SUSTAINABLE MINDS: A LEARNING EXPERIENCE ENHANCING SUSTAINABILITY AWARENESS THROUGH A CHALLENGE-BASED APPROACH

Soumaya ARGOUBI, Nawress RAFRAFI

ESPRIT School of Engineering, Tunis. Tunisia

ABSTRACT

Contemporary youth will face an exacerbation of environmental, social and economic issues such as deforestation, natural resources use and poverty. According to the World Meteorological Organization report on State of Climate Services published in 2023, air pollution engendered 7 million deaths worldwide in 2020. To raise students' awareness about sustainable development goals, we organized an event on March 4-5 at ESPRIT School of Engineering, celebrating World Engineering Day for Sustainable Development. Our main goal was to emphasize the positive impact of engineers on shaping a more sustainable world. The event structure includes a hackathon, with key phases, starting with keynote speakers to explore critical learning outcomes, followed by an exploration of challenges related to specific united nations sustainable development goals (SDGs) (Nations, 2015). Teams were then engaged in focused design-thinking (DT) and problem-solving sessions, leading to the creation of prototypes. In today's ever-changing educational environment, the ongoing challenge is engaging students while fostering their creativity and critical-thinking skills. This paper delves into the realm of the "Sustainable Minds" Hackathon, a challenge-based learning (CBL) experience that involves faculty members, non-governmental organizations (NGOs), and industry partners. We aim to share our experience and provide valuable insights into the implementation of CBL in higher education, particularly in the context of promoting sustainability and meeting some of the SDGs. We therefore discuss the findings arising from the event, highlighting that the integration of CBL with SDGs marks a major step forward in higher education. This association goes beyond simply improving understanding of real-world challenges; it also underlines the importance of responding to society's needs and promoting responsible innovation.

KEYWORDS

Challenge-based learning, Sustainability, hackathon, Innovation, Standards: 2, 3, 5, 6, 7, 8

INTRODUCTION

Today, in an ever-changing higher education context, the ongoing challenge of engaging and inspiring students, while encouraging critical thinking, is more pronounced than ever. The present paper is a gateway into the exploration of a dynamic educational paradigm - the fusion of challenge-based learning (CBL) (Gallagher & Savage, 2023) with the CDIO standards (Malmqvist, Edström, & Rosén, 2020). A relentless search marks the current educational environment for innovative methodologies, and CBL stands out as a pioneer of transformative pedagogy. By turning students into active participants in their educational journey, it aims to overcome the limitations of traditional learning. As we engage in this exploration, the backdrop is a hackathon - an immersive experience that encapsulates the essence of creativity, collaboration, and real-world problem-solving, all centered on solving global challenges encapsulated in united nations sustainable development goals (SDGs). The following paper is not a theoretical exercise; rather, it's a living journey into the heart of the "Sustainable Minds" hackathon held at ESPRIT School of Engineering on March 4th and 5th, 2023. An event that serves as a learning and development paradigm, moving participants from passive learners to active contributors as they navigate through ideation, design, implementation and operation phases. As a result, the hackathon becomes the canvas on which CBL, CDIO principles, and the pursuit of the SDGs paint a vibrant picture of a redefined educational and learning environment. Looking ahead, our mission is twofold: firstly, to sort out the complexities of CBL in the context of CDIO, and secondly, to highlight the hackathon as a living representation of these principles. The paper is an invitation to educators and stakeholders alike, showcasing how a carefully organized hackathon, guided by the principles of CBL, CDIO, and a dedicated commitment to the SDGs, can potentially push engineering education to new and greater levels. The aim of this paper is not only to attract attention, but also to spark curiosity about the transformative potential at the intersection of cutting-edge pedagogy, CDIO's structured approach and the global impact anticipated by the SDGs. We explore the different aspects of "sustainable minds", aligning them with the global commitment to contributing to a sustainable and equitable future envisaged by the SDGs.

