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Prototypes for Humanity 2025

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About Prototypes for Humanity

Prototypes for Humanity is a global platform dedicated to bridging the gap between academic research and real-world implementation. Founded in 2014 as a showcase of graduate projects contributing to a better planet, it has grown into a leading platform for academic innovation, drawing on a community of professors, graduates and students across all disciplines, from over 1,200 universities in 130 countries. Prototypes for Humanity is owned and managed by the Art Dubai Group.

Through its showcase and forums, prizes, venture development and funding programme, knowledge dissemination platforms and partnership frameworks, Prototypes for Humanity enables tangible collaborations between academics and key stakeholders from the global innovation community — to solve pressing challenges, structure market-driven ventures and support socio-economic progress.

The programme's flagship annual convening, the Dubai Future Solutions - Prototypes for Humanity summit, is delivered in strategic collaboration with the Dubai Future Foundation, offering global promotion, industry pilot and funding opportunities, awards and collaboration pathways to academics from around the world.

Prototypes for Humanity is held under the patronage of Her Highness Sheikha Latifa bint Mohammed bin Rashid Al Maktoum, Chairperson of Dubai Culture and Arts Authority (Dubai Culture).

For more information, visit www.prototypesforhumanity.com

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Foreword from the Organisation

Prototypes for Humanity is a global programme that accelerates the translation of academic research into applied solutions with tangible impact. We work hands-on with academics from across 1200 universities in 130 countries to bridge the gap between scientific discovery and real-world application, and connect that knowledge with the people, communities, places, and industries that need it most.

Historically, academic research has been critical to solving complex challenges and driving economic and social growth since the inception of the first universities. For that engine to work, however, there needs to be a deliberate and concerted effort towards research application, translation, and implementation. That was the north star of the 2025 Short Papers Platform, engaging academics from around the world whose work addresses pressing issues and responds to pragmatic industry, user and public requirements, in alignment with Dubai's forward-looking priorities—a vision the Dubai Future Foundation has been instrumental in enabling through its strategic support of our wider programme.

I am delighted to present the inaugural issue of our official publication, marking a significant milestone for the programme. A deliberate exercise in multi-disciplinary research, this edition highlights critical themes ranging from infrastructure resilience and sustainability to health, mobility, and the digital economy. These 56 short papers reflect a broad spectrum of contemporary inquiry and the urgency of the issues they address. Beyond their academic rigour, these contributions respond directly to challenges currently facing public and private organisations—a testament to the power of academic expertise when applied to live problems.

Prototypes for Humanity will continue to create the conditions for innovation to move beyond the laboratory and into practice. Through the Short Papers platform and our wider programme, we remain committed to amplifying the work of professors, graduates, and students whose research has the potential to drive meaningful change, and to strengthening the connections with industry and the public sector that make that journey possible.

I extend my sincere appreciation to the authors, reviewers, stakeholders, and our team, whose contributions have made this publication possible. The ideas gathered in this volume represent the beginning of a journey we support wholeheartedly.

Tadeu Baldani Caravieri
Managing Director, Prototypes for Humanity

Prototypes for Humanity 2025: The Short Papers

Naren Barfield, Editor-in-Chief

Prototypes for Humanity's expansion in 2025 into short papers, pecha kuchas and innovation sandpits marks a deliberate development in how academic research is convened. The aim is simple: to create a platform where serious researchers can interrogate real-world problems with clarity, rigour and imagination, and where ideas and outcomes can be tested, challenged and strengthened through contact with other fields. The premise is straightforward. Universities across the world generate extraordinary research, but much of it remains siloed, slow to circulate, or locked within disciplinary conventions that do not match the complexity of the challenges we face. The inaugural short papers platform provides a common format through which researchers from diverse disciplines can communicate insights quickly and precisely, while also providing a shared space in which problems can be examined and collaborations formed before solutions are attempted.

Across this year's submissions, a convergence of fields is visible. This is not interdisciplinarity as a requirement imposed on contributors, but an observed pattern: when researchers gather around shared challenges rather than disciplinary categories, new lines of inquiry open up. Problems are reframed, assumptions are questioned, and mechanisms that might remain invisible within a single field are revealed. Research across multiple domains show that when specialists work together, they tend to surface underlying drivers that single-discipline approaches might miss, and generate solutions that are both more innovative and more grounded in real-world contexts. The short papers platform is designed to make this possible: not by forcing interdisciplinarity, but by creating the conditions in which it can emerge naturally.

The thematic structure reflects this intention. The seven themes: **Wellbeing and Health Futures; Sustainable and Resilient Infrastructure; Artificial Intelligence and Augmented Intelligence; Environmental Sustainability and Climate Action; Socio-Economic Empowerment and Innovation; Open;** and **Speculative**, are not categories of research. They are problem-spaces: areas where global pressures, technological change and societal expectations intersect, and where new knowledge is urgently needed. Each theme is broad enough to accommodate diverse methods and perspectives, yet specific enough to anchor the work in recognisable global priorities.

