ENGINEERING EDUCATION IN THE ERA OF GLOBAL RESPONSIBILITY

Mourad ZERAI, Nadia AJAILIA

Mathematical Department, Civil Engineering Department, ESPRIT School of Engineering

ABSTRACT

The United Nations Sustainable Development Goals (UN SDGs) offer a framework for addressing global challenges. To contribute to these goals, engineers need a range of competencies, including technical skills, effective communication, and critical thinking. We suggest using the SDGs as an integrating theme in engineering programs, unifying various modules into a cohesive, multidisciplinary curriculum. The interdisciplinary nature of engineering makes it suitable for such integration. Achieving clean water and sanitation (SDG 6), for example, requires expertise in fluid mechanics and skills in communicating solutions to stakeholders. Ensuring access to affordable and sustainable energy (SDG 7) demands an understanding of energy systems and an ability to evaluate societal and environmental impacts. The SDGs can act as a unifying thread, linking subjects and skills in a way that reflects the real-world complexities engineers face. By integrating these goals into the curriculum, we address the concerns and interests of younger generations who are deeply concerned about environmental issues and the future of the planet. This approach also helps students to understand the interplay of technical, ethical, social, and environmental factors in creating sustainable solutions. In this paper, we propose a straightforward method for constructing engineering curricula that use the Sustainable Development Goals (SDGs) as a guiding thread. We'll apply this method not just to cross-disciplinary or specialised modules but also to basic courses like maths, physics, and algorithmic. Our goal is for students to see that these fundamental subjects are key to tackling environmental problems around the world. Integrating the SDGs can also invigorate teaching methods, promoting active learning and critical reflection. Project-based assignments on SDG challenges enable students to develop technical and interpersonal skills, preparing them as competent engineers and global changemakers, while also resonating with their desire to engage in work that contributes to sustainable and ethical development.

KEYWORDS

UN SDGs, Engineering Education, Multidisciplinary Skills, Integrated Curriculum, CDIO Standards: 1, 2, 3, 4, 7, 9, 11.

INTRODUCTION

The Intergovernmental Panel on Climate Change's (IPCC, 2023) Sixth Assessment Report (AR6) provides a comprehensive synthesis of current knowledge on climate change, its widespread impacts, and the necessary mitigation and adaptation strategies. The report emphasises the interdependence of climate, ecosystems, biodiversity, and human societies, highlighting the essential role of diverse forms of knowledge and the importance of various actors in climate action. It underscores the unequivocal impact of human activities, particularly greenhouse gas emissions, on global warming, with a significant rise in global surface temperature and a continuous increase in greenhouse gas emissions due to unsustainable practices. A critical aspect of this global challenge is its impact on food and water security, impeding efforts to meet Sustainable Development Goals. While overall agricultural productivity has increased, climate change has decelerated this growth over the past 50 years (IPCC, 2023). In response to these challenges, adaptation planning and implementation have made progress in various sectors and regions, demonstrating benefits and varying effectiveness. Despite this progress, significant adaptation gaps persist and are expected to grow if current implementation rates continue. In an era marked by unprecedented global challenges, ranging from climate change to resource scarcity, the role of engineering in shaping a sustainable future has never been more critical. The UN defines Sustainable Development (SD) as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). The Sustainable Development Goals (SDGs), a set of 17 interconnected objectives, outline a universal call to action to protect the planet, ensure prosperity, and promote peace and equity. These goals provide a comprehensive roadmap for addressing the most pressing issues of the 21st century. Engineering education, traditionally grounded in technical expertise, must evolve to encompass a broader understanding of the complex, interrelated social and environmental factors that define modern engineering challenges. This development requires a significant change in educational approaches, focusing on training engineers to be technically skilled and capable of contributing responsibly to sustainable development. Given this context, its essential to urgently adapt engineering education. Engineering disciplines must evolve to incorporate an understanding of climate change impacts and adaptation strategies, equipping future engineers with the knowledge and skills to contribute effectively to addressing these global challenges. Incorporating sustainability, environmental management and social awareness into engineering curricula is crucial. This approach equips engineers to tackle sustainable development goals such as reducing inequalities, preserving biodiversity, combatting hunger and conserving water. This shift in engineering education is a moral obligation to promote a sustainable and equitable future for all. The paper recommends a substantial reshaping of the engineering curriculum. This reshaping involves centering the curriculum around the Sustainable Development Goals (SDGs), which encompass a wide range of issues. The intention is to build the engineering curriculum upon these goals.

ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT

In 2004, the 2nd International Conference on Engineering Education for Sustainable Development issued the EESD Barcelona Declaration, urging engineering educators to train engineers with an expansive comprehension of complex issues, guided by long-term systemic thinking and ethical considerations in decision-making (EESD Barcelona Declaration (Final Version, October 2004)). This declaration has significantly influenced subsequent conference discussions, emphasising the integration of sustainability in engineering education. Given the escalation from urgency in 2004 to a critical state in 2024, there is a pressing need to transform the paradigm of engineering education to address the current alarming challenges more effectively. In the last three decades, there has been a growing push to incorporate concepts of sustainability and sustainable development into engineering education (Segalàs Coral, Drijvers, & Tijseen, 2018). Education for Sustainable Development (ESD) is perceived as an educational approach that promotes changes in knowledge, skills, values, and attitudes, aiming to cultivate a society that is both sustainable and equitable for everyone (UNESCO, 2017, p. 7). UNESCO declares that *Education for sustainable development (ESD) gives learners of all ages the knowledge, skills, values and agency to address interconnected global challenges including climate change, loss of biodiversity, unsustainable use of resources, and inequality* (UNESCO 2022). Several papers discuss the integration of sustainable development goals in engineering education, different methodologies are suggested, (Ramirez-Mendoza et al, 2020, Llopis-Albert et al., 2022) according to (Llopis-Albert et al., 2022) suggested some measures and indicators that can help to integrate SDGs in mechanical engineering syllabus. According to (Huimin Chen et al., 2022) governance constitutes a pillar in integration of SD in Engineering education. Active learning approaches are essential for Engineering Education for Sustainable Development (EESD) (Quelhas et al., 2019) we can use problem-based, project-based learning, challenge-based learning, etc. The PBL models can be considered as learning models in engineering syllabus (Pérez-Sánchez et al., 2020). The perceptions are different with a main goal, which is how to improve engineering education in a world continuously challenging. The limit in these works is a concrete approach that can be generalised to all disciplines.

THE EVOLUTION OF THE CDIO STANDARDS TOWARD SUSTAINABILITY

The Conceive-Design-Implement-Operate (CDIO) framework emerges as a pioneering educational approach, emphasising a practical, project-based learning paradigm that mirrors the complexities of real-world engineering. Within this context, the Optional Standard 1: Sustainable Development in the CDIO framework stands out. (Malmqvist et al., 2020). It advocates for the integration of sustainability—a triad of environmental, social, and economic considerations—into the engineering curriculum. This standard recognizes the imperative to imbue future engineers with the ethos of sustainability, ensuring that they are problem solvers and guardians of our planet’s future.

As the modifications in CDIO standards 2.1 (Bennedsen et al., 2016) have been relatively minor and have not changed the scope or the main contents of the standards. The version 2.1 does not present major changes from 2.0 , we are here comparing 2.0 Version to version 3.0. The shift from CDIO Standards version 2.0 (Crawley et al., 2014) to 3.0 (Malmqvist et al., 2022) reflects a significant evolution in engineering education, aligning it more closely with contemporary global challenges, especially in sustainable development. This transition is a strategic enhancement, integrating a deeper focus on sustainability and reflecting the changing landscape of engineering practice and education.

Enhancements in Version 3.0

Version 3.0 of the CDIO Standards (Malmqvist et al., 2022) marks a deliberate move towards embedding sustainability into the heart of engineering education.

Integration of Sustainability and SDGs:

A critical update in version 3.0 is the explicit inclusion of sustainability. This integration signifies a shift in engineering education towards a broader global and societal perspective, recognizing the crucial role of engineers in addressing global challenges.

