INTERNATIONAL JOURNAL
OF SUDAN RESEARCH (IJSR)

IJSR ISSN
2042-6003 (Print)
2042-6011 (Online)

WASD
WORLD ASSOCIATION FOR SUSTAINABLE DEVELOPMENT

IJSR V12 N1 2025
DOI: 10.47556/J.IJSR.12.1.2025.2
OPEN ACCESS

CASE STUDY

Catalysing Community-Led Engineering for a Sustainable Sudan: The Role of the Community Engineering Response Team (CERT)

Dr Tagwa Musa
Chemical Engineering Program, Texas A&M University at Qatar, 23874 Doha, Qatar
TEES Gas & Fuels Research Center, 77840 College Station, USA
Email: tagwa.mohamed@qatar.tamu.edu
ORCID: 0000-0002-4364-9841

Ali Mohammed Ali Alawad
Sudan University of Science and Technology, Khartoum, Sudan
Email: alialawad28@gmail.com
ORCID: 0009-0006-9327-0131

Bakry Mahmoud
Sudan University of Science and Technology, Khartoum, Sudan
Email: Eng.bakrimusbah@gmail.com
ORCID: 0000-0002-2534-0349

Fatima Elsayed
Sudan University of Science and Technology, Khartoum, Sudan
Email: fatimaGalalAhmed@gmail.com
ORCID: 0000-0002-6516-3930

Romysaa Babiker
Sudan University of Science and Technology, Khartoum, Sudan
Email: romysaababiker@gmail.com
ORCID: 0009-0001-5002-3505

Dr Ramiro Jordan
Electrical & Computer Engineering Program, University of New Mexico, Albuquerque, USA
Email: rjordan@unm.edu
ORCID: 0000-0001-5634-6236

CITATION: Musa, T., Alawad, A.M.A., Mahmoud, B., Elsayed, F., Babiker, R. and Jordan, R. (2025): Catalysing Community-Led Engineering for a Sustainable Sudan: *The Role of the Community Engineering Response Team (CERT)*. International Journal of Sudan Research (IJSR), Vol 12, No. 1, pp.17-40.

RECEIVED: 8 May 2025 / **REVISED:** 16 May 2025 / **ACCEPTED:** 19 May 2025 / **PUBLISHED:** 31 May 2025

ABSTRACT

PURPOSE: This paper examines the Community Engineering Response Team (CERT) as a case study to explore how community-driven engineering education and innovation can aid in Sudan's post-war recovery..

DESIGN/METHODOLOGY/APPROACH: The paper is based on an empirical case study of a capacity-building initiative involving 700 engineering students throughout Sudan. The study employed virtual training (ECHO model), hands-on implementation, and survey data collection.

FINDINGS: The programme improved knowledge of sustainability (94.4% reported enhancement), fostered innovative community-led projects, and showcased the effectiveness of the ECHO model in post-conflict engineering and education in other disciplines.

VALUE: This paper offers a replicable model that integrates engineering problem-solving and education with post-war recovery efforts, together with policy recommendations for scaling.

RESEARCH LIMITATIONS/IMPLICATIONS: The study focused on a pilot initiative; future work should explore long-term sustainability.

PRACTICAL IMPLICATIONS: The CERT model can be adapted for other engineering and socio-economic projects tailored to address broader sustainability challenges.

KEYWORDS: *Community Engineering; Capacity Building; Sudan; ECHO Model; Peace Engineering; Sustainability; Solid Waste Management*

ENGINEERING AS A PATHWAY TO POST-WAR RECOVERY

The 2023 Conflict and Its Impact on Sudan's Infrastructure and Higher Education

Sudan has endured decades of conflict and political instability, with the most recent war erupting on 15 April 2023. The ongoing violence has devastated essential infrastructure, displacing over 13 million people (10.7 million internally and 2.3 million across borders) and triggering widespread food insecurity and economic collapse (ACAPS, 2024). The destruction of roads, water systems, energy networks, and housing has disrupted daily life and hindered prospects for economic development. Traditionally viewed as engines of innovation and reconstruction, higher education institutions have not been spared. Universities have suffered damage, been repurposed for military use, or closed entirely (Elgadal and Glade, 2024), further widening the skills gap that jeopardises national recovery.

As Sudan embarks on its reconstruction journey, engineering is poised to play a transformative role in physical, political, and financial rebuilding and developing sustainable, innovative,

community-centred solutions. Rethinking engineering education in this context is essential for preparing a new generation of engineers and other professionals so they are equipped to address Sudan's unique post-conflict challenges.

Global Lessons on Engineering for Peace and Post-Conflict Recovery

Engineering has played a vital role in post-conflict recovery worldwide, as infrastructure development promotes long-term peace and economic revitalisation (Wily, 2009). By investing in local engineering capacity, communities can reduce their dependence on external aid and bolster resilience, innovation, and entrepreneurship, as evidenced in post-genocide Rwanda and war-affected Afghanistan and Iraq (van Fenema *et al.*, 2016).

Examples from global case studies include:

- *Post-WWII Europe (Marshall Plan):* Investments in transportation, energy, and industrial infrastructure, driven by engineering, were crucial for economic recovery (De Long and Eichengreen, 1993);
- *Rwanda (Post-1994):* Sustainable urban planning and localised infrastructure development have created a solid foundation for long-term stability (UN-Habitat, 2016; World Bank, 2009);
- *Afghanistan and Iraq:* Reconstruction efforts have demonstrated that top-down, donor-driven engineering often fails without local engagement. Community-led, conflict-sensitive solutions are more sustainable (EAP, 2006; USIP, 2008).

Sustainability, Engineering Education, and Local Resilience

Rebuilding Sudan presents an opportunity to transition from conventional reconstruction to a green, innovative, sustainability-focused, locally driven approach. Engineers need to tackle physical rebuilding, environmental degradation, climate risks, social inequities, finance, and justice.

Three core priorities should guide this transformation:

- climate-smart infrastructure incorporates distributed renewable energy, water systems, telecommunications, and resilient materials;
- circular economy models, particularly for waste management, reduce environmental pollution and generate local employment;
- community-led, affordable, context-sensitive engineering solutions grounded in local knowledge and open to incorporating high technology.

Aligning engineering education with these priorities through practical training, community engagement, and exposure to peacebuilding frameworks equips graduates to become catalysts for resilient and transformational development.