At best, the themes capture work that sits ahead of established fields, or that does not yet fit comfortably within existing academic or industrial frameworks. These themes act as discovery engines, ensuring that the programme remains receptive to emerging ideas, unfamiliar methods and early-stage insights that may later crystallise into new areas of research, innovation, or practice.

The selection process for the chapters presented in this volume was organised around three criteria: *insight, innovation* and *impact*. They are the criteria used to judge the submissions: the clarity with which a problem is identified or understood; the originality of the approach; and the potential for real-world benefit. They are neutral with respect to discipline and output type, and they align with the

programme's commitment to problem discovery, methodological diversity and solution-making. Their purpose is practical: to identify work that advances understanding and has the potential to shape futures in tangible and beneficial ways.

Taken together, the short papers format, the thematic structure and the evaluative criteria form a coherent architecture. It is inclusive across fields, aligned with global and local priorities, and designed to surface research that is both academically robust and capable of informing action. The aim is not to produce a catalogue of academic achievements, but to create a body of work that can be revisited, extended and recombined over time—a cumulative resource for researchers, policymakers, industry partners, and communities who are grappling with the same challenges from different vantage points.

The papers that follow demonstrate the value of this approach. They show how researchers from across the world are addressing problems that cut across health, infrastructure, climate, technology, and social systems. Collectively, they reveal patterns, tensions, and opportunities that no single field would be likely to identify alone, and they illustrate how academic work, when brought into contact with other perspectives, can generate insights that are both rigorous and actionable. This is the purpose of the short papers platform: to convene serious research, to create the conditions for collaboration, and to support the development of insight, innovation, and impact in ways that improve lives.

The contributors to the 2025 short papers platform form a genuinely global cohort. Authors and co-authors span multiple regions and research cultures, reflecting the reality that the challenges addressed across the seven themes are shared internationally, while informed by different social, environmental, and technological contexts.

Institutional diversity is equally marked. The short papers originate from research-intensive universities, specialist institutes, design schools, engineering faculties, medical schools, and applied research centres, alongside collaborations with industry partners, NGOs, communities, and public-sector organisations. This range demonstrates that the platform draws from a full research ecosystem. Single-authored papers are rare; most submissions are co-authored, and many involve teams spanning multiple departments, universities, or sectors. Several chapters emerge from academia-industry collaborations in problem definition, prototype testing, or real-world deployment. These partnerships shape research questions and methods; they are integral to the work, not peripheral.

The disciplinary spread is wide and intentional. The papers draw on engineering, medicine, public health, AI and data science, architecture, design, environmental science, economics, social policy, materials science, and speculative design. Many sit at, or across, the boundaries between fields, reflecting the platform's emphasis on the interstices of knowledge, where new mechanisms, overlooked approaches, and alternative framings emerge.

This diversity is deliberate and productive. Global challenges may be shared, but their drivers and interventions differ across contexts. A contributor base that spans continents, institutions, and sectors ensure that insights and proposed solutions are informed by multiple realities. It also strengthens engagement, ownership, and legitimacy for researchers, stakeholders, and the public.

In this configuration, the short papers platform operates as a global knowledge common: a space where disciplinary excellence, geographic breadth, and collaborative intent combine to generate insights. The papers that follow show this convening power at its clearest.

Wellbeing and Health Futures considers how societies understand, protect, and extend human wellbeing in an era shaped by demographic change, environmental pressures, and rapid technological development, encompassing the full spectrum of health, from prevention and early detection to treatment, recovery, and long-term care, while recognising that wellbeing is influenced as much by social conditions and environmental exposures as by clinical interventions. The theme brings together work on healthy ageing, maternal and child health, mental health, digital and precision medicine, public health policy, environmental determinants of disease and the design of products, materials, and systems that support healthier lives. As a body of work, it invites reflection on how health systems might evolve, how inequities can be reduced, and how new technologies can be harnessed responsibly to improve quality of life.

Plasma polymerised nanoparticles: from cell imaging to cancer therapy by Behnam Akhavan and colleagues develops plasma polymerised nanoparticles (PPNs) as a solvent-free, radical-rich nanoplatform that enables stable, linker-free conjugation of dyes and anticancer drugs. By unifying imaging and therapy within a single construct, it contributes to the theme's concern with integrated diagnostic-therapeutic systems that can simplify and strengthen cancer care pathways.

Amin Al-Habaibeh and colleagues' paper **Affordable Brainwave Reader to Help people with Motor Neurone Disease (MND) Communicate via Thoughts Using Novel AI Technology** presents a low-cost EEG-based brain-computer interface that uses novel AI methods to classify two mental imagery states for basic communication in people with MND and CLIS. It reframes assistive communication as a problem of affordability and accessibility rather than of high-end laboratory technology, with low-cost deployment potential.

Multimodal Platform for Objective Pain Measurement, by Yacine Hadjiat and colleagues develops an AI-powered multimodal Pain Index that integrates wearable biosignals to quantify pain objectively in real time, addressing a long-standing clinical gap: the absence of reliable pain assessment tools for patients who cannot self-report. Their work demonstrates insight into autonomic biomarkers, coupled with impact through a scalable clinical decision tool for diverse patient populations.