The updates affected the context (standard 1), learning outcomes (standard 2), Integrated Curriculum (standard 4), Engineering learning workplaces (standard 7), Enhancement of faculty competence (standard 9) and finally Learning assessment (standard 11). The new version places a greater emphasis on considering environmental, social, and economic sustainability as an integral part throughout the lifecycle, developing skills related for sustainable development (Malmqvist et al., 2022). For Integrated Learning Experiences (Standard 7), the updated standards encourage pedagogical approaches that enhance the learning of disciplinary knowledge, acknowledging the interconnected nature of modern engineering problems. This approach is vital for sustainability education, as it involves complex interactions between various fields. Regarding enhancement of faculty competence (Standards 9) version 3.0 underscores the need for faculty development in contemporary teaching methodologies and sustainability education. This ensures that educators are equipped to deliver a curriculum that is both modern and relevant to current global challenges.

Comparison with Version 2.0

While version 2.0 (Crawley et al., 2014) laid a strong foundation by emphasising integrated curriculum design and industry engagement, version 3.0 builds upon this by infusing sustainability throughout the educational process. The elements in version 3.0 (Malmqvist et al., 2020), such as the integration of sustainability and emphasis on personal and professional skills, are not entirely absent in version 2.0 but are significantly expanded and given more prominence in the latest version. This evolution reflects a response to the increasing importance of sustainability in engineering and the need for a curriculum that prepares students to meet these challenges.

METHODOLOGY

The primary aim of this paper is to propose a comprehensive framework that seamlessly integrates the principles of Optional Standard 1: Sustainable Development into the 12 fundamental CDIO standards. The paper "Mapping the CDIO Syllabus to the UNESCO Key Competencies for Sustainability" (Rosén et al., 2019), focuses on evaluating the relevance of the CDIO Syllabus in promoting engineering education for sustainable development. The evaluation employs a framework of key competencies for sustainability defined by UNESCO. This is conducted in two main steps: firstly, identifying topics, terms, and concepts in the CDIO Syllabus corresponding to the UNESCO key competencies, and secondly, a qualitative discussion highlighting areas of strong mapping and suggesting improvements to the Syllabus. The paper concludes that the CDIO Syllabus aligns well with the UNESCO framework but identifies several opportunities for further enhancement in relation to the key competencies. This study also acknowledges the UNESCO key competencies as essential instruments in guiding the evolution of the CDIO Syllabus, thereby paving the way for the development of version 3.0 of both the standards and Syllabus 3.0. Following this, we explore further the alignment between the CDIO Syllabus and the 17 UN SDGs, highlighting how certain CDIO elements can be achieved by incorporating courses or learning themes related on some selected SDGs:

CDIO Syllabus 1.4 (Knowledge of Social Science and Humanities) & SDG 4 (Quality Education)

In a course on engineering ethics, include case studies focusing on sustainable development and social responsibility. Students can learn about the ethical implications of engineering decisions on society and the environment, thus addressing both the knowledge of social sciences and humanities and promoting quality education through awareness of sustainable development.

CDIO Syllabus 2.2.3 (Experimental Inquiry) & SDG 6 (Clean Water and Sanitation)

In a laboratory module on environmental engineering, introduce experiments related to water purification technologies and wastewater management. This directly ties experimental inquiry with the goal of ensuring availability and sustainable management of water and sanitation for all.

CDIO Syllabus 2.3.3 (Prioritization and Focus) & SDG 13 (Climate Action)

In courses on project management and engineering design, include projects that focus on designing solutions for climate change mitigation or adaptation. This could involve prioritising and focusing on developing renewable energy sources, energy-efficient buildings, or climate-resilient infrastructure.

CDIO Syllabus 2.5.5 (Equity, Diversity, and Inclusiveness) & SDG 5 (Gender Equality)

In leadership and team management courses, emphasise the importance of gender equality, diversity, and inclusion in engineering teams. Addressing these issues can promote a more equitable and inclusive environment in the engineering profession, aligning with SDG 5.

CDIO Syllabus 3.1.3 (Stakeholder Engagement) & SDG 11 (Sustainable Cities and Communities)

In urban planning and civil engineering courses, incorporate projects that require engagement with community stakeholders to design sustainable urban spaces, thus teaching students the importance of considering diverse perspectives in creating sustainable cities and communities.

CDIO Syllabus 4.1.2 (The Impact of Engineering on Society and the Environment) & SDG 15 (Life on Land)

In environmental engineering courses, focus on the impact of engineering projects on terrestrial ecosystems and biodiversity. This could include studying the effects of construction on wildlife habitats and exploring engineering solutions to minimise negative impacts.