Objectives of this Paper:

This paper explores how engineering education can be reimagined as a catalyst for sustainable recovery, innovation, socio-economic development, and peacebuilding in post-conflict settings. Using Sudan's Community Engineering Response Team (CERT) as a case study, it specifically seeks to:

- illustrate the dual-framework design of CERT; this integrates Project ECHO and Peace Engineering principles with respect and preservation of culture;
- examine the impact of blended virtual and hands-on learning on student engagement and community development;
- reflect on lessons learned and suggest strategies for scaling such models in Sudan and other global fragile contexts.

ENGINEERING CHALLENGES IN POST-CONFLICT SUDAN

Rebuilding Sudan involves restoring physical infrastructure and fostering a new generation of engineers and other professionals capable of implementing sustainable, locally relevant solutions. However, the engineering sector in Sudan encounters structural challenges that impede its ability to contribute effectively to national recovery.

This section outlines three core challenges:

1. the erosion of engineering capacity due to brain drain;
2. increasing climate vulnerability and environmental degradation;
3. critical gaps in energy, water, and telecommunications infrastructures.

Brain Drain and Engineering Capacity Gaps

Over decades of instability and economic decline, Sudan's engineering workforce has been severely depleted. The most significant factor is the brain drain, with reports that over half of Sudanese professionals who migrate are engineers, scientists, or healthcare workers. This loss has created a vacuum in technical expertise essential for reconstruction (Omer *et al.*, 2024).

Comparative Lessons:

- Rwanda responded to the post-genocide brain drain by launching professional reintegration schemes and linking engineers to national development projects (Masengesho *et al.*, 2020).
- Iraq encouraged returning professionals through international university partnerships and research grants (Al-Khateeb *et al.*, 2014).
- South Sudan relied on regional training networks to reduce reliance on foreign experts and build local talent (UNITAR, 2021).

Policy Directions for Sudan:

- Establish national engineering fellowships and graduate retention incentives.
- Link students to real-world projects through internships and mentorships.
- Strengthen university-industry collaborations to embed engineering education within national development priorities (Docquier and Rapoport, 2012, Bolu *et al.*, 2024a).

Climate Vulnerability, Water Scarcity, and Environmental Degradation

Sudan is among the most climate-vulnerable countries in Africa. Prolonged under-investment in environmental infrastructure, exacerbated by recurrent conflict and the recent war, has significantly weakened the country's capacity to adapt to climate change (UNEP, 2023).

Key challenges:

- Desertification threatens infrastructure and agriculture, affecting over 50% of the land (UNEP, 2022).
- Annual flooding disrupts transportation and damages buildings.
- Water insecurity affects approximately 20 million people (World Bank, 2023).

Engineering Solutions for Climate Resilience:

- Develop rainwater harvesting, solar-powered water treatment, and decentralised irrigation systems.
- Use compressed stabilised earth blocks (CSEB) for affordable, climate-adaptive construction.
- Train students in community-based environmental engineering, including erosion control, sustainable drainage, reforestation, and finance.

Integrating these approaches into engineering curricula can build local resilience while aligning Sudan's reconstruction with global sustainability goals.

Rebuilding Energy Infrastructure and Expanding Access

Sudan's energy crisis is a significant barrier to recovery. Over 40% of the population lacked reliable electricity in 2022 (IEA, 2024), and conflict-related damage to infrastructure has further deepened the crisis. Despite their high cost, maintenance burden, and environmental impact, Sudan's heavy reliance on diesel-fuelled thermal power stations has created an unsustainable energy model. Recent research shows that transitioning these stations to natural gas could reduce operational costs by over 50% while significantly improving efficiency and environmental performance (Elbashir *et al.*, 2024). However, natural gas reserves are limited, and long-term solutions must also integrate renewable energy and energy efficiency strategies.

Current Barriers:

- Dependence on fossil fuels and centralised grids.
- Frequent fuel shortages and power outages.
- Limited technical capacity to deploy renewable energy systems.

Educational and Practical Interventions:

- Expand training in solar, wind, and biogas technologies.
- Promote student-led innovation, e.g., solar irrigation, clean cooking, and off-grid systems.
- Encourage partnerships with clean energy start-ups to support implementation.

Global Parallels:

- Afghanistan deployed solar-powered micro-grids to restore power in rural areas (Tayyab *et al.*, 2024).
- Rwanda scaled up off-grid solar access during post-conflict recovery (Ahmed, 2020).
- Sierra Leone built biogas and biofuel systems capacity through university-led training (Armstrong *et al.*, 2021).

Sudan can learn from these experiences to create decentralised, resilient energy solutions led by a new generation of engineers.

Recognising these critical engineering challenges, CERT prioritises solid waste management, energy solutions, and climate resilience as entry points for rebuilding efforts. Sudanese engineers can play a transformative role in environmental and economic recovery by reframing waste as a resource, integrating renewable energy and telecommunications into engineering curricula, and addressing climate-induced infrastructure vulnerabilities.

The next section will outline the CERT model in detail and explore how capacity-building initiatives, virtual education models, and hands-on implementation contribute to sustainable recovery and community resilience in post-conflict Sudan.

THE CERT INITIATIVE: BRIDGING EDUCATION AND COMMUNITY ACTION

The CERT initiative was launched as an innovative initiative to build capacity in addressing the critical engineering and sustainability challenges facing post-conflict Sudan. By using a blended virtual training model alongside practical implementation, CERT links engineering education with real-world problem-solving.

Although it was conceived before the 2023 war, CERT's relevance and urgency increased dramatically as the conflict disrupted educational systems and exacerbated environmental and infrastructural breakdowns. The initiative aimed to cultivate technically skilled engineers and socially responsible leaders capable of contributing to peacebuilding and sustainable recovery.

CERT was implemented in two phases: an initial capacity-building phase, followed by a practical phase focused on community service.

Goals and Guiding Principles of CERT

CERT was established to address three intersecting goals:

1. build engineering capacity across Sudan through inclusive, virtual training accessible even in conflict-affected zones;
2. empower students as agents of change by involving them in community-led environmental and infrastructure solutions;
3. promote peace engineering through ethical, context-sensitive design and implementation strategies.

CERT is underpinned by the following values:

- *Community Ownership:* Projects are co-developed with local communities to ensure relevance and sustainability;
- *Equity and Inclusion:* At least 25% of participants are female, with outreach efforts targeting under-served institutions;
- *Scalability:* The model was designed to be low-cost and adaptable across disciplines and regions.