BACKGROUND AND RELATED WORKS

CBL (Leijon, Gudmundsson, Staaf, & Christersson, 2022) constitutes a pedagogical approach rooted in the evolution of experience-based learning methods, which emerged over ten years ago thanks to John Dewey (1938; 1963) and were subsequently further developed in pedagogical approaches such as problem-based learning (PBL) (Krajcik & Blumenfeld, 2006). While PBL often seeks to deepen understanding of academic concepts, CBL is distinguished by a more real-world problem-solving approach, integrating values and adopting an entrepreneurial perspective to societal challenges. Both approaches offer unique opportunities for developing skills and preparing students to proactively address the complexities of the contemporary world. Improved skills in Conceive-Design-Implementation-Operation (CDIO) and conceptual thinking are possible through the effective implementation of DT (Brown et al., 2008) in engineering programs. This approach produces more competent and innovative professionals by leveraging innovative problem-based learning projects (Isa, Mustaffa, Preece, & Lee, 2019). Therefore, it is essential to explore the integration of design thinking and strategic sustainable development. In Shapira, Ketchie, and Nehe (2017) the authors explore the fusion between design thinking and strategic sustainability. It looks at how these two approaches can be harmonized to foster more sustainable design processes. The authors examine possible synergies between design thinking, which focuses on creativity and innovation, and strategic

sustainability, which aims to integrate sustainable principles into organizational activities. The study offers insights into how this integration can lead to more environmentally and socially responsible outcomes. Furthermore, the transition from the CDIO model to challenge-based learning experiences offers an opportunity to enhance student learning while having a wider impact on society. This evolution in engineering education could have significant implications for the way programs are designed and delivered. In-depth study into the effective implementation of these new pedagogical approaches is essential to maximize the benefits for both learners and society as a whole (Kohn Rådberg, Lundqvist, Malmqvist, & Hagvall Svensson, 2020).

EVENT STRUCTURE

The following section explores the entire structure of the event, focusing on the detailed planning and thoughtful insights that define its composition. Through the impactful ideas shared by the keynote speakers to the immersive problem-solving journey encapsulated in the hackathon, they all harmonize to create an educational symphony designed to respond to the principles of active learning, interdisciplinary collaboration and sustainable development.

Registration and group training

Initiating Sustainable Minds is much more than just signing up; a comprehensive form is sent out, providing crucial information not only for administrative purposes but also for strategically forming collaborative teams.

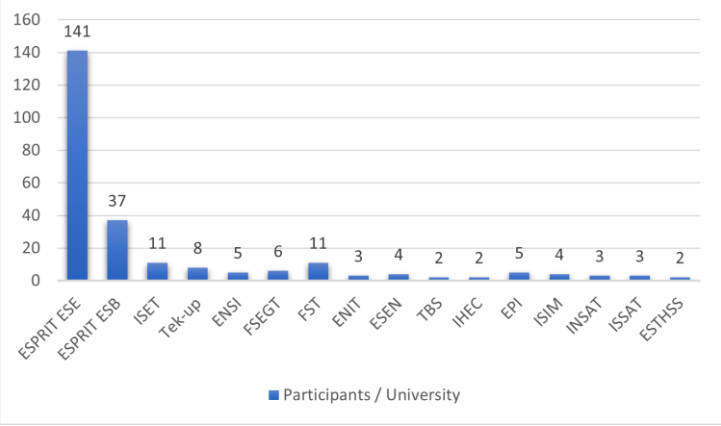

Figure 1. Universities diversity

What adds an extra layer of dynamism to this process is the conscious consideration of including participants from diverse universities, as shown in Figure 1, and varied fields of specialization. In recognition of the value of interdisciplinary collaboration, people from different fields actively contribute to the formation of these groups. Each group, made up of 3 to 5 members, represents a fine example of collaborative performance. The possibility of including a coach further enriches the learning dynamic, providing industry insight and mentoring. And for those without pre-formed groups, a matching process was implemented. Our process ensures that each team represents not only a diversity of skills but also a range of academic backgrounds, to ensure a blend of perspectives.

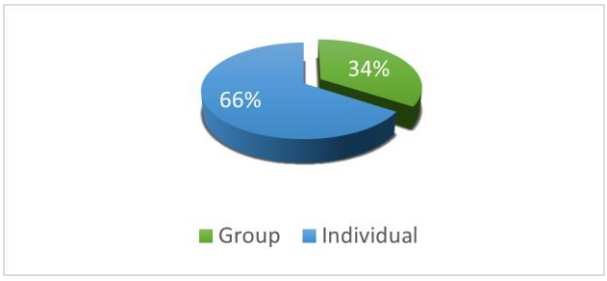

Figure 2. Group vs. individual subscription

As Figure 2 shows, the rate of individual registrations significantly exceeds that of group registrations. This observation suggests that participants showed a marked interest in registering independently rather than as part of a group. This preference can be interpreted as a potential inability to form teams and work collaboratively. The formation of groups was strategically envisaged to promote teamwork while taking into account the diversity of participants' skills, as detailed in Figure 3. Integrating this diversity aims to maximize individual strengths and offset probable weaknesses, thus contributing to a more complete and balanced learning environment.

