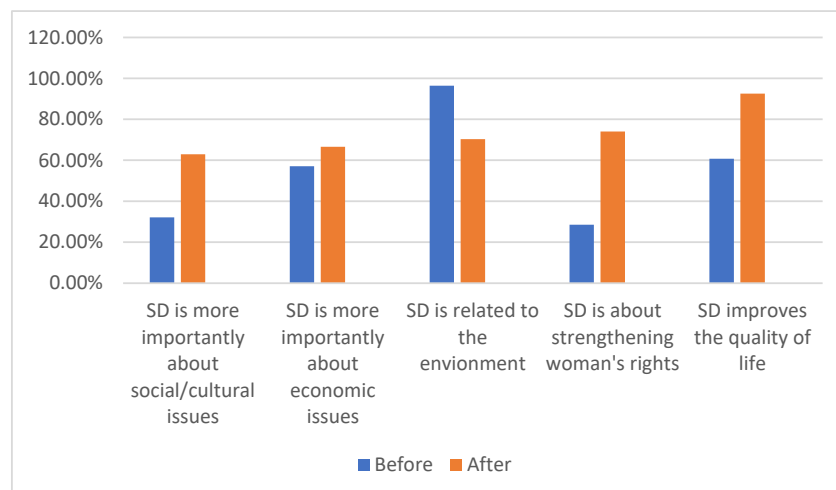


Figure 8. Statements about sustainability before and after the course.

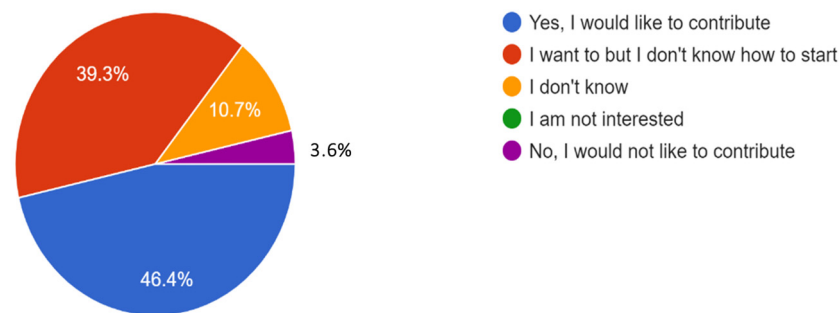
### 5.3. SD Practices and Strategies

The results regarding students' practices slightly improved, as per Table 1:

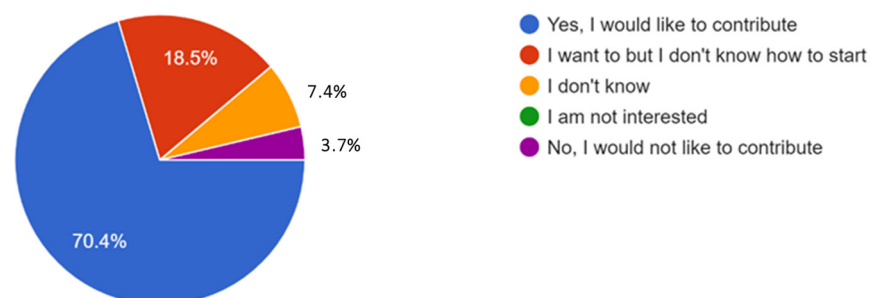
**Table 1.** SD practices before and after the course.

Practices	Before	After
Minimize energy	92.8%	96.2%
Walk, cycle, use public transport	78.5%	92.5%
Use eco-friendly and green energy products/materials	100%	100%
Environmentally friendly initiatives (cleaning, forestation, waste separation)	92.8%	96.2%

The number of engineering students who would like to contribute to making their university a more sustainable place slightly improved from 85.7% to 88.9% after course delivery, which provided ample examples on specific research centers, e.g., life cycle assessment (LCA) and geographical information systems (GISs), and EU-funded projects that are geared towards sustainability (Figures 9 and 10). The number of students who would like to contribute but do not know how to start has decreased from 39.3% to 18.5%, indicating a positive increase in students' knowledge of sustainability.



**Figure 9.** University contribution before course.



**Figure 10.** University contribution after course.

### 5.4. SD and Engineering Profession

Before the course, engineering students were aware of their key role in achieving sustainability. After the course, the percentage of students who were confident about their important role increased from 92.8% to 100%, and those who believed that SD can only be achieved through the engineering profession rose from 39.2% to 44.4% (Table 2). Additionally, the percentage of students who felt that knowledge of SD enhances their employability increased from 78.5% to 92.5%. Conversely, the percentage of students who believed that the engineering profession in Lebanon encourages its engineers to apply SD

practices decreased from 35.7% to 22.2%, which unfortunately reflects the true reality in Lebanon as the students have now understood the concept better.

**Table 2.** Students' perspectives regarding SD and engineering profession.

	Before	After
Engineers are key players in achieving sustainability	92.8%	100%
SD can only be achieved through the engineering profession	39.2%	44.4%
The engineering profession in Lebanon encourages its engineers to apply SD practices	35.7%	22.2%
Engineering students with SD knowledge have a higher chance with employability	78.5%	92.5%

## 6. Discussion

We can focus our discussion on key relevant points as highlighted by the students' survey in connection with the literature.

