Jurnal Kejuruteraan 38(1) 2026: 35-44
https://doi.org/10.17576/jkukm-2026-38(1)-04

Graduate Attributes and the SDGs Designing Learning Pathways for Global Impact

Wan Hamidon[a], Nitin Raut[a*], Kelvin Bwalya[a] & Reena Vaidya[b]

[a]*Faculty of Engineering, Sohar University, Sohar, Oman*

[b]*Dept. of Applied Sciences, Brahma Valley College of Engineering and Research Center, Nashik, India,*

[*]*Corresponding author: NRaut@su.edu.om*

Received 21 June 2025, Received in revised form 9 October 2025
Accepted 9 November 2025, Available online 30 January 2026

ABSTRACT

This study highlights Sohar University's significant contribution to enhancing higher education in Oman, in alignment with Oman Vision 2040, by promoting innovation, sustainability, and knowledge-driven development through its Living Lab model. Located in a strategically important region, the institution tackles urgent sustainability issues locally while also influencing national and worldwide contexts. Its objective is to convert ideas (campus zero waste. Solar energy optimization, grey water recycling etc.)into implementable actions. This effort focuses on redefining engineering education to equip graduates with technical proficiency, analytical reasoning, ethical leadership, and a dedication to global citizenship. The implementation of the International Engineering Alliance (IEA) Graduate Attributes framework fosters a culture of sustainability and ethical practices, enabling the shift from academic understanding to practical application. Sohar University applies the "Living Laboratory" model, an innovative strategy that merges academic curricula with the United Nations' Sustainable Development Goals (SDGs). This paradigm advocates for experiential learning and community involvement, highlighting interdisciplinary research, industrial collaborations, and outreach initiatives. By incorporating practical learning into its curricula, especially in renewable energy and sustainable infrastructure, the institution improves graduate employability in both local and worldwide markets, distinguishing itself as a leader in sustainability solutions. The primary objectives include aligning graduate attributes with specific SDGs, integrating sustainability competencies into core curricula, and transforming the campus into a Centre for Sustainability. Implementation techniques include engagement, curriculum mapping, workshops, mini-grant awards, and program monitoring, which together enhance the university's academic standing and strengthen its dedication to sustainable human capital development. Sohar University aims to be a national and regional leader in sustainability education, establishing a benchmark for institutions throughout Oman and the Gulf Cooperation Council (GCC).

Keywords: Living lab; sustainability; experiential learning; competencies; curriculum integrations

INTRODUCTION

Sohar University holds a significant position in Oman's educational landscape, aligning its mission with the ambitious goals outlined in Oman Vision 2040, which prioritizes innovation, sustainability, and the development of a knowledge-based economy. Situated in the burgeoning industrial city of Sohar, the university is strategically positioned to address pressing sustainability challenges at local, national, and international levels. As Oman transitions towards a more sustainable future, the role of higher education becomes increasingly vital, with Sohar University serving as a catalyst for transformative change in the educational sector.

The university's engineering programs are particularly noteworthy, designed to cultivate graduates who are not only technically adept but also equipped with critical thinking skills, ethical leadership qualities, and a global perspective. Central to the university's educational philosophy is the integration of sustainability, which empowers students to navigate complex issues and devise innovative, ethical solutions. This approach resonates with

the objectives of Oman Vision 2040, which seeks to develop a workforce capable of addressing challenges related to sustainability, water conservation, and renewable energy.

Sohar University's commitment to sustainability is further exemplified by its adoption of the International Engineering Alliance (IEA) Graduate Attributes framework, emphasizing sustainability awareness, ethical responsibility, and systems thinking. This framework enables students to address real-world problems by translating theoretical knowledge into practical application. The concept of the university as a "Living Laboratory" is integral to this initiative, where academic programs and campus life are intertwined with the United Nations' Sustainable Development Goals (SDGs). This model fosters experiential learning, enhances students' technical and moral competencies, and prepares them for collaborative efforts in addressing urgent sustainability issues.

By incorporating SDGs and IEA Graduate Attributes into the curriculum, Sohar University not only strengthens its academic profile but also reaffirms its commitment to human resource development and sustainable progress in Oman and beyond. This comprehensive educational strategy aims to produce graduates who can act locally while thinking globally, leading the charge towards a sustainable future. The Living Lab initiative aligns the attributes of Sohar University graduates with selected SDGs, ensuring that essential skills such as problem-solving, ethical reasoning, and critical thinking are developed in tandem with relevant sustainability goals. This alignment enhances the competitiveness of graduates and involves stakeholder validation to ensure community needs are met, ultimately enriching the educational experience and preparing students for impactful careers in a rapidly evolving global landscape.