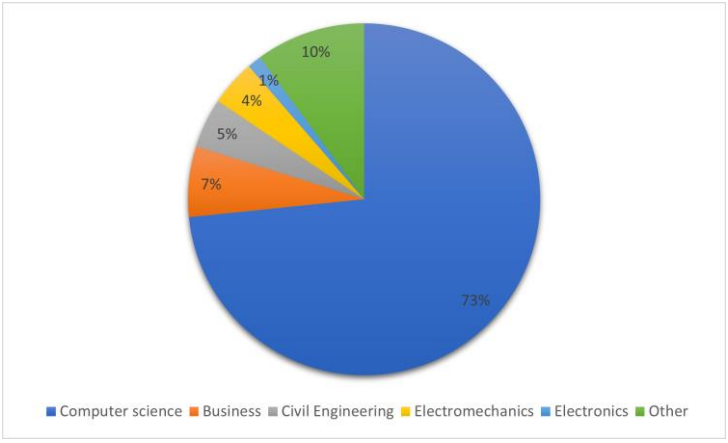

Figure 3. Diversity of participants' skills

In addition, to facilitate the harmonious integration of group members and stimulate collaboration, team-building activities have been specifically designed. These activities, based on playful games related to sustainable development, go beyond simple group formation, fostering a cooperative, interactive, and committed learning environment. This strategic approach aims to maximize the effectiveness of the teams formed while offering an enriching and stimulating learning experience for all participants.

Keynote speakers and exploration of SDGs

An essential part of the "Sustainable Minds" journey is for participants to immerse themselves in the wealth of knowledge shared by keynote speakers, selected to represent a wide range of expertise. Beyond industry, this event expands its focus by inviting speakers from the dynamic world of technology and social engagement. Such deliberate inclusion reflects the fact that engineering challenges are not limited to only technical complexities. Instead, the intersection with societal needs, community engagement, and innovative technology becomes a key focus. The keynote speakers bring valuable insight from a wide perspective, which aligns perfectly

with the CDIO framework's focus on integrated learning experiences. The key sessions, enriched by the diversity of the speakers, revolve around an exploration dedicated to the SDGs. For instance, the first speaker addresses the intersection of environmental responsibility with digital transformation. The second speaker focuses on Corporate Social Responsibility (CSR) initiatives. The third speaker highlights the significance of quality education for fostering sustainable development. Finally, the integration of technologies to advance sustainable agriculture is discussed, offering unique perspectives on shaping a more sustainable and technologically advanced future.

Challenge announcement: Sustainable universities

The highlight of "Sustainable Minds" takes place with the exciting announcement of the challenge, representing a departure from traditional competitions. The challenge is not merely an academic exercise, but a call to action, responding effectively to the theme of the university's responsibility to sustainable development. Precisely designed, it acts to guide participants toward innovative solutions for promoting sustainable development in the university environment. Besides being tasked with solving complex technical problems, participants also engage in an exploration of the university's central role in promoting sustainable development. As part of the challenge, they are invited to consider and implement ideas that extend their thinking further than engineering problem-solving, into the realms of social and environmental responsibility. They face both the challenges of engineering and the more general question of how universities can be agents of positive change. Once the challenge has been announced, participants proceed from theoretical understanding to the practical application of engineering principles.

Design thinking workshops: Foster innovation

Before tackling the challenge, competitors have the opportunity to take part in a preparatory phase - a design thinking workshop. It provides participants with invaluable tools for solving complex problems and designing innovative solutions. Design Thinking Workshop isn't a typical course; we created an interactive area where creativity and innovation take place side by side. Participants worked their way through an interactive session that encouraged them to think "outside the box" and move from traditional problem-solving approaches, to build skills and confidence to tackle diverse challenges.