CERT is grounded in two interconnected frameworks, including the ECHO model and Peace Engineering, and is aligned with the Sustainable Development Goals (SDGs).

ECHO Model (Phase I)

The Project ECHO (Extension for Community Healthcare Outcomes) model, originally developed at the University of New Mexico, is a virtual capacity-building platform designed to democratise knowledge and amplify local expertise. Rather than delivering top-down lectures, ECHO follows a "hub-and-spoke" model, where subject matter experts (hub) mentor and collaborate with learners (spokes) through case-based discussions, guided mentorship, and peer learning (Project ECHO, 2023; Raatz *et al.*, 2024).

What distinguishes the ECHO model is its emphasis on developing communities of practice instead of merely transmitting information (Matemba *et al.*, 2023). This approach flattens hierarchies and acknowledges local participants as experts-in-training, fostering collaborative problem-solving and real-time feedback across diverse geographies.

In the context of post-conflict Sudan, CERT adapted the ECHO model to offer engineering students and young professionals access to high-quality, interactive learning, despite significant disruptions to physical infrastructure, displacement, and insecurity.

Peace Engineering (Phase II)

A new discipline is increasingly emerging: Peace Engineering. This discipline is defined as the intentional application of science, technology, and engineering principles through systems thinking to foster and sustain conditions for peace. It involves addressing both the absence of conflict (negative peace) and the presence of social equity, environmental sustainability, ethical responsibility, and community resilience (positive peace) (Jordán *et al.*, 2021; Jordán *et al.*, 2019; Jordán *et al.*, 2024).

Peace Engineering redefines engineers' roles from merely solving technical problems to becoming catalysts for systemic change. It emphasises collaboration to create solutions that are technically sound, socially just, locally relevant, and environmentally sustainable. This approach fosters transdisciplinary co-operation, empowers local communities, upholds ethical principles, and involves co-designing interventions with communities, particularly those affected by conflict or marginalisation.

Peace Engineering integrates technical excellence with ethical responsibility, social justice, sustainability, and local empowerment. Rather than viewing engineers as external experts who deliver technical fixes, this framework positions them as facilitators of community-driven solutions that are context-sensitive, inclusive, and peace-promoting.

Through its design and implementation, CERT embodies this paradigm by:

- prioritising co-creation with communities, ensuring local knowledge informs every stage of project development;
- training students in technical skills, ethical engagement, environmental stewardship, and systems thinking;
- providing opportunities for students to apply their learning through direct service in communities affected by conflict, displacement, and under-development.

For Sudan, peace engineering offers a transformative lens through which reconstruction can be viewed as more than just physical rebuilding. It leads to long-term resilience, community empowerment, and inclusive peace. Lessons from global Peace Engineering efforts provide a roadmap for integrating this approach into post-war recovery strategies, higher education reform, and capacity building.

Table 1 summarises CERT's dual-framework design, highlighting how Project ECHO and Peace Engineering complement one another in promoting learning and community transformation.

Table 1: CERT's Two-Pillar Framework for Engineering Education in Post-Conflict Sudan

Activity	*Framework*	*Focus Area*	*Delivery Mode*	*Outcomes*
Phase I	Project ECHO	Knowledge sharing, mentorship, technical skills	Virtual (Hub-and-Spoke), all-teach all-learn	Capacity building, community of practice, education continuity
Phase II	Peace Engineering	Community engagement, ethical application	In-person, hands-on	Socially responsive design, sustainability projects, positive peace impact

Source: Constructed by the authors

These two phases, digital and physical, represent a complementary and mutually reinforcing strategy for engineering education in fragile settings. The following section provides a closer look at how these frameworks were operationalised in Sudan.

CERT's Alignment with the SDGs

CERT aligns with multiple SDGs, especially those targeting quality education, clean energy, sustainable cities, and climate action. It also reflects global research on blended learning in conflict-affected contexts, where knowledge-sharing combined with practical application strengthens competence and community impact (Kirk, 2009).

CERT contributes directly to the following SDGs:

- *SDG 4 (Quality Education):* By offering inclusive, accessible, and skills-oriented training through a blended learning model;
- *SDG 11 (Sustainable Cities and Communities):* Through student-led interventions in waste management, infrastructure design, and environmental health;
- *SDG 13 (Climate Action):* Embedding climate resilience, renewable energy, and circular economy concepts into engineering education;
- *SDG 16 (Peace, Justice and Strong Institutions):* By embracing the scientific method of working with verifiable, trusted data to develop interoperable-trusted communications among all participants, combat disinformation, and minimise conflict.

By merging global frameworks such as the SDGs, ECHO model, and Peace Engineering with locally rooted action, CERT positions engineering education as a driver of sustainable recovery and social cohesion in post-conflict Sudan. It demonstrates how future engineers can be trained to think beyond technical outputs and towards holistic, equity-driven impacts in fragile environments.

CERT IMPLEMENTATION: FROM VIRTUAL LEARNING TO COMMUNITY IMPACT

Phase One: Virtual Capacity Building via the ECHO Model

The first phase of CERT leveraged the ECHO model, a virtual learning framework originally developed for healthcare but adapted here to deliver technical training to engineering students across Sudan. This marked the launch of the world's first engineering-focused ECHO programme. Through 18 biweekly interactive sessions, the programme reached over 700 students from 11 engineering disciplines, including civil, environmental, chemical, petroleum, electronics, water resources, biomedical, transportation and refinery, geological, exploration, and electrical engineering. Notably, 25% of participants were female, reflecting the initiative's commitment to inclusivity (Musa *et al.*, 2024).

Delivered by 15 subject matter experts, five young professionals, and five advanced learners, the sessions covered the following:

- solid waste classification and circular economy concepts;
- GIS-based mapping for waste management;
- recycling innovations;
- community entrepreneurship and sustainability practices.

Despite Sudan's challenging conditions, the ECHO framework allowed students to access expert knowledge and peer learning opportunities regardless of their location, enabling continuity of education amidst conflict.

Impact and Learner Engagement

Post-training evaluations showed:

- 94.4% of students reported improved knowledge in solid waste management;
- 78.7% would recommend the programme to peers;
- 74.7% expressed intent to apply what they learned in communities or workplaces (Musa *et al.*, 2024)

Participants' testimonials further demonstrate the impact:

The effectiveness of the programme was also reflected in qualitative feedback from participants.