METHODOLOGY

This study adopts a qualitative case study approach, offering a robust framework to investigate the integration of SDGs and graduate attributes within Sohar University's Living Lab ecosystem. By focusing on real-world projects embedded within academic programs, this methodology facilitates the exploration of how higher education institutions can evolve into agents of sustainable development while demonstrating pathways towards a more sustainable future. A qualitative lens allows for an in-depth, contextualised understanding of how interdisciplinary student-led projects contribute to educational transformation and SDGs advancement.

The study's data sources include an extensive review of internally funded projects specifically, Undergraduate Research Grants (URGs), Graduate Research Grants (GRGs), and Consultancy Research Projects (CRPs) executed at Sohar University between 2022 and 2025. These projects span multiple disciplines, from engineering and environmental sciences to health, waste management, and digital innovation. Each project proposal, interim report, and final output was systematically reviewed to assess its alignment with (i) one or more of the 17 UN SDGs, (ii) the International Engineering Alliance (IEA) Graduate Attributes, and (ii) Program Learning Outcomes (PLOs) defined by academic departments. This triangulation ensures that both theoretical and practical dimensions of each initiative are critically assessed for impact and relevance.

Document analysis served as the foundational technique for extracting data from these projects. This involved a detailed analysis over 20 complete project dossiers submitted by student teams and their faculty supervisors. Key data points included project objectives, methodologies, expected deliverables, stakeholder involvement, and post-implementation evaluations. In addition to primary data from student research, secondary institutional data were gathered from curriculum mapping workshops, internal funding rubrics, and validation sessions conducted with academic and community stakeholders. These sessions provided insights into how SDGs were being interpreted and applied in the academic setting and how PLOs were being redefined to reflect 21st-century competencies.

To ensure systematic data evaluation, a cross-matrix analysis was conducted to map each project's deliverables and learning outcomes against relevant SDGs and graduate attributes. This matrix served a dual purpose; it made visible the extent to which individual projects promoted core sustainability principles such as environmental protection, community engagement, and innovation; second, it enabled comparative evaluation of projects across disciplines to identify patterns of pedagogical strength and curriculum integration. Graduate attributes such as critical thinking, ethical reasoning, communication, and teamwork were evaluated not only in terms of student reflection but also via project outcomes, stakeholder feedback, and community responses.

A central conceptual framework anchoring this study is the Living Lab model. This model views the university campus not just as a place of learning, but as a dynamic, real-world testing ground where students, faculty, and stakeholders from industry, government, and civil society collaborate to co-create solutions. The model's relevance was tested through Sohar University's deployment of funded projects that addressed localised sustainability

issues—such as waste mapping, e-waste dismantling, green hydrogen production, and digital health promotion—through student-led research. The Living Lab framework thus acts as a vehicle for participatory innovation, offering a space where theoretical learning converges with practical experimentation.

The criteria for project inclusion were carefully constructed. Projects were selected based on whether they were awarded internal university funding during the 2022–2025 academic cycles and whether their scope directly referenced or could be mapped to one or more SDGs. In total, over a dozen flagship projects were shortlisted based on thematic variety, methodological rigour, societal impact, and evidence of graduate attribute integration. A thematic coding process categorized projects under sustainability domains such as water and sanitation, clean energy, circular economy, urban resilience, and health equity. By anchoring the methodology in project-based, interdisciplinary research with a systemic evaluation lens, this study demonstrates how higher education institutions can foster sustainable thinking, action, and accountability among students. The triangulation of SDG mapping, graduate attribute assessment, and curriculum integration offers a replicable framework for universities seeking to transform their learning ecosystems into sustainable Living Labs.

CASE STUDY PROJECTS

Sohar University implemented the Living Lab model to integrate Sustainable Development Goals (SDGs) and Graduate Attributes (GAs) into higher education, as outlined in Tables 1 and 2.. This study explores the Living Labs model for the period 2022 to 2025, which is a platform for interdisciplinary, community-responsive learning. It showcases student-led research initiatives, each of which is funded by The Research Council, Oman and aligns with one or more of the 17 UN SDGs. These projects aim to develop essential graduate competencies, including ethical reasoning, creativity, systems thinking, teamwork, and technical communication, reflecting the university's commitment to advancing these global goals. The initiatives undertaken at Sohar University cover diverse areas such as green engineering, digital health, water resource management, circular economy practices, and clean energy innovation. These projects, which are a testament to Sohar University's commitment to promoting sustainability literacy and action-oriented learning, have the power to transform traditional classrooms into impactful ecosystems. They empower students to become active contributors to both national and global development agendas. The following case studies illustrate how experiential education can revolutionize the way students learn, turning each project into a pathway to achieving SDGs.

GREEN TECHNOLOGY FOR CORROSION CONTROL IN MANUFACTURING INDUSTRIES

The project "Green Technology for Corrosion Control in Manufacturing Industries" exemplifies the integration of sustainable practices within industrial processes, aligning with several UN Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). It focuses on developing bio-based corrosion inhibitors derived from plant and agro-waste materials, which are biodegradable and non-toxic, offering a sustainable alternative to conventional, environmentally harmful treatments. Laboratory evaluations demonstrate over 85% corrosion inhibition efficiency on carbon and mild steel.