CDIO Syllabus 4.6.5 (Disposal, End-of-Life, and Circularity) & SDG 12 (Responsible Consumption and Production)

In manufacturing and materials science courses, emphasise the principles of circular economy and sustainable material management, teaching students how to design products with sustainable life cycles, from production to disposal.

CDIO Syllabus 5.2 (Engineering Entrepreneurship) & SDG 8 (Decent Work and Economic Growth)

Encourage entrepreneurial thinking in engineering students by focusing on start-ups and innovations that contribute to sustainable economic growth and provide decent work opportunities. This could involve workshops on sustainable business models and green technologies. By brainstorming on relevant examples to introduce into the engineering curriculum, educators can create a more comprehensive and sustainability-focused educational experience that prepares students to address global challenges in their professional careers.

CDIO Standards 3.0 and UN SDGs: Synergizing for Impactful Engineering Education

We focus on examining CDIO standards, offering an interpretation and deployment strategy that aligns with institutions prioritising sustainability and environmental protection in their engineering curricula. This nuanced interpretation seeks to guide institutions in effectively adapting CDIO standards to meet the evolving demands of environmental stewardship within the engineering discipline.

CDIO Standard 1 "The Context," positions sustainability at the center of engineering education, emphasizing its integration as a core principle, not just an addition. This standard guides the conception, design, implementation, and operation of projects within a sustainability framework, creating a mindset among graduates that is technically adept, ethically grounded, and globally aware.

CDIO Standard 2, "*Learning Outcomes,"* requires specific and detailed outcomes for personal and interpersonal skills, product, process, system, and service building skills, along with disciplinary knowledge. These outcomes, aligned with program goals, are validated by key stakeholders. The CDIO Syllabus codifies these outcomes, outlining the knowledge, skills, and attitudes students should possess upon completing their engineering programs. Programs are encouraged to tailor the CDIO Syllabus to their specific needs and define the proficiency levels expected for each learning outcome.

Here is our concept for constructing an engineering education program centred around the SDGs: In the syllabus of each teaching unit, one or more learning outcomes should be defined in connection with the SDGs. This can be either a direct relationship with specific SDGs or targeting the key competencies for sustainable development as defined by the UN. This approach ensures that every aspect of the engineering curriculum is directly contributing to global sustainability goals. This strategy should be infused into all four areas of the CDIO Syllabus. There is always a possibility to align the CDIO Syllabus with the 17 SDGs and the 8 key competencies for sustainable development. For instance, in a fluid mechanics course, while the learning objectives might traditionally focus on establishing and utilising the Bernoulli equation, additional learning outcomes can be integrated to demonstrate how this equation can aid in designing systems that minimise fluid loss, such as in water systems. Alongside this, in thermodynamics, strategies to reduce or harness evaporation can be explored. Building on this approach, in a course on materials science, learning outcomes could include understanding the selection of sustainable materials and their life cycle impacts, aligning with SDG 12 on responsible consumption and production. Similarly, in a course on electrical engineering, students could explore the design of energy-efficient systems, contributing to SDG 7, which focuses on affordable and clean energy. In a civil engineering module, learning outcomes might involve planning sustainable urban infrastructures, thereby addressing SDG 11 on sustainable cities and communities. This holistic integration of the SDGs into the engineering curriculum broadens the scope of learning outcomes while aligning engineering education with global sustainability objectives.

This methodology does not require a complete overhaul or redesign of a course's learning objectives. It involves a thoughtful examination by the teaching team responsible for the module, exploring possible connections with sustainable development goals. Initially, this entails identifying learning achievements that can be incrementally added to the existing ones. Once this step is accomplished, the teaching team, utilising student feedback, will have the necessary insights to consider a total redesign of the teaching unit while consequently reevaluating pedagogical alignment. Furthermore, the process includes validation of the program by stakeholders – such as industry partners, alumni, and community representatives – ensuring that the modified curriculum aligns with academic standards and society's fast-changing requirements. Integrating the challenges faced by our planet brings relevance to the course and actively engages students who are part of a generation seeking meaningful contributions and deeply concerned about climate change, inequalities, and the scarcity of vital resources.