The research of Basri Abdullah and colleagues is presented in **Equira™ (VoxelPHITS): Democratising Precision Radiopharmaceutical Therapy for Global Cancer Care**, which converts routine CT/SPECT/PET imaging into patient-specific 3D dose maps using Monte Carlo kernels, enabling personalised radionuclide therapy without specialised dosimetry infrastructure, showing how precision radiopharmaceutical therapy can be extended beyond high-resource centres, bringing potential widening global access to precision cancer care.

Ernest Kamavuako's research introduces a compact multimodal device that captures ECG, EMG, and heart sounds with AI-based interpretation, validated against gold-standard cardiac systems. **A low-cost, portable and AI-powered device for cardiac investigation** targets early cardiac investigation in low-

and middle-income settings through integrated sensing rather than fragmented diagnostics, delivering impact through affordability and innovation in unified biosignal acquisition for frontline cardiac assessment.

Michele Magno and colleagues' **Edge AI-Enabled Smart Glasses and Companion Robots for In-Home Health Monitoring and Medication Adherence** integrates radar-based vital-sign sensing, hybrid EOG eye-tracking, and gaze-guided quadruped robots into a low-power ecosystem for in-home health monitoring and medication adherence, reframing ageing-in-place and chronic-disease management as problems of continuous, unobtrusive monitoring rather than episodic clinical contact.

Patricia Maguire and colleagues' chapter, **Transforming Preeclampsia Care Through Cross-Disciplinary Innovation: From Platelet Biomarkers to Real-Time Clinical Decision Support**, presents AI_PREMie, which combines platelet-derived biomarker panels with machine-learning models to support diagnosis, severity assessment, and delivery-timing decisions in suspected preeclampsia. It shows how molecular insight and computational modelling can jointly address a high-risk maternal condition with substantial global morbidity and mortality.

MONA: A Robotic Patient Simulator for Occupational Therapists Training by Perla Maiolino and colleagues describes a full-body robotic patient simulator equipped with 4,000 tactile sensors, motorised joints, and adaptive pain responses to support realistic occupational therapy training in mobility and touch-based assessment. It addresses workforce preparedness and the need for high-fidelity, repeatable training environments in rehabilitation and care for an ageing population.

Anthony McGarry's **PCAD: Prosthetic Comfort by Design An Educational Innovation in Prosthetic Measurement** combines pressure-based loaded limb capture with automated CAD scanning to produce accurate, modification-free prosthetic sockets within seconds, reducing clinical time and remakes. It reframes prosthetic provision as a workflow-efficiency and precision-fit challenge rather than a purely artisanal process, contributing to global accessibility, consistency, and training in prosthetic care.

Eleonora Secchi and colleagues present **PermeaSense: Rethinking how we test antimicrobials in the fight against biofilm infections** which cultivates biofilms on engineered membranes and quantifies antimicrobial penetration and matrix disruption in real time, generating spatial susceptibility profiles. It addresses the methodological gap between early-stage antimicrobial discovery and clinically relevant evaluation in biofilm-associated infections.

Nanoplants (Nanostructured Implants) by Bala Vaidhyanathan and colleagues develops nanostructured zirconia-based implants using additive manufacturing and microwave sintering to achieve exceptional hydrothermal ageing resistance and near-net-shape fabrication, linking advanced materials engineering with long-term implant durability and cost-efficient production in dental and orthopaedic applications.

Deisy Yurley Rodríguez-Sarmiento introduces **Artificial Intelligence and Quantum Computing for the Design of Novel Kisspeptin-10 Analogues and Their Experimental Evaluation in Cervical Cancer Cells**, where AI-driven peptide design and quantum-assisted docking are used to generate

Kisspeptin-10 analogues with enhanced Kiss1R affinity, followed by experimental validation of cytotoxicity and migration inhibition in cervical cancer cells. The research demonstrates how computational acceleration can reshape early-stage oncology drug discovery while remaining anchored in wet-lab evaluation.

The **Sustainable and Resilient Infrastructure** theme examines how infrastructure can be conceived, built and maintained in ways that support long-term environmental, social and economic resilience, spanning the design of buildings, transport, energy and water systems, as well as the materials, technologies and manufacturing pipelines that underpin them. The theme addresses climate-resilient planning, sustainable construction, mobility futures, occupational safety, air quality, waste reduction and the improvement of essential services for underserved communities. Drawing together engineering, architecture, urban design, environmental science, digital technologies and public policy, this theme recognises the need for integrated approaches that create environments capable of withstanding future shocks while improving everyday life.

Andrea Conserva and colleagues explore how AI and digital twins can be used to co-create cities in **Co-Creating Cities with AI and Digital twins: a multi-species participatory approach**. It positions urban infrastructure as something shaped not only by human stakeholders but by the wider ecological systems with which cities interact, providing insight into participatory and ecological urbanism, combining AI and digital twins with multispecies perspectives, and potential impact on how future cities are planned and governed.