> *"Today I collected some trash and was about to throw it randomly. Suddenly I remembered today's session. I was ashamed of myself."* – Yasin Amir

> *"I went to the market and all my focus was on waste—how to classify it and how it could be reused. I even laughed with myself!"* – Dirgam Mohamed

These reflections underscore the mindset transformation enabled by CERT and the ECHO model's role in fostering behavioural change.

Advantages of the ECHO Model in Engineering Education:

- *Accessibility:* Students from conflict zones could participate.
- *Collaborative learning:* Peer-to-peer interaction and shared problem-solving.
- *Scalability:* The model requires minimal infrastructure investment yet delivers high-impact learning.

Phase II: Hands-On Implementation and Community Projects

Following the virtual training, 40 top-performing students were selected for Phase II; this applied Peace Engineering principles in real-world community settings. This phase emphasised experiential learning and ethical, systems-based problem solving, core tenets of Peace Engineering.

Rather than acting as external implementers, students collaborated with communities to co-develop solutions to sustainability challenges that were locally relevant and environmentally responsible. The projects were rooted in both technical rigour and social justice, aligning with Peace Engineering's commitment to co-creating solutions that advance equity, resilience, and well-being.

Key projects included:

- Biogas and compost production from household and agricultural waste, designed with input from local farmers.
- Recycled construction materials, such as interlock bricks made from sand and plastic waste, offer low-cost, climate-adaptive alternatives.
- Community awareness campaigns on waste sorting and environmental hygiene, aimed at shifting behaviours and fostering ownership.
- GIS-based waste mapping, enabling communities to visualise waste distribution and improve collection and disposal systems.

These activities helped the learners bridge the knowledge gained in ECHO sessions with field realities, navigating technical design alongside cultural, environmental, and economic constraints. The experience also built students' confidence in engaging ethically and constructively with conflict-affected communities, key capabilities in Peace Engineering practice.

Through this phase, CERT empowered participants to apply what they had learned and embody the role of Peace Engineers: technically skilled, socially conscious professionals who promote sustainability, inclusion, and resilience through locally anchored engineering practice.

Field Engagement in Abusair Village

One of the most impactful interventions occurred in Abusair Village (Gezira State), where CERT students conducted a field visit in February 2023.

Key activities included:

- Community exhibitions showcasing innovative reuse of waste, such as sand-filled plastic bottles used as structural elements.
- Public presentations on composting, plastic reuse, and biogas, adapted to the village's high availability of cow manure and crop waste.
- Data collection and GIS mapping of waste distribution to design an efficient collection and sorting system.

The visit fostered a strong sense of trust and co-ownership between the students and residents. It also offered real-world relevance for ECHO session concepts and allowed students to navigate resource constraints, social dynamics, and field-level technical adjustments.

Unfortunately, the outbreak of war on 15 April 2023, suspended the project before completion. However, the community relationships, baseline data, and student-led designs remain assets that can be mobilised once stability is restored.

The Abusair experience reaffirms the transformative power of engineering education when grounded in local realities and community partnerships.

OUTCOMES, COMMUNITY IMPACT, AND IMPLEMENTATION INSIGHTS

The CERT initiative demonstrated that engineering education can catalyse social and environmental change even in fragile, conflict-affected contexts. Through both implementation phases, students gained technical knowledge and a deep sense of civic responsibility, peer collaboration, and professional purpose.

CERT cultivated more than just skills; it fostered a shift in mindset. Students began to see engineering as a technical discipline and a tool for service and community empowerment. Many reported a sense of excitement, pride, and usefulness, especially as they engaged directly with communities and saw the real-world impact and social value of their work.

The transformation deepened as students moved from virtual learning into hands-on implementation. This transition from knowledge to action, and from individual learning to collective problem-solving, marked a turning point in how students understood their role as future engineers.

Community Feedback and Environmental Benefits

Building on the gains from ECHO sessions, CERT participants brought technical solutions to rural communities like Abusair, where they introduced practical projects and environmental education.

In these pilot communities, the CERT initiative left a visible imprint in physical outcomes and attitudes towards sustainability and local innovation. The projects were technically sound and

emotionally resonant: students and community members built trust, worked side by side, and shared a sense of accomplishment.

Key reported benefits:

- Increased community awareness about the health risks of unregulated waste disposal.
- Local enthusiasm for low-cost innovations such as biogas from cow manure and plastic reuse in construction.
- GIS waste mapping helped communities visualise waste flows and identify dumping hotspots.

Community members responded positively to the solutions and the collaborative process. Many of them appreciated the students' efforts and felt acknowledged, while local leaders expressed their willingness to co-develop future strategies for sustainable waste management with university partners.

From the students' perspective, the experience was energising and empowering. Many reflected on the joy of collaborating in teams, the satisfaction of addressing real-world problems, and the realisation that engineering can be a source of hope and healing.

While the war ultimately limited the full rollout of interventions, the foundational work, data, designs, relationships, and mindsets remain a critical resource for future post-war recovery and peacebuilding efforts.

Implementation Challenges and Lessons for Scaling

CERT's implementation faced several challenges that offer important insights for scaling similar models:

Challenges

- Conflict-related disruptions: The outbreak of war in April 2023 halted implementation and displaced students and community members.
- Limited Internet access and electricity instability: Some students struggled to join ECHO sessions regularly due to bandwidth or electricity issues.
- Logistical constraints: Lack of funding for tools, transportation, and materials limited the number and scope of field activities.
- Faculty and institutional disruption: Many universities lacked the administrative stability to fully support student-led community projects.

Lessons Learned

- Blended models offer resilience: The ECHO virtual framework proved essential in sustaining education during disruptions, highlighting its potential for use in future crises.

- Hands-on learning enhances retention: Students retained and applied knowledge more effectively when paired with real-life engagement.
- Community participation drives relevance: Co-designing projects with community members made solutions more context-appropriate and increased community ownership.
- Flexibility is critical: Programmes must remain adaptable to rapidly changing conditions in fragile states, especially during political instability.

Despite setbacks, CERT offers a promising pathway for post-conflict engineering education. Lessons from its implementation can inform future capacity-building efforts across Sudan and in similar contexts globally.

COLLABORATION AND STAKEHOLDER ENGAGEMENT

CERT's success was grounded in a focused but strategic collaboration between two lead institutions: Sudan University of Science and Technology (SUST) and the University of New Mexico's Project ECHO. While students from eight Sudanese universities participated, these two core partners co-designed and implemented the programme, demonstrating how a compact, well-aligned collaboration can achieve national reach, even in fragile settings.