Standard 3: Integrated Curriculum

Designing an engineering program under CDIO Standard 3, focused on SDGs, involves a strategic, multidisciplinary curriculum aligned with sustainability goals. Key steps include curriculum mapping for sustainability competencies, balanced SDG coverage, interdisciplinary faculty training, and practical projects addressing real-world sustainability issues. Continuous program evaluation with feedback from students, faculty, and industry, plus involvement of external stakeholders in development and assessment, ensures the program stays relevant and responsive to evolving sustainability challenges.

Incorporating Standard 5

Integrating Design-Implement Experiences in an SDG-focused engineering program requires a methodical approach, progressively aligning with SDGs and escalating from simple to complex projects. This aligns with Standard 1, ensuring a comprehensive grasp of product and system development from conception to operation. Emphasizing sustainability and ethics, these experiences connect with real-world challenges through industry and NGO partnerships. Co-curricular activities, such as research and internships focused on SDGs, further enrich student understanding and engagement with global issues.

Standard 9: Enhancement of Faculty competence

To align faculty competence with SDG-focused engineering programs under Standard 9, a multi-dimensional strategy is needed. Faculty development should include sustainable development skills, professional development opportunities in sustainable engineering, and industry collaborations. Practical industry experience in sustainability roles is crucial for faculty.

Hiring and promotion criteria should prioritize sustainable development expertise, and a support system with training, mentorship, and resources is essential. This comprehensive approach enhances faculty's capability to effectively teach and engage in SDG-related research and education.

Implementing Standard 11: Learning Assessment

The assessment should measure understanding and application of sustainability concepts, in accordance with Standards 2, 3, and 7. Techniques like written, online, and oral exams, observations, rating scales, journals, portfolios, and peer/self-assessments ensure a comprehensive evaluation of students' capabilities in sustainability and engineering.

DISCUSSION

Integrating sustainability and the UN Sustainable Development Goals into engineering curricula brings several challenges. First, teachers’ challenges can be resumed in four blocks: shifting paradigms around sustainability, the rigidity of the existing curricular structure; requirement of new teaching methods and lack of resources to teach sustainability in faculty (Zhang et al, 2012). Therefore, training and adaptation are imperative; educators must be sufficiently equipped and confident in incorporating these new concepts into their teaching methodologies, resource allocation also becomes a significant factor, necessitating additional investment for the development of new materials, faculty training, and course restructuring. Furthermore, the process of assessment and evaluation demands innovation, requiring new metrics and methods to effectively measure student learning within this sustainability-focused context. Finally, aligning the interests and expectations of diverse stakeholders, including industry partners, academic institutions, and students, presents a complex challenge. This alignment is crucial to ensure the relevance and effectiveness of the modified curriculum and its alignment with broader educational and societal goals. Several studies have found that while students recognize the importance of sustainable development (SD), many are not familiar with its concepts . This leads to a disconnect between valuing sustainability and implementing it in practice (Dagiliūtė et al., 2018, Perrault et al., 2017, Chaplin et al., 2014). However, they are more inclined to engage in sustainable behaviours, such as eco-friendly purchasing, recycling, and conserving energy or water, when they reflect on their consumer responsibilities (Chaplin et al., 2014). To enable students to successfully integrate the process, it's crucial to blend essential knowledge, skills, and attitudes. This combination leads to the creation of innovative, sustainable solutions aligned with their chosen UN SDGs. To enhance students' capacity to effectively amalgamate these skills, it's important to initially offer ample practical application opportunities for developing these fundamental skills. By offering adequate support and guidance, we can assist students in building robust knowledge frameworks, “that are accurately and meaningfully organized and help students to better able to retrieve and apply their knowledge effectively.” (Ambrose, Bridges, Lovett, & Norman, 2010, pp. 4-5).

Sustainable development, with its multi- and transdisciplinary nature, presents a unique challenge in the context of higher education's traditional discipline-based approach to knowledge and research. Balancing these two aspects poses a significant hurdle for universities in incorporating sustainable development learning into their curricula (Van Dam-Mieras, 2006; Mulder et al., 2006).