ThermoChroma-smart colorimetric sensors as cold chain indicators by Ahu Gümrah Dumanli presents ThermoChroma-smart colorimetric sensors designed to act as indicators for cold chain integrity. Temperature sensitive logistics are treated as a critical component of resilient infrastructure, particularly for food and medical supply chains, demonstrating how smart sensing materials have the potential to reduce spoilage, waste, and risk in distributed supply networks.

Anwar Khitab and colleagues investigate, in **Reengineering Ancient Materials for Durable, Low-Carbon Structures**, how ancient materials and construction practices can be reengineered to produce durable, low carbon structural solutions, linking historical material knowledge with contemporary sustainability imperatives in the built environment, potentially reducing the carbon footprint of infrastructure.

Designing and Verifying Computational Models for Human-Agent Teamwork in Future Cities by Alexandros Konios and Leon Goncharov focuses on the design and verification of computational models that describe human-agent teamwork in the context of future cities. It frames urban infrastructure as a sociotechnical system in which humans and autonomous agents must coordinate reliably through modelling human-agent interaction with impact on the governance and operation of smart urban systems.

Multifunctional Hybrid Hierarchical Composites by Patrick Lee and colleagues examines multifunctional hybrid hierarchical composites designed to deliver enhanced mechanical and possibly additional functional properties within a single material system. It considers how advanced composites

can underpin lighter, stronger, and more resilient infrastructure components, improving the durability and efficiency of future infrastructure.

Elizabeth McCormick's **Building Health: Resilient Building Materials for Global Health and Sustainability** investigates building materials that support both resilient structures and global health outcomes, linking material choice to indoor environmental quality and sustainability, by treating buildings as health relevant infrastructure rather than neutral shells, examining the relationship between materials, health, and sustainability, innovation in material selection or design strategies, and potential building standards and policy.

In **AeroFeathers: Biomimetic Propellers with 3D-Printed Flexible Fibers for Quieter Drones**, Bisham Sharma and colleagues explore biomimetic propellers incorporating 3D printed flexible fibres to reduce drone noise. Innovation in biomimetic propeller design addresses acoustic pollution and performance in aerial systems that increasingly interact with urban and natural environments.

The **Artificial Intelligence and Augmented Intelligence** theme explores how artificial intelligence is reshaping governance, industry, public services and daily life, and how human capabilities can be extended rather than displaced by computational systems. It encompasses cognitive cities, digital citizenship, cybersecurity, machine learning, data science, AI-enabled personalisation, human-AI collaboration, and the ethical and governance frameworks required to guide responsible deployment. This theme draws on computer science, design, law, ethics, public administration, behavioural science and systems engineering, and considers how AI can improve resource use, strengthen decision-making, support healthcare and industry, and create new forms of civic participation, while also addressing risks and inequities.

Baseline Evaluation for Enhancing Human-Robot Collaboration (HRC) in Industry 5.0 Manufacturing from Erick Cedillo and colleagues establishes a multimodal psychophysiological baseline for human-robot collaboration during cobot-assisted assembly tasks. It shows how AI enabled sensing and modelling can support adaptive, human-centred Industry 5.0 systems, offering insight into operator stress and fatigue signatures, innovation in multimodal baseline design, and impact for developing responsive cobot strategies.

Wahbi K. El-Bouri and Rémi J. Hernandez develop, in **Digital Twins of the Retina: A Computational Framework for Personalised Microvascular Health Assessment**, image-based retinal digital twins that simulate individualised haemodynamics, validate flow metrics against literature, and model disease scenarios such as diabetic retinopathy. Their work shows how AI-supported computational modelling can personalise diagnostics and risk prediction in ophthalmology, highlighting innovation in digital twin construction and insights into microvascular biomarkers such as MTT and CTH.

In **The Internet of Beings: The Nightmares and Dreams of Digitalising Human Bodies**, Francesco Grillo outlines a conceptual framework for the "Internet of Beings," examining how the integration of bodies, sensors, and AI could transform healthcare, pharmaceuticals, insurance, and geopolitics. It interrogates the sociotechnical, ethical, and economic implications of embedding AI within human

biological data systems, considering competing futures of digital embodiment and identifying policy and governance challenges.

Jeremy Howick proposes a cultural AI empathy assistant that augments clinicians' ability to recognise culturally specific expressions of distress, grounded in systematic reviews, harm databases, and ethical frameworks, in **Augmenting Human Empathy: AI-Assisted Solutions for Cross-Cultural Healthcare Communication**. This research positions AI as a mediator that enhances, rather than replaces, empathic human-patient communication in cross-cultural contexts.

Iasef Md Rian presents **An Integrated ARFEMAI System for Real-Time Structural Simulations and "XRay" Visualization of Heritage and Aging Buildings**, research which develops an integrated framework that generates digital twins, trains AI surrogate models on FEM outputs, and overlays real-time structural insights onto heritage buildings through augmented reality, demonstrating how AI can accelerate structural diagnostics and enable non-invasive, immersive conservation workflows for scalable heritage preservation.