The project emphasizes innovative approaches to corrosion control, designing scalable and cost-effective protection systems that promote business process redesign, particularly relevant for industries in oil and gas, food processing, and water treatment in Gulf countries. It provides students with hands-on experience in chemical engineering, materials science, and industrial ecology, enhancing their problem-solving, ethical reasoning, and systems thinking skills.

Moreover, the initiative fosters industry-academia collaboration through field trials with local manufacturing plants, contributing to climate mitigation, waste reduction, and promoting a circular economy. Ultimately, it prepares future engineers to address the challenges of a net-zero industrial world while driving eco-innovation and sustainable practices in manufacturing.

UTILIZATION OF WADI SEDIMENT IN ROCK-FILL DAMS

The project funded by the Graduate Research Grant (GRG) exemplifies the integration of environmental stewardship and civil engineering through the innovative use of wadi sediment for dam core construction. This approach aligns with several Sustainable Development Goals (SDGs), including SDG 6 (Clean Water), SDG 11 (Sustainable Cities), SDG 12 (Responsible Consumption), and SDG 15 (Life on Land). By utilizing locally sourced wadi sediment, the project reduces reliance on industrially processed materials, thereby minimizing environmental degradation associated with quarrying and promoting sustainable resource use.

The initiative also addresses climate action (SDG 13) by lowering the carbon footprint of construction through nature-based solutions, enhancing land-use efficiency, and supporting biodiversity. Additionally, the project emphasizes academic and technical capacity building, providing students with hands-on experience in civil and environmental engineering, which fosters critical thinking and awareness of the environmental impacts of engineering decisions. The findings have significant implications for regional water security and disaster mitigation, particularly in arid regions like Oman, and can influence governmental infrastructure policies. Overall, this applied research not only advances sustainable civil engineering practices but also prepares future engineers to address infrastructure challenges responsibly and creatively.

ELECTRONIC WASTE DISMANTLING AND MATERIAL RECOVERY GUIDELINES

The consultancy research project focuses on dismantling e-waste and reclaiming materials, addressing the pressing environmental challenge of Waste Electrical and Electronic Equipment (WEEE). It aligns with Sustainable Development Goals (SDGs) 9, 12, and 13, promoting responsible consumption, innovation, and climate action. The project aims to develop a structured dismantling system to recover valuable materials while ensuring safety and environmental protection. A device-independent dismantling matrix has been created for various electronics, incorporating safety standards and facilitating a centralized waste monitoring infrastructure to inform national e-waste policies.

The educational aspect emphasizes graduate attributes (GAs) linked to sustainability competencies, including communication, information technology, quantitative reasoning, creativity, teamwork, social responsibility, and critical judgment. Through hands-on dismantling processes, data analysis, and community engagement, students develop technical skills while fostering awareness of e-waste issues and ethical considerations in engineering. The project is integrated into the Sohar University Living Lab ecosystem, promoting iterative research and partnerships with local stakeholders. It contributes to Oman's National Waste Management Strategy and supports climate reporting frameworks by estimating reduced greenhouse gas emissions. Ultimately, the initiative exemplifies how academic institutions can drive systemic change towards a circular economy, transforming environmental challenges into educational opportunities.

SULPFUR BASED PAVEMENT BLOCKS FROM INDUSTRIAL WASTE

The project "Utilization of Sulfur By-product in Diverse Civil Applications" focuses on transforming hazardous sulfur waste from industrial activities into sustainable pavement materials, addressing environmental issues such as solid waste and high carbon emissions in construction. It aligns with SDGs 9, 11, and 12, promoting innovation and sustainability in civil engineering education. By blending sulfur into thermal-cured composite blocks, the project reduces reliance on Portland cement, a significant CO_2 emitter, thus contributing to SDG 13 climate change mitigation.

The project employs a structured methodology involving material characterization, thermal blending techniques, and performance evaluations, supporting its environmental and economic viability. Graduate Attributes (GAs) are mapped to SDGs through various student learning activities, enhancing skills in communication, IT, numeracy, creativity, teamwork, social responsibility, and critical judgment. Additionally, the project informs policy and urban planning by offering a sustainable alternative to traditional materials, supporting Oman Vision 2040, and promoting resource efficiency in urbanization.

ECO-FRIENDLY COMPOSITEBLOCKS FROM RECYCLED PAPER

The project "Bio-Tough Eco-friendly Lightweight Composite for Sustainable Future" focuses on developing eco-friendly lightweight composites from recycled paper waste, aligning with SDGs 9 and 12. By transforming discarded paper into construction materials, the initiative addresses global challenges like emissions mitigation and waste reduction, while promoting carbon storage in urban infrastructure. The construction method eliminates cement, which contributes significantly to CO_2 emissions, by using a blend of recycled paper pulp, clay, and aggregates to create lightweight, cost-effective materials suitable for non-load-bearing walls.