Kick-off hackathon

As participants step into the hackathon arena, they bring with them a symphony of ideas gathered from industry experts, as well as a profound understanding of the societal challenges encapsulated in the SDGs, and the problem-solving skill cultivated by design thinking. This combination of knowledge forms a solid basis on which participants can build their engineering solutions for a sustainable university.

Random draw: Integrate the designed SDG

In the middle of the hackathon, participants were confronted with an exciting surprise: the SDG random draw. At this point, participants proceeded to a random draw, selecting specific SDGs except SDG 4 (quality education). Their task was clear: each team had to integrate the chosen SDG into their current solution. This unexpected element introduced an innovative layer of complexity, which forced participants to quickly adapt and integrate a new dimension into the design process. This unannounced integration of the SDGs reflects the agile problem-solving

skills recommended by the CDIO framework. Besides being a challenge, this initiative was also an innovation and adaptability stimulator. They were challenged to be creative and to think not only about their initial project but also about how they might integrate the designed SDG into their projects.

Evaluation Phase: 20 juries

Sustainable Minds reached its high point through an exhaustive two-phase evaluation of the participants' ideas, a process that involved 20 expert teachers from ESPRIT in various fields of the presented projects to assess the proposed solutions and enhance their value through evaluation. The evaluation criteria during phase 1 included several key aspects to assess team performance. Idea generation scored 15 points, focused on adherence to the hackathon theme and objectives, aligning solutions with the CDIO standard 5 (Design-Implement Experiences) . Innovation and creativity, assessed on 10 points, focused on the degree of originality of the solutions, in line with the CDIO standard 8 (Active Learning) . Impact on the SDGs, rated out of 25 points, introduced an innovative approach, awarding points according to the number of SDGs addressed, in line with the CDIO standard 2 (Learning Outcomes). Presentation quality, assessed on 20 points, focused on clarity, conciseness, and compelling content, in alignment with the CDIO standard 7 (Integrated Learning Experiences). Finally, implementation and adaptability, each scored 15 points, considered solution demonstration and ability to meet challenges, corresponding to CDIO standards 3 (Integrated Curriculum) and 6 (Engineering Learning Workspaces), emphasizing practical experience and adaptability. These overall criteria ensured a comprehensive assessment of the teams' performance in the hackathon context. The six highest-ranked teams from the first evaluation were selected to participate in the second phase of the presentation, where they faced a shorter deadline, limited to a threeminute presentation. The submissions were evaluated by five experts according to identical, comprehensive evaluation criteria, to identify the three most outstanding solutions. Evaluation criteria included relevance, measured by the clarity of the identification of a distinct need contributing to the university's sustainability, and originality, assessed by the degree of innovation and originality of the suggested solutions. The overall impact of the project, beyond short-term considerations and beneficial to the environment and the university economy, was another essential criterion. Finally, the quality of the presentation was also taken into account, based on clarity, conciseness, and persuasiveness in communicating the project's objective. The three teams with the highest overall scores won, not only by triumphing at the hackathon but also by demonstrating outstanding achievements in developing sustainable solutions for the university. These winners demonstrated the innovation, originality, and relevance of their engineering solutions, setting a high standard for the transformative potential of CBL events.

Figure 4 provides a schematic overview of the process evaluation stages and criteria.