AI-Driven XR Platform for Cognitive and Motor Empowerment in Young Students with Disabilities, by Mario Rodriguez presents an AI-adaptive XR platform that personalises cognitive and motor training for young adults with disabilities, validated through a pilot study showing improvements in memory, reaction time, and coordination. It shows how AI-driven personalisation enhances accessibility, inclusivity, and learning outcomes in immersive environments.

In **Revolutionizing Filmmaking: Artificial Intelligence Driven Motion Control with the Cinema Camera Robot,** Ishwar Singh and colleagues, in collaboration with AXIBO, introduce a low cost, modular, portable and intelligent solution to enable the democratisation of advanced filmmaking techniques across virtual production, VFX, and autonomous cinematography, with deployments at major studios and for creators at all scales.

The **Environmental Sustainability and Climate Action** theme addresses the urgent need to transform production, consumption and resource management, to mitigate climate change and protect ecological systems. It encompasses sustainable cities, renewable energy, green mobility, biodegradable materials, conservation, biodiversity, circular economy models, sustainable construction, pollution reduction and safer food systems. The theme draws on environmental science, engineering, materials research, design, agriculture, public health and policy, reflecting the interconnected nature of environmental challenges, and considers how industries can decarbonise, how waste can be reduced, how ecosystems can be restored and how communities can adapt to changing climatic conditions.

Faris Almalki presents **Integration of Deep Learning with CubeSat Technologies for Environmental Monitoring**, an intelligent CubeSat framework combining adaptive MIMO antennas, ANNs for link budget optimisation, YOLOv9 for object detection, and blockchain for secure data transmission across four environmental monitoring tasks (water detection, tree counting, vegetation assessment, oil spill detection), demonstrating how low cost, rapidly deployable space systems can strengthen climate action capabilities in regions with limited terrestrial monitoring infrastructure.

SEAWEED FOAM. A bio-foam material for home-compostable packaging products by Austeja Platukyte develops a fully organic, home compostable seaweed-based foam as an alternative to petrochemical and food-based packaging foams, validated through material testing, prototyping, and public exhibitions. It contributes to how marine biomass can support circular design, reduce packaging waste, and avoid competition with agricultural land.

Chinaedu Maduagwu's chapter, **Advancing Circular Economy through Ad-Tech for Optimizing Future Manufacturing,** proposes a digital platform that merges Ad-tech behavioural analytics, lifecycle assessment, and real-time inventory data to drive circular manufacturing, product returns, and resource recovery. It reframes consumer engagement as a critical lever for circularity, enabling manufacturers to close material loops through predictive nudging and personalised sustainability interventions.

Transesterification Optimization of Vhembe Macadamia Nuts Oil into Biodiesel Using Inorganic KOH Catalyst, by Mamookho Elizabeth Makhatha and colleagues optimises biodiesel production from macadamia nut oil using KOH catalysis and Box-Behnken statistical modelling, achieving a 91% yield and ASTM compliant fuel properties, which demonstrates a viable, non-food, regionally abundant feedstock for renewable fuel production in South Africa with potential impact through rural economic benefits and reduced reliance on fossil diesel.

Transforming Agricultural and Plant-based Byproducts into Compostable Hygiene Materials for a Circular Economy by Rashmi Prakash describes the extraction of cellulose fibres from agricultural residues to produce high performance fluff pulp and nonwovens, and demonstrates that prototype menstrual pads achieve 96.7% disintegration under ISO 16929 composting conditions. The research shows how agricultural waste streams can replace cotton, bamboo, wood pulp, and plastics in absorbent hygiene products, reducing landfill burden and providing a credible pathway to circular, low carbon hygiene products.

Shabib Al Rashdi and colleagues describe, in **AI-Optimised Green Hydrogen Production from Biomass and Wastewater with Integrated CO_2 Capture Pathways via Solar-Fenton and Natural Catalysts,** how wastewater valorisation and solar driven processes can reduce freshwater demand, emissions and energy costs in hydrogen production, particularly in arid regions, aligning with Oman Vision 2040 and scalable national hydrogen strategies.

Patrick Rice and Walter Schurtenburger describe the development of a pilot project for sustainable fuel production with zero carbon dioxide (CO_2) emissions in **Using Hydrokinetic Energy for Green Hydrogen and Green Oxygen Production.** A floating platform equipped with patented hydrokinetic turbines generates continuous power from the Gulf Stream to desalinate seawater and produce green hydrogen and oxygen offshore, demonstrating a zero carbon, cable-free marine energy system that supports both renewable fuel production and onshore aquaculture operations.

Dipa Roy and colleagues engineer hybrid composites from waste mixed plastics, waste glass fibres, and recycled carbon fibres, validating their structural performance in C-sections and high-velocity impact tests in their chapter, **Mixed Waste Plastics Derived Composites for Flood and Hurricane Protection**,

which demonstrates how low value waste streams can be transformed into disaster resilient infrastructure materials that outperform plywood, and meet hurricane resistance standards.