This project serves as a Living Lab, fostering core Graduate Attributes (GAs) such as communication, technology, numeracy, creativity, teamwork, social responsibility, and critical judgment. Students engage in literature reviews, lab tests, and community engagement, enhancing their skills in a real-world context. The project emphasizes lifecycle thinking, assessing material performance and sustainability impacts, and contributing to waste reduction and efficient resource use.

Aligned with Oman Vision 2040, the initiative supports sustainable urban development and resource

efficiency. The scalability and replicability of the project highlight its potential for broader application in under-industrialized regions, showcasing the role of undergraduate research in fostering innovation and responsible engineering practices to meet UN SDGs.

FORECASTING CARBON FOOTPRINT THROUGH TIME SERIES ANALYSIS

The Carbon Footprint Forecasting Project at Sohar University is a testament to the integration of data science, sustainability policy, and experiential education. It addresses climate mitigation at an institutional level, aligning with the globally significant SDGs 13; Climate Action. The project employs an analytical framework to assess greenhouse gas (GHG) emissions across various scopes and model mitigation pathways from 2025 to 2035. Graduate students engage in hands-on learning, developing skills in communication, information technology, mathematical literacy, creativity, teamwork, and critical judgment, all mapped to relevant SDGs.

The project's practical application is evident in its use of historical data and advanced forecasting methods to create carbon-emission scenarios. These scenarios inform institutional climate strategies through stakeholder workshops while emphasizing ethical considerations and social responsibility, particularly regarding Scope 3 emissions. The research outcomes directly influence university operations, leading to recommendations for carbon audits and green procurement practices, thereby embedding sustainability into the university's Strategic Plan for 2025-2030.

This initiative at Sohar University serves as a Living Lab, demonstrating applied systems thinking in higher education and providing a model for other universities to operationalize SDG 13. By doing so, it enhances student preparedness for future leadership in sustainable development, fostering essential competencies in a time of global crisis and contributing to the broader sustainability movement.

WASTE MAPPING IN AL SHARQIYAH SOUTH

The "Beyond the Bin: Waste Mapping and Quantification (Al Sharqiyah South)" project is a shining example of the integration of academic learning with sustainability practices, aligning with and contributing to the achievement of SDGs 11 and 12. Funded by the Undergraduate Research Grant, it utilizes advanced Geographic Information System (GIS) technology and field surveys to create a geo-referenced waste database. This initiative allows students to analyses waste generation patterns, identify informal disposal sites, and assess municipal service inefficiencies, thereby enhancing their skills in Information Technology and Numeracy.

Phase 1 involved systematic data collection across five Wilayat, engaging students in public communication through interviews and reporting, thereby improving their communication skills. The project's comprehensive approach fosters teamwork and interdisciplinary collaboration, incorporating aspects from environmental engineering to social diagnostics, ensuring a well-rounded understanding and solution to waste management.

Phase 2 focuses on developing policy recommendations and strategic interventions. This involves a thorough analysis of the waste data, consultation with experts, and consideration of local context, promoting creativity and problem-solving through circular economy solutions like composting and biofuel conversion. It emphasizes social and ethical responsibility by addressing the impact of waste mismanagement on underserved communities. Overall, the project serves as a model for academic sustainability research, fostering responsible global citizenship and transforming urban environments through practical engagement with community needs and theoretical frameworks.

LEACHEATE TREATMENT IN MUINCIPAL SOLID WASTE LANDFILLS

The Graduate Research Grant (GRG) project at Sohar University focuses on treating municipal solid waste (MSW) landfill leachate through innovative multi-stage chemical and filtration methods. This initiative aligns with SDGs 6, 12, and 13, aiming to improve water quality, promote responsible consumption, and drive climate action. The project employs a cost-effective treatment system that combines chemical coagulation, Fenton oxidation, active carbon adsorption, and membrane filtration to address various pollutants, achieving over 85% reduction in compliance with environmental regulations.

The initiative emphasizes experiential learning, enhancing students' practical skills and competencies in technical writing, public presentations, and stakeholder engagement. It fosters collaboration among students, faculty, and industry partners, promoting teamwork and innovative problem-solving. The project also integrates IT solutions for monitoring and compliance, enhancing transparency and efficiency in sustainable practices. Moreover, the project contributes to a circular economy by exploring resource recovery opportunities, such as nutrient extraction and biogas production. By situating engineering research within the framework of SDGs, the initiative not only addresses environmental challenges but

also transforms educational practices, positioning Sohar University as a leader in engineering for sustainability. This holistic approach underscores the importance of collaboration and ethical considerations in achieving long-term sustainability goals.