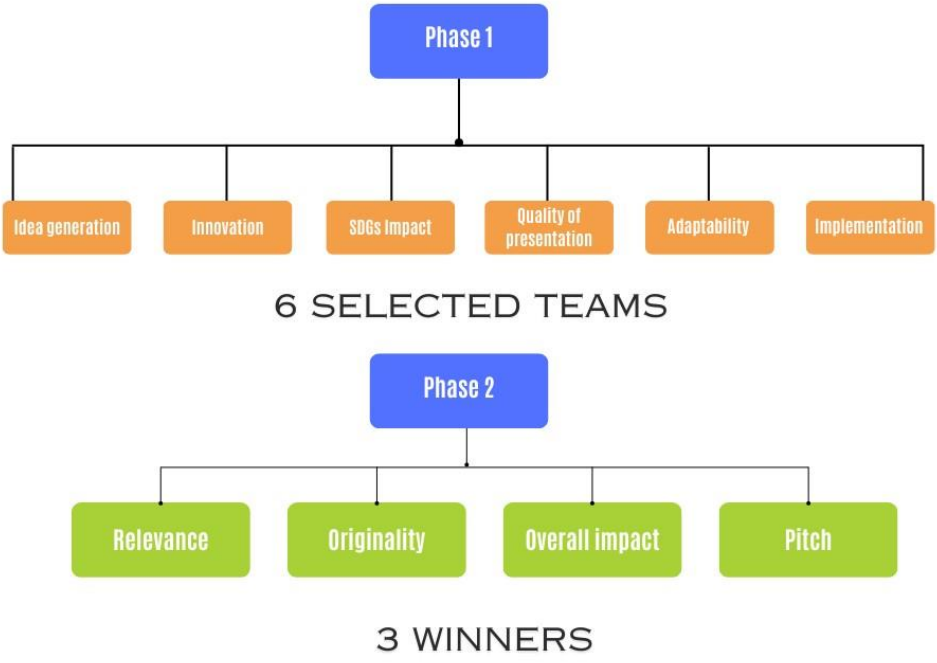

Figure 4. Evaluation process

ALIGNEMENT WITH CDIO STANDARDS

CDIO Standard 7 (Integrated Learning Experiences): Forming diverse groups, including participants from different specialties, encapsulating the best of integrated learning experiences. The purposeful organization of diverse teams reflects the collaborative environments of authentic engineering challenges, where individuals from different disciplines come together to solve multifaceted challenges.

CDIO Standard 2 (Learning Outcomes): The purposeful presentation of the SDGs enhances the learning outcomes for participants. Attendees gain an understanding of the societal context in which their engineering solutions will operate. Such an alignment ensures that the educational journey goes further than technical skills, giving participants a sense of responsibility and awareness of the wider implications of their future engineering projects.

CDIO Standard 5 (Design-Implement Experiences): Once the challenge has been announced, participants proceed from theoretical understanding to the practical application of engineering principles.

CDIO Standard 8 (Active Learning): During the hackathon, learning was not a matter of passively receiving information, but rather an active, interactive process. Participants are engaged actively in problem-solving methodologies, developing their thinking skills and adopting a proactive learning approach to shape the sustainable solutions that will define the ”Sustainable Minds” hackathon. Furthermore, the design thinking workshop was used as a model of active learning.

INTERSECTION OF CBL AND SDGS: SUSTAINABLE MINDS IMPACT

We believe The intersection of CBL, pedagogy, and SDGs represents a transformative approach to education, in which traditional boundaries become overcome in favor of an engaging learning experience. As a pedagogical approach, CBL reshapes the education environment by placing students at the center of their learning experience. This approach reaches for more than traditional knowledge transfer, promoting critical thinking, problem-solving skills, and collaborative abilities. This impact was profound through the event, creating an environment where students move from passive learners to active contributors, in alignment with SDGs. It goes further than academic success. It extends to the development of a mindset that is both socially aware and environmentally responsible. Through CBL initiatives related to the SDGs, students become active contributors to sustainable solutions. The connection between CBL and the SDGs becomes evident when students take on concrete challenges, using the SDGs as a guiding tool for their projects. Through strategic alignment, each CBL initiative becomes an example of sustainability, addressing specific SDGs and developing a sense of responsibility for global issues. Through the intersection of CBL, pedagogy, and SDGs, the winning projects are proving to be invaluable tools. By exploring these projects in detail, we highlight the alignment between challenge-based learning and the Sustainable Development Goals, demonstrating the real impact of this educational approach on sustainable development and societal improvement.