CONCLUSION

The presented work offers an incremental framework for integrating sustainable development principles, particularly those outlined in Optional Standard 1: Sustainable Development, into the 12 core CDIO (Conceive-Design-Implement-Operate) standards. This initiative is designed to address the urgency of contemporary global challenges, as summarised in the United Nations Sustainable Development Goals (UN SDGs). Recognising the significant impact of the engineering profession on life on Earth, our proposition seeks to reorient engineering education to equip future engineers with the necessary tools to confront and mitigate the pressing threats facing our societies, the planet, and its inhabitants. By aligning engineering curricula with the UN SDGs, this approach focuses on the critical role of engineers in responding to these imminent challenges with precision and efficacy.

The framework introduced in the paper does not call for a complete revamp of existing curricula. Instead, it suggests a meticulous examination and gradual incorporation of sustainable development objectives. This process requires the integration of relevant learning outcomes within the current curriculum, with a focus on ensuring that every element of engineering education is directly contributing to global sustainability objectives. This approach is meant to be comprehensive, permeating all facets of the CDIO Syllabus for thorough integration of the SDGs.

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author(s) received no financial support for this work.

REFERENCES

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). How learning works: Seven research-based principles for smart teaching. Jossey-Bass.

Beagon, U., Bowe, B., Gillet, C., Kövesi, K., Tabas, B.S. (2022). Insights into the integration of the SDGs in engineering program curricula as seen through the prism of the perceptions of engineering students ans educators.

Brundtland, G.H. (1987) Our Common Future: Report of the World Commission on Environment and Development. Geneva, UN-Dokument A/42/427. http://www.un-documents.net/ocf-ov.htm.

Chaplin, G., & Wyton, P. (2014). Student engagement with sustainability : understanding the value–action gap. *International Journal of Sustainability in Higher Education, 15*, 404-417.

Chen, H., Wang, S., & Li, Y. (2022). Aligning Engineering Education for Sustainable Development through Governance: *The Case of the International Center for Engineering Education in China. Sustainability, 14(21)*, 14643.

Crawley, Edward & Malmqvist, Johan & Lucas, William & Brodeur, Doris. (2011). *The CDIO Syllabus v2. 0 An Updated Statement of Goals for Engineering Education*.

Crawley, E. F., Malmqvist, J., Östlund, S., Brodeur, D., & Edström, K. (2014). Rethinking Engineering Education *The CDIO Approach, 2nd ed., Springer-Verlag*, New York, USA

Dagiliūtė, R., Liobikienė, G., Minelgaitė,A. , Sustainability at universities: Students' perceptions from Green and Non-Green universities, *Journal of Cleaner Production, Volume 181*, 2018, Pages 473-482,ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2018.01.213.

IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34.

Hoffmann, M. H. W. (2005) , "An engineering model of learning," *Proceedings Frontiers in Education 35th Annual Conference, Indianopolis, IN, USA*, 2005, pp. T2C-1, doi: 10.1109/FIE.2005.1611887.

Llopis-Albert, C., Rubio, F., Zeng, S., Grima-Olmedo, J., Grima-Olmedo, C. (2022). The Sustainable Development Goals (SDGs) applied to Mechanical Engineering. Multidisciplinary. *Journal for Education, Social and Technological Sciences, 9(1)*, 59-70.

Malmqvist, J., Knutson Wedel, M., Lundqvist, U., Edström, K., Rosén, A., Fruergaard Astrup, T., Vigild, M. E., Munkebo Hussman, P., Kamp, A., & More Authors (2019). Towards CDIO standards 3.0. Paper presented at *15th International CDIO Conference*, Aarhus, Denmark.

Malmqvist J, Edström K, Rosén A, Hugo R, Campbell D, (2020). A First Set of Optional CDIO Standards for Adoption, *Proceedings of the 16th International CDIO Conference, hosted on-line by Chalmers University of Technology, Gothenburg, Sweden*.

Malmqvist, J., Lundqvist, U., Rosén, A. et al (2022). The CDIO Syllabus 3.0 - An Updated Statement of Goals. *Proceedings of the 18th International CDIO Conference, Reykjavik University, Reykjavik Iceland*

Miñano Rubio, R., Uruburu Colsa, Á., Moreno Romero, A. M., Lumbreras Martín, J., Carrasco Gallego, R., & Borge García, R. (2016). Designing a comprehensive methodology to integrate sustainability issues in CDIO projects.