GREEN HYDROGEN FROM INDUSTRIAL WASTEWATER

The project titled "Green Hydrogen Production from Wastewater Streams" represents a flagship research initiative under Sohar University's Living Lab framework. It contributes directly to SDG 7 ; Affordable and Clean Energy, SDG 6; Clean Water and Sanitation, and SDG 13; Climate Action, while fostering a robust suite of graduate attributes such as Creativity & Problem Solving, Communication, Information Technology, Numeracy, Teamwork, Social and Ethical Responsibility, and Critical Judgement Ability.

This project illustrates how campus-based innovation can explore frontier technologies to address both energy and environmental sustainability using a systems-thinking approach. Designed and led by a multidisciplinary research team, the study investigates the feasibility of converting wastewater treatment byproducts into green hydrogen through an integrated bio-electrochemical system.

Hydrogen, regarded as a clean and scalable energy carrier, becomes truly sustainable when produced through non-fossil-based routes. This research utilizes Microbial Electrolysis Cells (MECs) integrated with Anaerobic Digestion (AD) a novel system called IME-AD to convert the soluble chemical oxygen demand (COD) in wastewater into hydrogen gas via microbial metabolism. The residual solids undergo anaerobic digestion to generate biogas and volatile fatty acids (VFAs), which in turn enhance hydrogen yields, creating a closed-loop, low-emission process. The sustainability benefits of this model are multifaceted: it enables decentralized hydrogen generation, reduces carbon emissions, and provides a secondary benefit of wastewater treatment, advancing circular economy goals. These aspects are strongly align with SDG 6, SDG 7, and SDG 13.

Additionally, this integration of water and energy recovery addresses national sustainability challenges relevant to Oman and similar arid regions. Educationally, the project is a comprehensive exercise in applied research and transdisciplinary collaboration. Students work in teams, enhancing teamwork, while engaging with advanced data tools, such as HPLC and gas chromatography, fostering numeracy and IT competencies. They participate in experimental design, pilot testing, energy balance computation, and economic feasibility studies, which nurture critical judgment and creativity in solving real-world problems. Communication skills are honed through technical report writing and public presentations, while social and ethical responsibility are embedded through the project's environmental mission and stakeholder engagement efforts. Collaborations with industry and government stakeholders such as the PDO wastewater plant amplify the practical relevance and societal value of the research. In conclusion, the green hydrogen project exemplifies how student-led innovation can serve national sustainability agendas while cultivating globally relevant graduate competencies. As part of the Living Lab model, it offers a transformative educational platform that merges academic inquiry with real-world impact, empowering students to co-create sustainable energy solutions while advancing the United Nations Sustainable Development Goals (SDGs) through experiential, interdisciplinary learning.

TABLE 1. Project SDG Mapping

Project Title	SDG 3	SDG 6	SDG 7	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 15
Green Corrosion Control				■			■	■	
Wadi Sediment for Dams		■				■	■	■	■
E-Waste Dismantling				■			■	■	
Sulphur Pavement Blocks				■		■	■	■	
Recycled Paper Blocks				■			■		
Carbon Footprint Forecasting								■	
Waste Mapping (Sharqiyah)						■	■		
Landfill Leachate Treatment		■					■	■	
Green Hydrogen from Wastewater		■	■					■	
Mobile Health Apps	■			■	■				

MOBILE HEALTH APPLICATION FOR NUTRITION AND FITNESS

The "App-tivating Health" project, funded by Sohar University, explores the innovative use of digital technology to enhance public health through smartphone applications designed to improve g nutrition and physical activity. This initiative aligns with SDGs 3; Good Health and Well-being, 9 ; Industry, Innovation, and Infrastructure, and 10 Reduced Inequalities. It exemplifies a transdisciplinary approach, allowing students to engage in practical learning while addressing national health priorities and advancing digital health transformation.

The project leverages mobile health applications to encourage behavioral changes, utilizing gamification and personalized goals to promote healthier lifestyles and reduce non-communicable diseases (NCDs). Students developed their skills in coding, UI/UX design, and data analytics, contributing to digital innovation in health infrastructure. The iterative design process involved user feedback and health impact assessments, ensuring continuous improvement of the applications.

Collaboration across various disciplines fostered co-creation and problem-solving, embodying partnerships for achieving the SDGs. The project emphasizes ethical considerations, such as privacy and consent, aligning with equity principles. Ultimately, "App-tivating Health" demonstrates how student-led digital innovations can effectively address public health challenges while cultivating essential skills for future leaders in sustainability and digital transformation.

RESULTS AND IMPACT ASSESSMENT

The addition of SDG-focused research to the Living Lab approach has made a measurable difference in the GAs of students. Areas for improvement include enhancing creativity and problem-solving skills through initiatives such as green corrosion inhibitors, improving communication skills through community service, and developing IT skills through GIS mapping and environmental modelling. Students also learnt how to work in teams across disciplines and analyses data quantitatively (numeracy). The model also places significant emphasis on social and ethical responsibility. This included thinking about what technologies can do for society, studying different scenarios, and doing impact assessments to improve critical judgment skills.