Leveraging AI-coupled Digital Twin Ecosystems for all Sustainable Development Goals in the Built Environment by Noha Saleeb presents the FRESH-BIM/FRESH-DT ecosystem integrating AI, digital twins, IoT telemetry, and VR/AR to optimise heritage restoration, building performance, and lifecycle sustainability across all 17 United Nations SDGs, demonstrating how intelligent, data driven systems can reduce waste, improve energy performance, enhance social equity, and support national scale heritage revitalisation.

Chosel Lawagon and colleagues present **Simultaneous Selective Recovery of Lithium and Cobalt from Spent Lithium-ion Batteries using Modified Bipolar Membrane Electrodialysis**, in which they describe a modified bipolar membrane electrodialysis process that simultaneously recovers high purity lithium hydroxide and cobalt hexacyanoferrate from spent lithium-ion battery leachates with >90% efficiency, reduced chemical inputs, and significantly lower energy demand, offering a scalable, low waste, low carbon recycling pathway.

The theme of **Socio-Economic Empowerment and Innovation** examines how societies can create fairer economic opportunities, strengthen governance and support innovation that benefits diverse communities. It encompasses the dynamics of contemporary labour markets, gender equality, diversity, micro-enterprise, technology for social good, policy design and the infrastructures that enable inclusive growth. The theme draws on economics, sociology, political science, design, technology and development studies, and considers how digital tools can expand access to services, how small-scale entrepreneurship can be supported, how governance structures can be improved and how innovation can be directed toward social rather than purely commercial outcomes.

John Gershenson and colleagues, in their chapter **Tools2Thrive: A Scalable Tool Rental Model for Smallholder Farmers in Kenya** report on a year-long, evidence-driven trial of a community based organisation-run tool rental model that expanded from 20 tools and 549 farmers to 300 tools and nearly 6,000 members, demonstrating that structured access to basic hand tools significantly increases farmer productivity, reduces labour time, and generates reinvestable revenue for community organisations. It shows how low cost, community embedded innovation can strengthen rural livelihoods, build organisational capacity, and create scalable socioeconomic infrastructure across the Global South.

Katherina Kuschel analysed 34 US-based podcast episodes to reveal that midlife entrepreneurship is driven less by technical training and more by narratives of identity reinvention, purpose, and navigating complex life transitions. **The second act of Life: Unveiling podcast narratives of purpose and reinvention among midlife entrepreneurs** positions midlife founders as a dynamic entrepreneurial demographic whose socioeconomic participation is shaped by wellbeing, relationships, and financial restructuring.

In **Eco-Efficient Valorisation of Spent Yeast: Protein and β-Glucan Fractions Recovery for Health-Promoting Applications**, Joelle Nader and colleagues present an integrated green processing strategy that converts spent yeast into high purity protein and β-glucan fractions, achieving 40-45% higher

extraction yields and improved thermal stability with significantly lower environmental footprint compared to traditional techniques. It demonstrates how circular bioeconomy approaches can generate impact through scalable, low waste valorisation pathways.

Willis Owino and colleagues present **Innovative Invasive Cactus Management: A Sustainable Solution for Kenya's Rangelands**, in which they document a novel intervention that converts invasive Opuntia stricta into nutrient dense livestock pellets, with trials showing goats gaining up to 9 kg in 91 days while simultaneously reducing rangeland degradation. Their research shows measurable impact on animal performance gains, innovation in transforming an ecological threat into a feed resource, and insight into scalable models that create green jobs for women and youth.

Alejandro Robledo and Domagoj Bui present **Next-Generation Community Hubs for Socio-Economic Empowerment: A Pilot Human-Centered Framework and Participatory Digital Twin Approach**. Their work introduces a human-centred, mixed methods, and Digital Twin-enabled framework for co-designing multifunctional community hubs that integrate mobility, essential services, and participatory planning, demonstrating how immersive simulations and structured stakeholder engagement can democratise infrastructure planning and address access inequities across rural, suburban, and urban contexts.

Weaving Economic Dignity: A Framework for Re-Engineering Value with Botswana's Heritage Basketry Artisans, by Keiphe Setlhatlhanyo and colleagues exposes systemic inequities in Botswana's basketry value chain-middleman exploitation, policy neglect, and erosion of intergenerational knowledge, based on fieldwork with rural women weavers. It proposes a four strand framework (codesigned innovation, fairtrade governance, youth digital empowerment, and policy integration) to reposition artisans as primary economic beneficiaries.

In **The Re-habitualisation of Boycotts: From Disruption to Everyday Life**, Wang-Shu Liu theorises "rehabitualisation" as the long-term process through which boycott-driven consumption disruptions evolve into new everyday routines, drawing on practice theory and the Fair Trade movement as an illustrative case. It reframes political consumerism as a socioeconomic practice that embeds political meaning into ordinary life.

The **Open** theme provides space for research that does not sit neatly within a single category or that spans multiple domains. It encompasses cross-disciplinary innovation, novel approaches to longstanding problems, experimental methods, early-stage prototypes and disruptive technologies whose implications are not yet fully understood. The theme values intellectual curiosity, methodological diversity and conceptual risk-taking, acknowledging that progress often begins with exploratory work that challenges established assumptions. As a body of work, it underscores the importance of openness in academic inquiry and the generative potential of research that resists categorisation.