Mulder, K.F., Jansen, L.A. (2006). Integrating sustainable development in engineering education reshaping education by organizational learning. Drivers and Barriers for Implementing Sustainable Development in Higher Education. Education for Sustainable Development in Action. Technical paper 3. UNESCO.

Pérez-Sánchez, M., Díaz-Madroñero, M., Mula, J., Sanchis, R. (2020). The sustainable development goals (sdgs) applied to higher education. A project-based learning proposal integrated with the sdgs in bachelor degrees at the campus alcoy (upv). 3997-4005. 10.21125/edulearn.2020.1078.

Perrault, E., Clark, S.,. (2017). Sustainability Attitudes and Behavioral Motivations of College Students: Testing the Extended Parallel Process Model. In *International Journal of Sustainability in Higher Education*. 19. 00-00. 10.1108/IJSHE-09-2016-0175.

Quelhas, O., Lima, G., Ludolf, N.,Meirino, M., Abreu, C., Anholon, R.,Neto, J., Rodrigues, L., (2019). Engineering education and the development of competencies for sustainability. In *International Journal of Sustainability in Higher Education*. 20. 10.1108/IJSHE-07-2018-0125.

Ramirez-Mendoza, R. A., Morales-Menendez, R., Melchor-Martinez, E. M., Iqbal, H. M., Parra-Arroyo, L., Vargas-Martínez, A., & Parra-Saldivar, R. (2020). Incorporating the sustainable development goals in engineering education. *International Journal on Interactive Design and Manufacturing (IJIDeM), 14*, pp 739-745.

Rosén, A., Edström, K., Grøm, A., Gumaelius, L., Hussmann, P.M., Högfeldt, A., Karvinen, M., Keskinen, M., Wedel, M.K., Lundqvist, U., Lyng, R., Malmqvist, J., Nygaard, M.K., Vigild, M.E., & Astrup, T.F. (2019). Mapping the CDIO syllabus to the unesco key competencies for sustainability.

Segalàs Coral, J., Drijvers, R., & Tijseen, J. (2018). 16 Years of EESD. A Review of the Evolution of the EESD Conference and its Future Challenges. In *EESD 2018: 9th International Conference on Engineering Education for Sustainable Development: Glassboro, New Jersey: June 3-6, 2018: proceedings* (pp. 12-19).

Svanström, M., Lozano-García, F.J. and Rowe, D. (2008), "Learning outcomes for sustainable development in higher education", *International Journal of Sustainability in Higher Education, Vol. 9 No. 3*, pp. 339-351. https://doi.org/10.1108/14676370810885925

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. Sustainable Development.

UNESCO. (2021). Engineering for Sustainable Development. ISBN 978-92-3-100437-7.

UNESCO. (2022). What you need to know about education for sustainable development. https://www.unesco.org/en/education/sustainable-development/need-know.

Van Dam-Mieras, R. (2006). Learning for sustainable development: Is it possible within the established higher education structures? Drivers and Barriers for Implementing Sustainable Development in Higher Education. Education for Sustainable Development in Action. Technical paper 3. UNESCO.

Vehmaa, A., Karvinen, M., Keskinen, M. (2018). Building a More Sustainable Society? A Case Study on the Role of Sustainable Development in the Education and Early Career of Water and Environmental Engineers. Sustainability.

Zhang, Q.,Vanasupa, L., Mihelcic, J. R., Zimmerman, J. B.,Platukyte, S. (2012, June), Challenges for Integration of Sustainability into Engineering Education Paper presented at *2012 ASEE Annual Conference & Exposition, San Antonio, Texas*. 10.18260/1-2--21052

BIOGRAPHICAL INFORMATION

Mourad ZERAÏ is an engineer with a PhD degree in applied mathematics. He is Associate Professor and researcher at ESPRIT since 2008. His research interests include pedagogical innovation, the mathematics of AI, and the philosophy of science.

Nadia AJAÏLIA is Associate Professor at the Civil Engineering Department at ESPRIT School of Engineering. Her focus areas are education, technology-enhanced learning, sustainability in engineering education and courses and programs development.

Corresponding author

Mourad ZERAI
ESPRIT School of Engineering
1,2 street Andre ampere
Technological pole el Ghazela
2083 Ariana Tunisia
Mourad.zerai@esprit.tn