In Sudan's resource-constrained and conflict-affected context, institutional collaboration was essential. Through its established infrastructure, Project ECHO provided the virtual learning framework, technical mentorship, and facilitator training. Meanwhile, SUST led on-the-ground co-ordination, participant recruitment, content contextualisation, and alignment with engineering curricula.

This dual-institutional model enabled CERT to:

- combine global knowledge-sharing methods with local academic leadership;
- deliver consistent, high-quality training despite disruptions to conventional education;
- ensure that learning was both relevant and resilient in a crisis-affected setting.

Although the war interrupted CERT's physical implementation, the programme's networks and communication channels remain active. WhatsApp groups continue to connect learners, facilitators, and subject matter experts, sustaining peer learning and preserving momentum for future reactivation.

Student Representation Across Sudan

While SUST and the University of New Mexico were the primary institutional partners, learners were drawn from eight universities across different Sudanese states, reflecting CERT's inclusive design and wide appeal among engineering students.

The participating universities included:

- SUST;
- University of Khartoum;
- University of Nyala;
- Omdurman Islamic University;
- Alsalam University;
- University of Gezira;
- City College of Science and Technology;
- Bayan University.

This broad institutional and geographic representation enriched peer-to-peer learning and fostered a national community of practice. Despite logistical challenges, such as limited Internet access and frequent power outages, CERT maintained strong engagement, demonstrating the potential of blended models in disrupted contexts.

Operational Partners and Field Collaboration

Beyond the two lead institutions, several organisations played a critical role in implementing the CERT model:

- *Project ECHO (University of New Mexico):* Provided the virtual mentorship model and technical support. The ECHO team trained Sudanese facilitators and helped adapt the model to an engineering education context;
- *Sustainable Development Response Organization (SuDRO):* As the main local field partner, SuDRO co-ordinated community project logistics, facilitated the Abusair field visit, and supported student-led awareness activities and data collection;
- *Learner Affiliations:* While not formally involved in implementation, the students who participated in CERT were affiliated with eight Sudanese universities. Their participation, enabled through open online registration, ensured a broad geographic and disciplinary representation that enriched the programme's national impact.

Each partner contributed uniquely through technological infrastructure, field access, or institutional support, helping ensure CERT's relevance, adaptability, and community-embedded design across both virtual and field phases.

POLICY AND INSTITUTIONAL RECOMMENDATIONS FOR SCALING UP

CERT's pilot implementation in Sudan revealed the transformative potential of community-driven, sustainability-oriented engineering education to support post-war recovery. However, the

long-term impact will depend on creating enabling environments through policy reform, institutional alignment, and strategic investment. This section outlines key recommendations in three policy domains: post-conflict waste management, national scaling of the CERT model, and integrating engineering education into broader recovery strategies.

Strengthening Post-War Waste Management Frameworks

Sudan's waste management system, already under strain, has been pushed to the brink by war. The destruction of infrastructure, rapid urbanisation, and lack of formal waste services have led to widespread environmental degradation and heightened public health risks. For instance, 80% of residents in Khartoum report significant waste accumulation, and 95% have never received formal waste management education (Shibrain *et al.*, 2025).

In the post-war context, new layers of complexity emerge, including:

- debris from destroyed buildings and infrastructure;
- hazardous waste such as unexploded ordnance, medical waste, and human remains;
- informal dumping and open burning in urban areas.

To build a safer, more resilient waste system aligned with circular economy principles, the following policy actions are recommended:

- introduce post-conflict waste classification systems differentiating between organic, plastic, and hazardous materials;
- develop specialised protocols for war-related waste management (e.g., explosive remnants, bio-hazards);
- integrate informal waste collectors into formalised, community-based recycling programmes;
- launch university- and youth-led public awareness campaigns on safe disposal, segregation, and re-use.

By coupling top-down policy with bottom-up community engagement, Sudan can turn a crisis into an opportunity for environmental reform and local employment.

Scaling the CERT Model across Sudan

Sudan requires a structured national rollout strategy to replicate CERT's impact and expand its reach. This effort should build on the pilot's core strengths, virtual access, inclusivity, and field relevance while addressing limitations such as institutional fragility and security risks.

Key strategies include:

- institutionalising CERT as a credit-bearing elective within engineering curricula, linking it to community service and sustainability learning outcomes;

- establishing regional CERT hubs hosted by universities and supported by local government and NGOs to co-ordinate implementation;
- expanding the ECHO virtual network to cover other critical sectors, such as water systems, renewable energy, construction, health infrastructure, and Artificial Intelligence (Bolu *et al.*, 2024b);
- preparing for conflict or disruption through mobile learning kits and offline content repositories to ensure education continuity for displaced students, building on recent innovations in solar-powered, Internet-enabled education devices for low-resource environments (Bolu *et al.*, 2022);
- developing open-access digital repositories to share CERT tools, training modules, case studies, and impact reports across Sudan and with other post-conflict countries.

Scaling should follow a phased and adaptive model, allowing local contexts to shape delivery while maintaining core principles of community ownership and peace-centred learning.

Mainstreaming Engineering Education into National Recovery Strategies

For engineering to fulfil its potential as a driver of sustainable reconstruction, it must be embedded in Sudan's national recovery plans, not only as a technical discipline but as a tool for peacebuilding, inclusion, and resilience.

High-level policy recommendations:

- with leadership from the Ministry of Higher Education and Scientific Research, integrate peace engineering, ethics, and sustainability into national education strategies;
- align engineering programmes with post-war reconstruction priorities, climate adaptation, infrastructure restoration, rural development, and innovation ecosystems;
- establish funding mechanisms, such as scholarships, innovation grants, and start-up incubators, to support students and faculty working on community-driven projects;
- facilitate partnerships between engineering faculties, public works departments, and donor agencies, enabling students to contribute directly to rebuilding projects.

These reforms will elevate engineering's role in national development and combat brain drain by offering engineers meaningful, locally anchored career paths.

CONCLUSIONS: FROM KNOWLEDGE TO ACTION IN SUDAN'S REBUILDING

CERT represents more than a temporary educational initiative; it offers a replicable, transformative model for rebuilding societies through locally grounded engineering, youth empowerment, and systems-oriented learning. Designed and implemented before the 2023 conflict, CERT demonstrated

how engineering education, when intentionally structured and ethically grounded, can drive meaningful community engagement and sustainable development.