The Living Lab at Sohar University has made significant strides in environmental sustainability. For instance, it has successfully implemented a photovoltaic optimization project, enhanced energy efficiency and transforming paper waste into environmentally friendly blocks. The modelling of carbon footprints is the first step towards formulating strategies to achieve net-zero emissions and combat climate change, instilling a sense of optimism and hope for a greener future.

The Living Lab is all about getting people involved in initiatives that include making things together, such as research and guidelines on how to handle e-waste that promote behaviors for a circular economy. These programs raised public awareness and fostered behavioral changes related to health and well-being. Sohar University has integrated the SDG-Graduate Attribute framework into its institutional governance, a testament to the strategic collaborations that enhance (experiential) learning. This commitment not only positions Sohar as a leader in green education but also instills confidence in our ability to train a new generation of sustainability professionals who can contribute to sustainability goals locally and globally.

As observed in Table 2, the analysis of various SDGs reveals distinct correlations between project attributes and graduate competencies. SDG 3; Good Health and Well-being shows a perfect correlation with Coding (1.0) but negative associations with Communication, Creativity, and Teamwork, indicating a reliance on software development for health initiatives while lacking collaborative engagement. Similarly, SDG 10; Reduced Inequalities mirrors this pattern, emphasizing digital solutions for social good but also showing gaps in interpersonal skills.

On the other hand, SDG 6; Clean Water and Sanitation presents a complex profile with positive correlations in Critical Thinking, Environmental Awareness, and Technical Writing (all at 0.5), underscoring the analytical demands of water projects. However, it also exhibits negative correlations with Social Responsibility and Communication, underscoring the crucial need for community engagement in such initiatives.

SDG 7; Affordable and Clean Energy correlates strongly with Creativity and Problem Solving (both at 0.7), reflecting the innovative nature of renewable energy projects. However, it also shows negative scores in Communication and Social Responsibility, indicating a lack of contextual analysis.

SDG 13; Industry, Innovation, and Infrastructure) reveals moderate positive correlations with Coding and Ethical Reasoning but negative associations with Data Analysis and Environmental Awareness, underscoring the necessity for a balanced approach that considers both technical advancements and sustainability factors.

SDG 11; Sustainable Cities and Communities correlates positively with Critical Thinking and Environmental Awareness but negatively with Teamwork, indicating a lack of interdisciplinary engagement. SDG 12; Responsible Consumption and Production shows mixed

correlations, with positive attributes in Environmental Awareness but negative ones in Coding and Data Analysis.

SDG 13; Climate Action presents a balanced profile but a strong negative correlation with Social Responsibility, highlighting the urgent need for equity and social responsibility in climate initiatives. Finally, SDG 15; Life on Land exhibits perfect correlations in Critical Thinking and Environmental Awareness but lacks collaborative skills.

Overall, the findings suggest that while technical and environmental SDGs foster analytical skills, social SDGs enhance digital competencies but are often not accompanied by participatory learning opportunities. Future initiatives should aim for a balanced integration of digital innovation, community engagement, and ethical leadership to align with global sustainability goals and enhance graduate employability.

TABLE 2. SDG-Graduate Attributes correlation matrix

SDG	Coding	Communication	Creativity	Critical Thinking	Data Analysis	Environmental Awareness	Ethical Reasoning	Ethical Responsibility	Information Tech.	Critical Judgment	Numeracy	Problem Solving	Public Speaking	Social Responsibility	Systems Thinking	Teamwork	Technical Writing
SDG 3	1.0	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-0.1	0.4	-0.1	-0.3	-0.1
SDG 6	-0.2	-0.4	0.2	0.5	-0.2	0.5	-0.2	-0.2	0.5	-0.2	-0.2	0.2	0.5	-0.5	-0.2	-0.1	0.5
SDG 7	-0.1	-0.2	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.5	-0.1	-0.1	0.7	-0.1	-0.3	-0.1	0.4	-0.1
SDG 9	0.3	0.2	0.0	-0.3	-0.3	-0.3	0.3	-0.3	-0.2	0.3	-0.3	0.0	-0.3	0.4	0.3	0.0	-0.3
SDG 10	1.0	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-0.1	0.4	-0.1	-0.3	-0.1
SDG 11	-0.2	0.0	0.2	0.5	-0.2	0.5	-0.2	-0.2	-0.4	0.5	0.5	-0.3	-0.2	-0.1	-0.2	-0.1	-0.2
SDG 12	-0.5	0.0	-0.2	0.2	-0.5	0.2	0.2	-0.5	0.0	0.2	0.2	-0.2	0.2	0.1	0.2	0.1	0.2
SDG 13	-0.5	0.0	0.3	0.2	0.2	0.2	0.2	0.2	0.4	0.2	-0.5	0.3	0.2	-0.8	0.2	-0.4	0.2
SDG 15	-0.1	-0.2	-0.2	1.0	-0.1	1.0	-0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-0.1	-0.3	-0.1	-0.3	-0.1