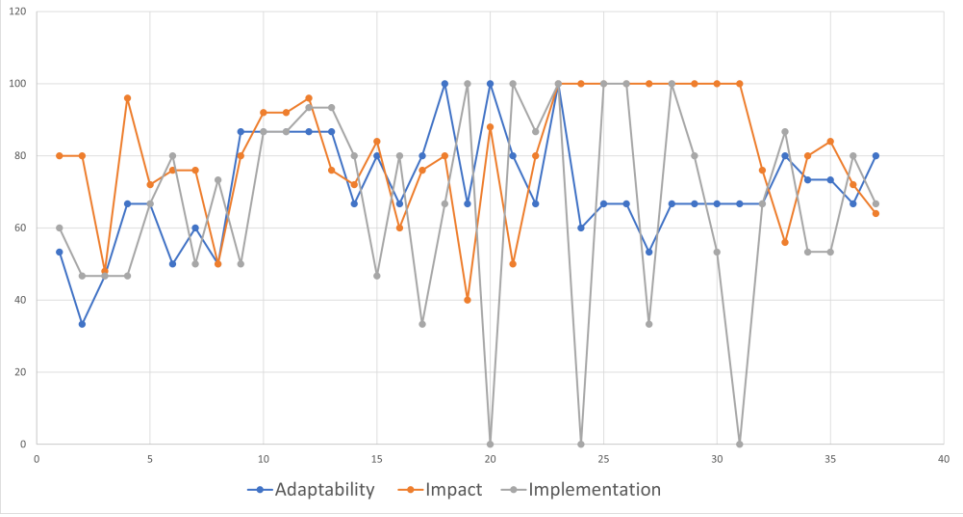

Figure 5. Teams performance comparison: Phase 1

Figure 5 shows the performance of all teams in terms of adaptability, impact, and implementation. Each data point on the graph corresponds to a team, and its position indicates the points reached in these three aspects. The results show that, on average, the teams demonstrated a good capacity in terms of adaptability to the encountered challenges and an overall positive impact on their projects, but a certain variability in the quality of the implementation of their solutions. Due to time and skill constraints, certain teams were unable to progress beyond the ideation phase and were limited to proposing innovative ideas. These data could suggest specific strengths and areas for improvement, enabling further reflection on the adaptive aspects, overall impact, and effective implementation of the proposed solutions.

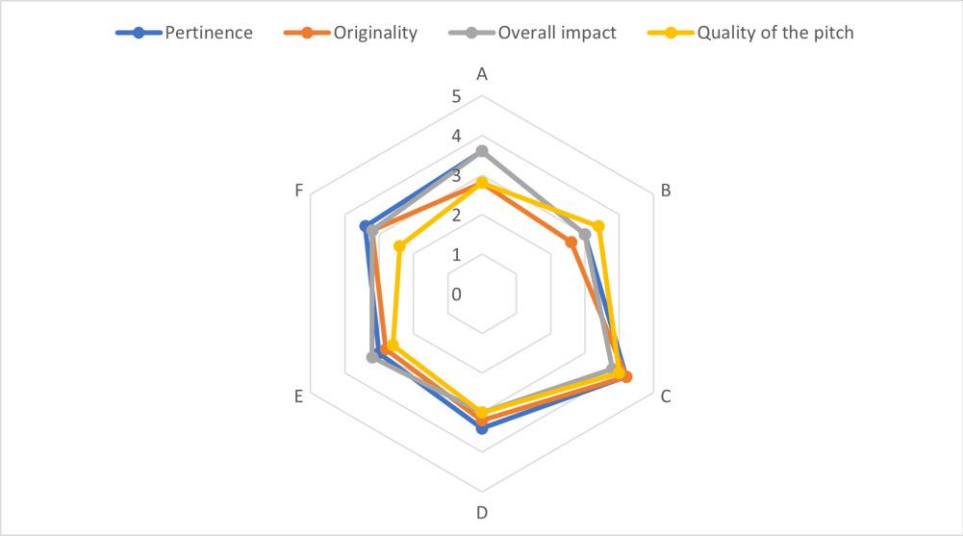

Figure 6. Teams performance comparison : Phase 2

Figure 6 provides an easy visual overview of each team's performance, helping to identify their strengths and improvement targets as part of the hackathon evaluation. Team C stands out for its performance, while others may consider refining specific aspects of their projects.

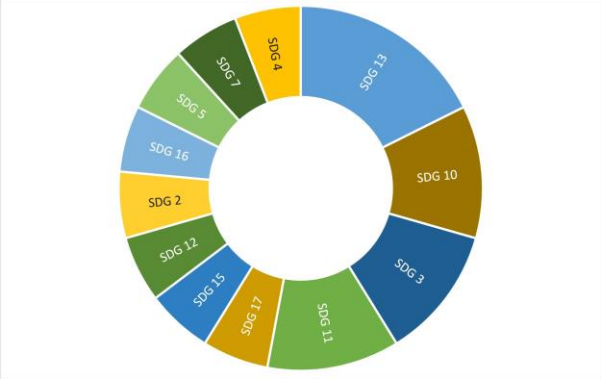

Figure 7. Overall impact on SDGs

In Figure 7, we illustrate the project's impact on the various SDGs (Nations, 2015) according to their frequency of use. The focus is on SDG 13 (Climate Action), followed by SDGs 11 (Sustainable cities and communities) and 3 (Good health and well-being). The chart shows the different contributions made, highlighting the alignment of projects with the various SDGs for a comprehensive approach to sustainability.