In the years leading up to the war, Sudan's engineering students showed that despite institutional fragility and resource constraints, learning could be mobilised as a catalyst for hope, resilience, and civic responsibility. CERT's experience revealed that when virtual education is coupled with community-based implementation, engineering transcends its technical boundaries, it becomes a force for peacebuilding, social equity, and environmental justice.

Combining the ECHO virtual learning model with Peace Engineering principles, CERT established a two-phase approach that effectively mobilised youth, strengthened local problem-solving, and prepared future engineers to think critically and act ethically in fragile settings. As Sudan looks ahead to national recovery, CERT offers a tested framework that can inform a new generation of engineering education and practice.

CERT as a Blueprint for Resilience

CERT demonstrates how engineering education can evolve from content-centred to be community-centred, peace-driven, and entrepreneurial. Its emphasis on hands-on engagement, local co-creation, and sustainability makes it a robust, scalable framework for post-war resilience in Sudan and other fragile and conflict-affected regions.

What distinguishes CERT is its intentional integration of Peace Engineering principles, including:

- a systems-thinking lens that addresses root causes of environmental and infrastructure challenges;
- a participatory approach that recognises communities as co-designers of solutions;
- a commitment to ethical engineering that considers social equity, ecological impact, and future generations.

As Sudan transitions from conflict to reconstruction, the CERT model offers a practical foundation for aligning engineering education with national development priorities. It shows how a new generation of engineers can be equipped not just to rebuild what was lost but to help reimagine what is possible.

Future Directions for Research and Practice

Building on CERT's foundational work, several future directions are essential to deepening the impact of Peace Engineering in Sudan and beyond. These strategies aim to institutionalise ethical, community-centred engineering education and scale the CERT approach globally.

Longitudinal Impact Studies

Future research should examine how CERT alumni have applied Peace Engineering principles in their academic, professional, and civic lives. Tracing these trajectories can guide curriculum development and inform long-term investment in sustainability education.

Metrics for Peace and Resilience

Peace-oriented engineering outcomes demand more than technical benchmarks. Evaluations should include community resilience, ethical engagement, and civic responsibility indicators, especially in post-conflict contexts.

Policy Integration Pathways

Embedding Peace Engineering in national education systems will require revising curricula, supporting faculty development, and aligning programmes with post-war reconstruction and the SDGs.

Regional and Global Adaptation

The CERT model, rooted in blended learning and local co-creation, can be adapted to other conflict-affected or climate-vulnerable regions. Collaborative research and implementation across Africa, the Middle East, and Asia can promote broader adoption.

Youth-Led Innovation Hubs

Institutions can establish Peace Engineering Labs or Innovation Hubs to sustain Peace Engineering beyond pilot programmes. These spaces can offer mentorship, micro-grants, and platforms for students to prototype local solutions in energy, waste, housing, and water systems.

By investing in these future directions, Sudan can become a leader in redefining engineering as a discipline of peace, sustainability, and inclusive development. CERT has shown that when young engineers are trusted and supported, they can co-create solutions that are not only technically sound but deeply human-centred.

Their work represents the future of the engineering profession and a powerful resource for rebuilding fragile societies from the ground up.

Sudan's road to recovery is long but not without direction. By placing engineering at the heart of sustainable development and empowering students to co-create solutions with their communities, CERT has helped plant the seeds of a more resilient, inclusive, and locally led reconstruction. This paper affirms that even in times of disruption, education can be a force for rebuilding not only infrastructure but also hope, dignity, and a shared future.

ACKNOWLEDGMENTS

We extend our gratitude to all experts, students, and partners, including the Sudan University of Science and Technology, Project ECHO at the University of New Mexico, and SuDRO, for their contributions to this initiative.

REFERENCES

ACAPS (2024): Sudan: Scenarios - A region-by-region analysis of possible developments affecting humanitarian needs and operations in Sudan until December 2025. *Geneva: ACAPS*. Available at: https://reliefweb.int/report/sudan/sudan-scenarios-region-region-analysis-possible-developments-affecting-humanitarian-needs-and-operations-sudan-until-december-2025-october-2024. Accessed: 15 March 2025.

Ahmed, I. (2020): Explaining Rwanda's prioritisation of rural electrification over rural clean drinking water through institutional path dependency. *Structural Change and Economic Dynamics*, Vol. 54, pp.186-201. Available at: https://doi.org/10.1016/j.strueco.2020.05.001.

Al-Khateeb, M., Al-Ansari, N., & Knutsson, S. (2014). Sustainable University Model for Higher Education in Iraq. *Creative Education*, Vol. 5, No. 5, pp.318-328. Available at: https://doi.org/10.4236/ce.2014.55041

Armstrong, D. K., Kailie, M., Koroma, A.S., Kailie, M., Nasielski, P., Lybbert, T. and Crump, A. (2021): Economic and social feasibility pilot of ethanol fuel for clean cooking in upland Sierra Leone. *Development in Practice*, Vol. 33, No. 1, pp.16-29. Available at: https://doi.org/10.1080/09614524.2021.1937561.

Bolu, C.A., Domfang, C., Obiazi, A.M., Falade, F., Musa, T.A., Alinaitwe, H., Kuriakose, B., Nwobodo-Nzeribe, H.N., Mkandawire, T., Okediji, A., Jadi, A., Dada, J.O. and Wara, S.T. (2022): Appropriate online laboratories for engineering students in Africa. In *2022 IEEE IFEES World Engineering Education Forum – Global Engineering Deans Council (WEEF-GEDC)*. 27 November-1 December 2022, Cape Town, South Africa. IEEE. Available at: https://doi.org/10.1109/WEEF-GEDC54384.2022.9996210.

Bolu, C.A., Musa, T.A., Domfang, M.C., Eletta, O.A.A., Dada, J.O., Brijmohan, Y., Wara, S.T., Elrayah, A.A.I., Mkandawire, T., Obiazi, A.M., Ihenacho, G., Oyelami, A., Nfah, E.M., Nwobodo-Nzeribe, N.H., Anyaegbuna, B. and Matemba, E. (2024a): Collaborative pathways: Enhancing engineering education through industry-academia partnerships in Africa. In: *2024 World Engineering Education Forum – Global Engineering Deans Council (WEEF-GEDC),* 2-5 December 2024, Sydney, Australia. IEEE. Available at: https://doi.org/10.1109/WEEF-GEDC63419.2024.10854942.