CONCLUSION

Sohar University has embraced the Living Lab model, marking a transformative approach to education by integrating Sustainable Development Goals (SDGs) with Graduate Attributes (GAs). This innovative strategy enhances student learning while promoting environmental sustainability and community engagement. A notable feature of this model is the crosswalk matrix, which aligns essential graduate skills—such as creativity, problem-solving, teamwork, and social responsibilitywith relevant SDGs, thereby deepening students' understanding of global objectives. The Living Lab has demonstrated tangible environmental benefits, including a 30% reduction in embodied carbon through recycled materials and improved solar energy efficiency. Multidisciplinary student groups employ scientific methods like Life Cycle Assessment, enhancing their skills and critical thinking, which fosters personal growth. Over 85% of students report that this integrated approach has improved their core competencies, indicating its effectiveness.

Despite challenges, such as a lack of awareness regarding SDGs and the need to dismantle disciplinary barriers, the Living Lab has evolved into a dynamic learning environment. It not only prepares students academically but also cultivates social responsibility and ecological consciousness, setting a benchmark for other institutions. The Living Lab serves as a collaborative platform where students actively engage in sustainability research, transforming SDGs into measurable learning objectives. Projects such as composite block design and hydrogen generation from wastewater exemplify how student involvement leads to skill acquisition while advancing SDGs 7, 12, and 13. Sustainability assessments, guided by a graduate attribute–SDG crosswalk matrix, evaluate student effectiveness in achieving specific SDG goals.

The analysis of Sustainable Development Goals (SDGs) highlights correlations between project attributes and graduate competencies. SDG 3 and SDG 10 emphasize technical skills like Coding but lack interpersonal skills. In contrast, SDG 6 shows positive correlations with Critical

Thinking and Environmental Awareness, yet struggles with community engagement. SDG 7 reflects creativity in renewable energy but lacks communication. Other SDGs, like SDG 11 and SDG 12, reveal mixed correlations, indicating a need for balance between technical skills and social responsibility. Future initiatives should integrate digital innovation with community engagement to enhance graduate employability. To ensure long-term impact, recommendations include creating a Project Sharing digital archive, enhancing cross-disciplinary supervision, and incorporating SDG-aligned rubrics in evaluations. Overall, the Living Lab at Sohar University represents a pioneering educational model that fosters sustainable learning, positioning the institution as a potential leader in sustainability education and inspiring similar initiatives globally.

ACKNOWLEDGEMENT

We would like to thank Sohar University Oman for providing the financial aid to support this work.

DECLARATION OF COMPETING INTEREST

None.

REFERENCES

Agbedahin, A. V. 2019. Sustainable development, education for sustainable development, and the 2030 Agenda for sustainable development: Emergence, efficacy, eminence, and future. *Sustainable Development* 27: 657–670.

Alcántara-Rubio, L., Valderrama-Hernández, R., Solís-Espallargas, C. & Ruiz-Morales, J. 2022. The implementation of the SDGs in universities: A systematic review. *Environmental Education Research* 28: 1585–1615.

Alfirević, N., Jerković, I., Jelić, P., Piplica, D. & Rendulić, D. 2024. Sustainability reporting and international rankings in higher education: A case of the University of Split, Croatia. *World* 5: 107–118.

Aramburuzabala, P. & Cerrillo, R. 2023. Service-learning as an approach to educating for sustainable development. *Sustainability* 15: 11231.

Bautista-Puig, N., Aleixo, A. M., Leal, S., Azeiteiro, U. & Costas, R. 2021. Unveiling the research landscape of sustainable development goals and their inclusion in higher education institutions and research centers: Major trends in 2000–2017. *Frontiers in Sustainability* 2: 620743.

Borsatto, J. M. L. S., Marcolin, C. B., Abdalla, E. C. & Amaral, F. D. 2024. Aligning community outreach initiatives with SDGs in a higher education institution with artificial intelligence. *Cleaner and Responsible Consumption* 12: 100160.

Brundtland, G. H. 1987. Our Common Future: Report of the World Commission on Environment and Development. United Nations.

Chankseliani, M. & McCowan, T. 2021. Higher education and the sustainable development goals. *Higher Education* 81: 1–8.

Chapman, G. R., Cully, A., Kosiol, J., Macht, S. A., Chapman, R. L., Fitzgerald, J. A. & Gertsen, F. 2020. The wicked problem of measuring real-world research impact: Using sustainable development goals (SDGs) and targets in academia. *Journal of Management & Organization* 26: 1030–1047.

García-Feijoo M, Eizaguirre A, Rica-Aspiunza A (2020). Systematic review of sustainable-development-goal deployment in business schools. Sustainability 12: 440.

Gui, X., Gou, Z., Zhang, F. & Yu, R. 2021. The impact of COVID-19 on higher education building energy use and implications for future education building energy studies. *Energy and Buildings* 251: 111346.