CONCLUSION

In conclusion, CBL's exploration within the context of CDIO and its alignment with the United Nations' Sustainable Development Goals (SDGs) through the "Sustainable Minds" hackathon reveal a transformative educational environment. The presented projects highlight CBL's ability to meet real-world challenges. As educators, this journey encourages a review of traditional

approaches, promoting CBL as a key facilitator of pedagogical innovation. The impact of the SDGs, demonstrated in various projects, emphasizes the societal importance of these educational efforts. This journey through ”Sustainable Minds” reflects CBL’s transformative potential and invites us to align engineering education with global challenges and goals. As part of this challenging higher education environment, the convergence of CBL and the SDGs represents a step towards an engineering education that promotes positive societal impact and responsible innovation.

FINANCIAL SUPPORT ACKNOWLEDGEMENT

We extend our sincere gratitude to our valued sponsors, as their generous support has been instrumental in making this journey a reality. Special thanks to ESPRIT, Hydatis, Vermeg, Adservio and Cours-Élysée for their commitment to innovation and education. Their financial support contributed significantly to the success of our ”Sustainable Minds” hackathon.

REFERENCES

Brown, T., et al. (2008). Design thinking. *Harvard business review*, *86*(6), 84.

Gallagher, S. E., & Savage, T. (2023). Challenge-based learning in higher education: an exploratory literature review. *Teaching in Higher Education*, *28*(6), 1135-1157. Retrieved from https://doi.org/10.1080/13562517.2020.1863354 doi: 10.1080/13562517.2020.1863354

Isa, C. M. M., Mustaffa, N. K., Preece, C. N., & Lee, W.-K. (2019). Enhancing conceive-design-implement-operate and design thinking (cdio-dt) skills through problem-based learning innovation projects. In *2019 ieee 11th international conference on engineering education (iceed)* (pp. 41–46).

Kohn Rådberg, K., Lundqvist, U., Malmqvist, J., & Hagvall Svensson, O. (2020). From cdio to challenge-based learning experiences–expanding student learning as well as societal impact? *European Journal of Engineering Education*, *45*(1), 22–37.

Krajcik, J. S., & Blumenfeld, P. C. (2006). *Project-based learning*. na.

Leijon, M., Gudmundsson, P., Staaf, P., & Christersson, C. (2022). Challenge based learning in higher education–a systematic literature review. *Innovations in education and teaching international*, *59*(5), 609–618.

Malmqvist, J., Edström, K., & Rosén, A. (2020). Cdio standards 3.0–updates to the core cdio standards. In *16th international cdio conference* (Vol. 1, pp. 60–76).

Nations, U. (2015). *Transforming our world: the 2030 agenda for sustainable development.* Retrieved from https://sustainabledevelopment.un.org/post2015/transformingourworld

Shapira, H., Ketchie, A., & Nehe, M. (2017). The integration of design thinking and strategic sustainable development. *Journal of Cleaner Production*, *140*, 277–287.

BIOGRAPHICAL INFORMATION

Soumaya Argoubi is a Faculty member and head of the algorithms and programming pedagogical unit at ESPRIT School of Engineering, Tunisia. She holds a PhD, a Research Master's in Protocol, Networks, Images, and Multimedia Systems, and a National Engineer's Diploma in computer sciences. The research areas in which she is involved revolve around wireless networks, the incorporation of Sustainability in engineering education, and innovation in educational strategies. She teaches courses related to algorithms and C/C++ programming as well as networking. She has published 4 scientific papers in international conference proceedings.

Nawress Rafrafi is a software engineer and computer science trainer at Esprit School of Engineering. Interested in research and development, Nawress takes on the role of project coordinator within an R&D team, actively contributing to innovative projects. A passionate promoter of experiential learning, she is also an internship coordinator. Nawress' approach to education, research, and project coordination reflects its commitment to training the next generation of software engineers and encouraging innovation within the field.

Note

Authors contributed equally.

Corresponding author

Soumaya Argoubi
ESPRIT School of Engineering
1, 2 rue André Ampère - 2083 Technological Pole - El Ghazala
soumaya.argoubi@esprit.tn