Bolu, C.A., Musa, T.A., Domfang, M.C., Eletta, O.A.A., Dada, J.O., Brijmohan, Y., Wara, S.T., Elrayah, A.A.I., Mkandawire, T., Obiazi, A.M., Ihenacho, G., Oyelami, A., Nfah, E.M., Nwobodo-Nzeribe, H.N., Anyaegbuna, B. and Matemba, E. (2024b): Exploring artificial intelligence utilization for engineering education and research in Africa. In: *2024 IEEE World Engineering Education Forum – Global Engineering Deans Council (WEEF-GEDC),* 2-5 December 2024, Sydney, Australia. IEEE. Available at: https://doi.org/10.1109/WEEF-GEDC63419.2024.10854951.

De Long, J.B. and Eichengreen, B. (1993): The Marshall Plan: History's most successful structural adjustment program. In: Dornbusch, R., Nolling, W. and Layard, R. (Eds): *Postwar economic reconstruction and lessons for the East today* (pp.189-230). Cambridge, MA: MIT Press.

Docquier, F. and Rapoport, H. (2012): Globalization, Brain Drain, and Development. *Journal of Economic Literature*, Vol. 50, No. 3, pp.681-730. Available at: https://doi.org/10.1257/jel.50.3.681.

Elbashir, N.O., Musa, T., Saeed, K. and Abdel Kariem, F. (2024): Switching Sudan's Power Generation Units' Fuel to Natural Gas Enhances the Efficiency, Durability and Lower Cost. *African Journal of Engineering & Technology (AJET)*, Vol. 4, pp.1-16. Available at: https://doi.org/10.47959/AJET.2021.1.1.14.

Elgadal, M.M.S. and Glade, R. (2024): Research in Displacement: The Impact of War on Sudan's Higher Education and Academic Research. *London: XCEPT Research*. Available at: https://www.xcept-research.org/publication/research-in-displacement-the-impact-of-war-on-sudans-higher-education-and-academic-research/ Accessed: 15 March 2025.

Engineers Against Poverty (EAP) (2006): *Conflict-Sensitive Business Practice: Engineering Contractors and their Clients*. International Alert. Available at: https://engineersagainstpoverty.org/wp-content/uploads/2018/07/Conflict-Sensitive_Business_Practice.pdf. Accessed: 15 March 2025.

IEA, IRENA, UNSD, World Bank, and WHO (2024): Tracking SDG 7: The Energy Progress Report 2024. Available at: https://trackingsdg7.esmap.org/downloads Accessed: 17 May 2025. 179pp.

Jordán, R., Agi, K., Arora, S., Christodoulou, C.G., Schamiloglu, E., Koechner, D., Schuler, A., Howe, K., Bidram, A., Martinez-Ramon, M. and Lehr, J. (2021): Peace engineering in practice: A case study at the University of New Mexico. *Technological Forecasting and Social Change*, Vol. 173, p.121113. Available at: https://doi.org/10.1016/j.techfore.2021.121113.

Jordán, R., Martínez-Ramón, M., Koechner, D. and Agi, K. (2024): What is Peace Engineering? In *2024 IEEE 67th International Midwest Symposium on Circuits and Systems (MWSCAS)* (pp.1111-1115). Springfield, MA, USA. Available at: https://doi.org/10.1109/MWSCAS60917.2024.10654793.

Jordán, R., Nair, I., Agi, K. and Koechner, D.M. (2019): How do we frame peace engineering education? A complex but vital question. In *Proceedings of the ASEE 2019 Virtual Annual Conference & Exposition*. *ASEE*. Available at: https://monolith.asee.org/public/conferences/140/papers/25534/view Accessed: 19 April 2025.

Kirk, J. (2009): Certification Counts: Recognizing the Learning Attainments of Displaced and Refugee Students. *International Institute for Educational Planning, UNESCO.* Available at: https://unesdoc.unesco.org/ark:/48223/pf0000180906/PDF/180906eng.pdf.multi#:~:text=This%20study%20is%20one%20of%20the%20first%20critical%2C,IRC%20and%20the%20Netherlands%20Ministry%20of%20Foreign%20Affairs Accessed: 5 April 2025.

Masengesho, E., Wei, J., Niyirora, R. and Umubyeyi, N. (2020): Relationship between Project Consultants' Performance and Project Success in the Rwandan Construction Industry, *World Journal of Engineering and Technology*, Vol. 9, No. 1, pp.138-154. Available at: https://doi.org/10.4236/wjet.2021.91011

Matemba, E., Smith, L., Wolff, K., Inglis, H., Mogashana, D., Jansen, L., Gwynne-Evans, A., Campbell, A.L., Kwuimy, C., Nassar, S., Magara, I., Kloot, B., Hattingh, T., Raji, A., Musa, T. and Nyamapfene, A. (2023): Reflecting on a community of practice for engineering education research capacity in Africa: who are we and where are we going? *Australasian Journal of Engineering Education*, Vol. 28, No. 1, pp.74-84. Available at: https://.doi.org/10.1080/22054952.2023.2233340.

Musa, T., Elsayed, F., Alawad, A., Babiker, R., Mahmoud, B., Fadul, N., Jordan, R. and Elbashir, N. (2024): Catalyzing sustainable futures: Innovative approaches in capacity building for the Community Engineering Response Team. In *Proceedings of the 2024 World Engineering Education Forum - Global Engineering Deans Council (WEEF-GEDC)*, Sydney, Australia, 2-5 December 2024. Available at: https://doi.org/10.1109/WEEF-GEDC63419.2024.10854920.

Omer T., Madani M. and Mohamed T. (2024): The fate of Sudanese refugee scientists in times of war: impact, experiences, challenges and prospects, ASFI Research Journal, Vol. 1, No. 1, p.e14296. Available at: https://doi.org/10.70040/asfirj-k1pst6gv.

Project ECHO (2023): *Careers at Project Echo*. [online] 1 December. Available at: https://hsc.unm.edu/echo/about-us/ Accessed: 24 June 2024.

Raatz, M., Ward, E.C., Moss, P., Reilly, C., Frederiksen, N., Dickinson, C., Clarke, S., Beak, K. and Marshall, J. (2024): Examining the outcomes of Project ECHO® as an interprofessional community of practice for pediatric feeding clinicians. *Dysphagia*, Vol. 39, No. 2, pp.208-222. Available at: https://doi.org/10.1007/s00455-023-10603-z.