Jésus Carbajo and colleagues present the development and testing of PET-based acoustic panels made from recycled plastic bottles in **Eco-friendly and biocompatible materials for noise reduction in healthcare environments**, demonstrating high acoustic absorption, low toxicity, and strong biocompatibility for healthcare settings, showing how sustainable materials can simultaneously

improve patient wellbeing, reduce environmental impact, and meet stringent clinical safety requirements, while also driving innovation through circular economy material engineering.

In **Beyond the Object: Product and Furniture Design as Critical and Social Practice,** Jason Cleverly and Adrienne Bennie examine how interdisciplinary, socially engaged design pedagogies reposition designers as facilitators who use ethnographic and participatory methods to interrogate everyday practices and co-create contextually responsive artefacts. They demonstrate how design education can cultivate practitioners capable of addressing complex socioecological challenges by reframing design as social practice, and through student led interventions embedded in real communities.

Prototype of the Sustainable Tourism Promotion Model based on Technology 4.0 in post-conflict regions. Case study: La Palma and Yacopí (Colombia), by Melva Inés Gómez-Caicedo and colleagues, presents a Technology 4.0 enabled sustainable tourism promotion model co-created with communities in two post conflict Colombian municipalities, integrating AR/VR tools, territorial characterisation, and participatory governance. It shows how digital innovation can support territorial recognition, economic revitalisation, and community centred development in regions recovering from violence.

Gauri Karanjkar and Reena Pandey analyse the role of handknitting in Uttarakhand as a vehicle for intergenerational bonding, cultural transmission, and community cohesion, while documenting the decline of youth participation due to economic and social pressures, in **Study of Intergenerational Craft and Revival in Himalayan Communities**. They highlight the fragility of intangible heritage systems and the need for revival strategies that integrate livelihoods, identity, and contemporary relevance, and articulation of pathways for sustaining Himalayan craft traditions.

Dario Krpan describes, in **Agentic AI for Sustainable Behaviour: A Coaching Framework and Workflow**, a multiagent AI coaching system that uses behavioural science, personalised diagnostics, and adaptive interventions to help individuals adopt and maintain low-carbon lifestyles across multiple domains, offering a scalable, evidence-based digital infrastructure for transformative behavioural change aligned with sustainability goals.

In **Design for Change: Transformational cross-cultural and transdisciplinary learning experiences to solve global healthcare sustainability challenges**, Lisa Scharoun and colleagues describe a cross-cultural, transdisciplinary design sprint model that brings together students to co-create sustainable healthcare solutions through experiential and problem-based learning. Their research investigates how global collaboration and design thinking can generate context-sensitive responses to healthcare waste, emissions, and inequities.

The **Speculative** theme invites research that looks beyond current constraints to imagine alternative futures, emerging paradigms, and untested possibilities. It encompasses speculative design, early-stage insights, exploratory methods, reimagined systems and interdisciplinary ventures into new technological or conceptual frontiers, encouraging work that probes the limits of what is known, asks what might be possible, and considers how future societies could be organised, governed, or experienced. It recognises that speculation is a tool for exploring uncertainty and shaping long-term trajectories.

Livia Alexander argues in **GameShift Futures: Reimagining the University Through Speculative Play** that gaming and immersive media, framed as expanded media, offer speculative, systems-based methodologies for rethinking higher education pedagogy and institutional practice, demonstrated through the prototype GameShift platform. This research positions universities as iterative, participatory futures laboratories.

Prototypes of Personalisation and Customisation for Next-generation Medicines, by Subhan Banerjee surveys pharmaceutical additive manufacturing (3D/4D printing) as a platform for producing personalised, patient-specific drug delivery systems, supported by experimental outputs from the author's Lab of Additive Manufacturing in Pharmaceuticals (LAMP) laboratory. Emerging fabrication technologies can transform therapeutic precision, dosage control, and patient-centred pharmaceutical design.

In **The Role of Design in Challenging Exclusionary Urban Spaces**, Adrienne Bennie examines hostile architecture in London and uses 3D printed replicas of exclusionary design elements as pedagogical and public engagement tools to expose spatial injustice. The paper shows how design can materialise and critique the politics of public space, enabling new forms of social awareness and discourse, demonstrating insight into affordances and exclusion, and transferable tools for community, professional, and policy engagement.

Yoram Chisik explores the intersection of food and play, analysing the physical affordances of food and the challenges of integrating gustatory, olfactory, and embodied eating experiences into interactive systems, in the chapter **Gastroludology: Gastronomy Meets Ludology**. The research reframes food as a medium for human-technology interaction, sensory communication, and playful experimentation, proposing new mechanics for food-based play.

From Walls to Worlds: Co-creating Heritage Narratives with AR Murals by Agnes Michalczyk investigates how augmented reality murals can support equitable heritage management by enabling participatory storytelling, digital restoration, and community-centred cultural representation, drawing on case studies from Cairo and international contexts. It considers how immersive technologies can democratise heritage narratives and reconnect marginalised communities with their tangible and intangible cultural assets.