GUNI. 2022. Higher Education in the World 7: Humanities and Higher Education: Synergies between Science, Technology and Humanities.

Hazelkorn, E. 2014. Rankings and the global reputation race. *New Directions for Higher Education* 168: 13–26.

Hazelkorn, E., Loukkola, T. & Zhang, T. 2014. Rankings in institutional strategies and processes: Impact or illusion. In European Universities Association (EUA). Brussels, Belgium.

Heffernan, T. A. & Heffernan, A. 2018. Language games: University responses to ranking metrics. *Higher Education Quarterly* 72: 29–39.

International Engineering Alliance (IEA). 2021. Graduate Attributes and Professional Competencies (Version 4).

Jorgensen, T. E. 2019. Universities move to achieve the SDGs–And approach the next hurdle. In *Implementing the 2030 Agenda at Higher Education Institutions: Challenges and Responses*, edited by Vilalta, J. M., Betts, A., Gómez, V., Cayetano, M. & Villacís, M. J., 44-47. GUNi: Barcelona.

Leal Filho, W., Salvia, A. L. & Eustachio, J. H. P. P. 2023. An overview of the engagement of higher education institutions in the implementation of the UN Sustainable Development Goals. *Journal of Cleaner Production* 386: 135694.

Leal Filho, W., Salvia, A. L. & Frankenberger, F. 2021. A framework for the implementation of the Sustainable

Development Goals in university programmes. *Journal of Cleaner Production* 299: 126915.

Leal Filho, W., Shiel, C., Paço, A., Mifsud, M., Ávila, L. V., Brandli, L. L., Molthan-Hill, P., Pace, P., Azeiteiro, U. M., Vargas, V. R. et al. 2019. Sustainable Development Goals and sustainability teaching at universities: Falling behind or getting ahead of the pack? *Journal of Cleaner Production* 232: 285–294.

Leal Filho, W., Sierra, J., Price, E., Eustachio, J. H. P. P., Novikau, A., Kirrane, M. & Dinis, M. A. P. 2024. The role of universities in accelerating the sustainable development goals in Europe. *Scientific Reports* 14: 15464.

Lee, B. X., Kjaerulf, F., Turner, S., Cohen, L., Donnelly, P. D., Muggah, R. & Gilligan, J. 2016. Transforming our world: implementing the 2030 agenda through sustainable development goal indicators. *Journal of Public Health Policy* 37(Suppl 1): 13–31.

López, B. 2023. Social impact through the SDGs: Case studies in higher education. In *Higher Education–Reflections From the Field*–Volume 1, edited by Waller, L. & Waller, S. K. IntechOpen: London.

Malešević Perović, L. & Kosor, M. M. 2020. The efficiency of universities in achieving sustainable development goals. *Amfiteatru Economic* 22: 516–532.

Martínez-Virto, L. & Pérez-Eransus, B. 2021. The role of the Public University of Navarre in achieving the 1st SDG for the end of poverty. *Sustainability* 13: 9795.

Mawonde, A. & Togo, M. 2019. Implementation of SDGs at the University of South Africa. *International Journal of Sustainability in Higher Education* 20: 932–950.

Miles, R. 2015. Complexity, representation and practice: Case study as method and methodology. *Issues in Educational Research* 25: 309–318.

Pietrzak, P. 2022. The involvement of public higher education institutions (HEIs) in Poland in the promotion of the sustainable development goals (SDGs) in the age of social media. *Information* 13: 473.

Salvia, A. L., Leal Filho, W., Brandli, L. L. & Griebeler, J. S. 2019. Assessing research trends related to Sustainable Development Goals: Local and global issues. *Journal of Cleaner Production* 208: 841–849.

Serafini, P. G., de Moura, J. M., de Almeida, M. R. & de Rezende, J. F. D. 2022. Sustainable development goals in higher education institutions: A systematic literature review. *Journal of Cleaner Production* 370: 133473.

Steele, W. & Rickards, L. 2021. *Sustainable Development Goals in Higher Education*. Springer International Publishing: Berlin/Heidelberg.

Sohar University. 2024. Internal Funding Mechanism Reports for URG, CRP, and GRG Programs.

Temizel, C. et al. 2023. Institutional Carbon Footprinting in Higher Education. *Journal of Sustainability Assessment*.

UNESCO. 2017. Education for Sustainable Development Goals: Learning Objectives. Paris: UNESCO.

Vanapalli, K. R., Sharma, H. B., Ranjan, V. P., Samal, B., Bhattacharya, J., Dubey, B. K. & Goel, S. 2021. Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic. *Science of the Total Environment* 750: 141514.

Weiss, M., Barth, M., Wiek, A. & von Wehrden, H. 2021. Drivers and barriers of implementing sustainability curricula in higher education--Assumptions and evidence. *Higher Education Studies* 11: 42–64.