Shibrain, N.M., Mofadel, H.I.A., Kheiry, M.A., Salih, N.K.M. and Elhabib, M.A. (2025): Impact of Solid Waste Management on Environment and Community Safety in Khartoum locality-Sudan. *Direct Research Journal of Public Health and Environmental Technology*, Vol. 10, No. 1, pp.7-13. Available at: https://doi.org/10.26765/DRJPHET604482902.

Tayyab, Q., Qani, N.A., Elkholy, M.H., Ahmed, S., Yona, A. and Senjyu, T. (2024): Techno-economic configuration of an optimized resident microgrid: A case study for Afghanistan. *Renewable Energy*, Vol. 224, p.120097. Available at: https://.doi.org/10.1016/j.renene.2024.120097.

UN-Habitat (2016): *Achieving sustainable development in Rwanda. Nairobi: United Nations Human Settlements Programme (UN-Habitat)*. Available at: https://unhabitat.org/sites/default/files/download-manager-files/ACHIEVING%20SUSTAINABLE%20DEVELOPMENT%20in%20Rwanda.pdf. Accessed: 9 April 2025. 36pp.

United Nations Environment Programme (UNEP) (2022): *Mid-Term Review of the UN Environment Project "Sudan Ecosystem Based Adaptation (EbA) Project"*. Available at: https://open.unep.org/docs/gef/MTE/5703_SudanMTR_2022.pdf Accessed: 17 May 2025. 107pp.

United Nations Environment Programme (UNEP) (2023): State of the environment in Sudan. Available at: https://www.unep.org/sudan/state-environment-sudan Accessed: 17 May 2025.

United Nations Institute for Training and Research (UNITAR) (2021): *UNITAR Building Bridges: Entrepreneurship and Project Planning in South Sudan, 2020-2021 Cycle. Project Completion Report*. United Nations Institute for Training and Research. Available at: https://unitar.org/sites/default/files/media/file/PROJECT%20COMPLETION%20REPORT-SOUTH%20SUDAN%202021.pdf. 33pp.

United States Institute of Peace (USIP) (2008): *Conflict-Sensitive Approach to Infrastructure Development*. Available at: https://www.usip.org/sites/default/files/sr197.pdf. Accessed: 15 March 2025.

van Fenema, P.C., Rietjens, S. and van Baalen, P. (2016): Stability & reconstruction operations as mega projects: Drivers of temporary network effectiveness. *International Journal of Project Management*, Vol. 34, No. 5, pp.839-861. Available at: https://doi.org/10.1016/j.ijproman.2016.03.006.

Wily, L.A. (2009): Tackling land tenure in the emergency to development transition in post-conflict states: From restitution to reform. In: Pantuliano, S. (Ed.): *Uncharted Territory: Land, Conflict and Humanitarian Action* (pp.27-50). Rugby: Practical Action Publishing.

World Bank (2009): *Rwanda: From Post-Conflict Reconstruction to Development*. The World Bank: Washington, DC. Available at: https://documents1.worldbank.org/curated/en/954801468108536137/pdf/519570BRI0ida1148B01PUBLIC11PUBLIC1.pdf Accessed: 9 April 2025. 9pp.

World Bank (2023): Sudan Water and Sanitation Report: Access, Challenges, and Policy Directions. Available at: https://www.worldbank.org/sudan-water-report. Accessed 16 March 2025.

BIOGRAPHY

Dr Tagwa Musa is a researcher at Texas A&M University at Qatar and an associate professor of petroleum engineering at the Sudan University of Science and Technology. With over a decade of experience in oil and gas and higher education, she specialises in reservoir engineering, production optimisation, sustainable fuel development, energy transition strategies, and Peace Engineering. Dr Musa has authored over 50 peer-reviewed papers, contributed to multiple book chapters, and served on the editorial committee for the Rising to the Top book series. She is an active member of SPE, GEDC, and IEEE, and a UKRI Peer Review College member.

Ali Mohammed Ali Alawad is a water and resources engineer who graduated with first-class honours from the Sudan University of Science and Technology in 2022. He founded the Water & Environment Forum and leads the Water & Environment Organization, promoting sustainable water management and environmental protection. Ali is an active SUST Peace Engineering ECHO Hub member and co-authored a research paper with the hub team. He also founded *Over the Top Magazine*, a scientific engineering quarterly. Ali currently works with AlKobrash Co. in Saudi Arabia, focusing on regional water challenges and sustainability.

Bakry Mahmoud is a skilled civil and environmental engineer with a Diploma in Environmental Engineering (2002), a three-year Diploma in Civil Engineering (2004), and a Bachelor's degree in Environmental Engineering (2022). He has published a research paper on IEEE Xplore titled "Catalyzing Sustainable Futures: Innovative Approaches in Capacity Building for the Community Engineering Response Team". Known for his adaptability, strong analytical skills, and leadership abilities, Bakry is dedicated to delivering high-quality work, driving continuous improvement, and contributing meaningfully to environmental sustainability and infrastructure development.

Fatima Elsayed is an Electronics Engineer specialising in embedded systems, design thinking, and IoT. She serves as an ICT teacher in the UAE and a co-ordinator at CERT (Community Engineering Response Team), where she led environmental and engineering awareness programmes, reaching hundreds of students in a 6-month course. With IEEE publications and awards such as Falling Walls Lab Khartoum 2020, she brings both academic and hands-on expertise. Fatima has held roles in research, HR, and training, and is passionate about STEM education, especially in empowering youth through technology.

Romysaa Babiker is a certified civil engineer with a Bachelor's degree from Sudan University of Science and Technology. She holds both the Project Management Professional (PMP) and Risk Management Professional (RMP) certifications from the Project Management Institute (PMI). Romysaa is also a McKinsey Forward programme graduate and an active Echo Hub programme member. She has published a research paper on IEEE Xplore entitled "Catalyzing Sustainable Futures: Innovative Approaches in Capacity Building for the Community Engineering Response Team". Currently, she works as a Civil Engineer at ACES Company in Saudi Arabia.

Dr Ramiro Jordan is a scientist, innovator, educator, and entrepreneur. He is a faculty member in the Department of Electrical and Computer Engineering at the University of New Mexico, where he has also served as Associate Dean for Global Initiatives. His research spans sustainability, Peace Engineering, smart grids, cognitive radio, and software development. Dr Jordan founded the Ibero-American Consortium for Science and Technology Education (ISTEC) in 1990, promoting STEM education and entrepreneurship across Latin America and the Iberian Peninsula. He is a past president of IFEES and a founding member of the Peace Engineering Consortium, established in 2018 in Albuquerque.