Owain Pedgley and Bahar Şener's chapter, **Design for Emergency and Disaster Scenarios: Concepts that Serve Humanity,** presents 47 student-generated industrial design concepts for emergency and disaster scenarios, analysed across the disaster readiness and response framework to reveal gaps, opportunities, and high-potential innovations. Design education can generate speculative yet actionable solutions for emergency response, while highlighting the need for cross-sector collaboration to realise them.

Back to the Future: Exploring the Untapped Potential of Freehand Weaving by Tania Ursomarzo repositions indigenous freehand weaving, specifically khoos, as an architectural material technology through collaborative experimentation with Egyptian artisans and hybrid analogue-digital prototyping. It examines how ancestral craft knowledge can inform sustainable, culturally grounded, and materially

intelligent design futures, proposing new artisan-designer collaborations for contemporary architecture.

The almost 60 chapters presented across the seven themes reveal a set of cross-cutting insights that illuminate the developing character of contemporary research and its capacity to address complex global challenges. Across the programme there is a clear movement towards integrated approaches that treat technological, environmental, social, and economic systems as interdependent. This shift is not rhetorical but methodological, shaping the questions posed, the evidence gathered, and the forms of analysis deployed. The work demonstrates that the most pressing issues of the present moment often benefit from cross-domain expertise, and that effective solutions increasingly emerge from collaborations that combine scientific, engineering, design-led, and socially grounded perspectives. This interdisciplinarity underpins the intellectual coherence of the themes as a whole.

Several patterns recur across the papers, including the prominence of circularity, expressed through the recovery of critical materials, the revitalisation of traditional crafts, the redesign of food systems, and the reconfiguration of urban and infrastructural assets. Circularity appears as a practical organising principle that links environmental sustainability with economic resilience and technological innovation. A second pattern is the emphasis on concerns about access to healthcare, the distribution of environmental burdens, the governance of digital systems, and the empowerment of communities. A third pattern is methodological hybridity: many of the projects presented in these chapters combine laboratory experimentation, digital modelling, prototyping, ethnography, participatory design, and speculative inquiry. This hybridity reflects a recognition that complex challenges require forms of knowledge that are empirical yet situated, technical yet socially attuned, and capable of supporting both immediate application and long-term progress.

The seven themes reveal convergences that might not be immediately apparent. Work on artificial intelligence shares concerns with heritage preservation about authorship, agency, and the risks of technological dependency. Research on wellbeing aligns with environmental sustainability through its attention to material exposures, urban form, and the design of supportive environments. Studies of socio-economic empowerment intersect with infrastructure and mobility research through their focus on access, safety, and the conditions for participation in economic and civic life. These convergences indicate that global priorities are not neatly divisible into sectors but instead form a network of overlapping challenges that require coordinated responses. They also suggest that the boundaries between technological, social, and environmental research are becoming increasingly porous, creating opportunities for new forms of collaboration.

A number of shared concerns run through the papers. These include the ethical deployment of emerging technologies, the reduction of waste and harm, the design of systems that are resilient in the face of uncertainty, and the need to ensure that innovation benefits the widest range of communities. The work highlights the importance of responsible governance, whether in the management of data, the stewardship of natural resources or the design of public services. It also underscores the need for infrastructures that can adapt to changing climatic, demographic, and technological conditions. These

concerns reflect a broader shift toward anticipatory thinking, in which research is expected not only to respond to present challenges but also to prepare for future ones.

Many projects propose modular, decentralised, or low-waste approaches that can be scaled or adapted to different contexts. Others emphasise the value of local knowledge, whether in the form of artisanal craft traditions, community-based heritage practices, or users navigating complex systems. These approaches suggest that innovation is perhaps most effective when it is accountable to the contexts in which it operates, and when it recognises that technological solutions must be embedded within social and environmental realities.

The themes also point toward emerging global priorities. These include resilience, sustainability, ethical governance, resource stewardship, and the design of systems that can support well-being across the course of life. There is a growing recognition that technological progress must be aligned with environmental limits, social expectations, and long-term public value. This alignment is evident in work on renewable energy, sustainable materials, digital healthcare, circular manufacturing, mobility futures, and the governance of artificial intelligence. It is also visible in the attention given to vulnerable populations, whether through improved access to healthcare, safer infrastructures, or more inclusive economic opportunities.

Taken together, the chapters demonstrate that the whole is more than the sum of its parts. When viewed collectively, they reveal a research landscape that is converging on shared principles even as it spans diverse domains. The themes offer a coherent intellectual backbone for future collaboration between academia, industry, policymakers, and civil society. They show that meaningful progress depends to a significant extent on the ability to connect insights across fields, and that the most promising innovations are those that combine technical excellence with social purpose and environmental responsibility. The work presented in these chapters suggests that the future of research lies not in isolated breakthroughs but in integrated systems of knowledge capable of shaping futures that are both ambitious and achievable.

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