### 6.1. SD Understanding and Awareness

The newly introduced course has significantly enhanced the undergraduate engineering students' understanding and awareness of SD. According to Figure 1, before the course, 57.1% of students understood the concept of sustainability, but only 7.1% felt confident enough to explain it, and just 35.7% were aware of the SDGs. This suggests that their understanding was superficial, with 57.1% merely having heard of the concept. After the course, 96.2% of students felt confident explaining sustainability. Our results complement those of Ashraf and Alanezi, who advocated to develop and integrate a standalone course into the curriculum [11].

The above was further complemented with no students having reported no knowledge of sustainability after completing the course (Figure 3). As per Figure 4, most students before the course associated sustainability primarily with environmental preservation. However, after the course, as per Figure 5, 96.3% considered sustainability to be an approach to developing or growing by using resources in a way that allows for them to renew or continue to exist for others. The latter is in line with Svanström's findings of the SD course introduced to encourage first-year engineering students to assess sustainability in their daily life [14]. It is crucial to note that the source of knowledge impacts the quality of information students receive. Before the course, most engineering students, as indicated in Figure 2, identified social media and the internet as their primary sources of SD knowledge. However, after the course, most students indicated that schools and universities were their primary source of SD knowledge. This shift demonstrates that social media and the internet alone cannot provide comprehensive SD awareness, underscoring the need for formal education and core courses like this one to promote SD knowledge, as was the case with Gröndahl and Franzen who introduced a new course of "Applied Ecology" to enhance their students' knowledge about ecological methods [15].

Additionally, Figures 2 and 3 reveal that the number of students who recognized books, documentaries, or personal interests as sources of their sustainability knowledge increased from 8 to 14. This indicates that the course encouraged students to read, research, and make personal efforts to learn more about sustainability.

### 6.2. SD Perceptions and Interests

It is evident that, before the course, the engineering students did not recognize the connection between sustainability and social issues, perceiving it to be solely an environmental matter, as indicated in Figures 4, 6 and 8, and in line with Nakad and Kovesi and Nakad et al. [9,10]. After completing the course, the students understood that sustainability also involves creating a well-balanced society with equal rights (Figure 5). The students agreed that SD projects should encompass environmental, economic, and social issues (Figure 7) and improve overall quality of life (Figure 8). This proves without any doubt that introducing such a focused course on SD made learning more meaningful, complementing the findings of Molina-Salís et al. [19].

### 6.3. SD Practices and Strategies

Table 1 shows a surprising outcome, that SD practices were already high among students before the course, which contradicts the results in Figure 9 that show that 39.3% of the students wish to contribute to SD practices and strategies but do not know how. Whilst the course had contributed to a slight improvement in these practices, it is important to point out that the surprisingly high percentages in Table 1 may reflect the students' common sense in comparison to their lack of knowhow to contribute to SD actions. Students were already interested in taking environmental actions for the planet, and the course provided a modest boost to this interest. Regarding the number of engineering students who wanted to make their university more sustainable, there was a slight increase after course delivery (Figures 9 and 10). A significant improvement was observed in the number of students who wanted to contribute but did not know how to start, which decreased. This demonstrates that the course played a crucial role in raising awareness, as many students developed a clear strategy and understanding of where to start after completing the course. It proves that the course clarified the concept of sustainability and showed them how to work and think for sustainability.

### 6.4. SD and Engineering Profession

Regarding SD and the engineering profession, Table 2 indicates that, prior to the course, engineering students were aware of their key role in achieving sustainability. After the course, the percentage of students who felt confident in their important role and those who believed that SD could only be achieved through the engineering profession increased, confirming the role engineers had been playing for years [21].

Additionally, Table 2 shows that the number of engineering students who believed that knowledge of SD enhances their employability also rose after the course. However, the percentage of students who felt that the engineering profession in Lebanon encourages its engineers to apply SD practices decreased. This indicates that after gaining a deeper understanding of the broad concept of sustainability, engineering students became more aware of their vital role in achieving it and recognized that working on sustainability could enhance their job prospects. The latter is in support of the findings of Barrella and Watson, who showed that the horizontally integrated curriculum enhanced the engineering students' profound knowledge of SD [16]. At the same time, they also realized that their country does not support or encourage the application of sustainable practices.

## 7. Conclusions

The study presented in this article introduced a newly added course on sustainability for engineering students and demonstrated its positive outcomes. The course was first introduced, then the same survey was conducted before and after the course delivery to the first batch of students in fall 2023–2024 to assess its effectiveness. The survey results proved

that the course significantly improved the understanding and awareness of engineering students regarding SD from only 7.1% to 96.2% of students feeling confident in explaining sustainability. This improvement influenced their perceptions, practices, and views on the importance of SD in engineering education. As such, the importance of publishing the results from the first cohort is to show the instant impact the course had and to share this experience with the aim of inspiring similar initiatives at other universities in Lebanon and globally.

Our analysis emphasized the importance of obtaining SD knowledge from higher education institutions (HEIs). It is evident that a better understanding is achieved, enabling engineering students to recognize the significance of their role in achieving sustainability with the percentage of students who were confident about their important role increasing from 92.8% to 100%. This underscores the necessity of integrating such courses into the curriculum. After taking the course, engineering students shifted their opinion from seeing sustainability solely as an environmental issue to understanding its social, environmental, and economic pillars. The course encouraged students to consider social matters, which are often overlooked in engineering. Thus, the course highlighted the importance of social issues in the context of sustainability. Furthermore, the study showed that once students comprehended the concept, they realized that committing to sustainability, even in an unsupportive country, may enhance their employability.

Future work will involve analyzing students' deliverables and design projects to provide qualitative results regarding their understanding of the concept and to identify which SDG(s) the engineering students aim to target in their future careers after gaining detailed knowledge in this course.

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