
Royal Academy of Engineering
Empowering handcraft women with entrepreneurial skills in Uganda
GCRF
Global Challenges Research Fund

Empowering handcraft women with entrepreneurial skills in Uganda

1 The World Bank. https://tcdata360.worldbank.org/indicators/344319cd?country=BRA&indicator=28116&viz=line_chart&years=1990,2019

Project

Critical success factors for facilitating building manufacturing capacity for handcraft women in Uganda

Awardee

Evdoxia Viza, University of the West of Scotland

Collaborators

- Adelaide Marzani, University of the West of Scotland
- Hindu Nabulumba, Yaaka Digital Network
- Amadou Boly, African Development Bank
- Million Mafuta, University of Malawi – The Polytechnic
- Katherine Kirk, University of the West of Scotland
- Dina Nziku, Centre for African Research on Enterprise and Economic Development
- Michele Cano, University of the West of Scotland
- John Struthers, Centre for Africa Research on Enterprise and Economic Development
- Thanos Kourouklis, University of the West of Scotland

Challenge

The traditional art of handcrafting has been passed from generation to generation for many years. From jewellery to weaving, handcrafting is a predominantly female trade and often the only way that families can make a living.
In Uganda, women make up 67% of the labour force[1], but many of them face legal impediments, established cultural norms about women's roles and unequal demands of domestic responsibilities that can hamper their business progress. The lack of business expertise is a barrier to starting and managing their own craft making businesses. There is an opportunity for them to develop their business skills and examine how their manufacturing processes can be improved.

Project solution

To empower women in Uganda's informal craft sector, researchers from the UK, Malawi, and Uganda sought ways to foster their entrepreneurial skills and apply operational principals widely used in manufacturing, in a

local context. In a research trip to Uganda, the team interviewed 84 craft women in informal settlements in and around Kampala to identify critical success factors and barriers they faced in growing their business. They found that many resources were wasted due to the lack of standardisation, which contributed to time and financial loss. Following their findings, the project team ran a workshop for 20 of the women, training them in standardised procedures as well as building and costing of their products. The team hoped that the women would go on to train more people in their communities.

Interdisciplinary collaboration

The project brought together academics from engineering, quality management, economics and business with community groups in Kampala. While building entrepreneurial and engineering capacity were important goals in the project, the researchers thought it paramount that they were not simply instructing the craft women to improve their operational methods. Working closely and building partnerships with these women allowed the team to tailor their approach for the local circumstances, facilitating long-term changes to methods of manufacturing within the community.

Sustainable Development Goals

Impact

Upon revisiting the community six months later, the researchers saw a transformation in the handcraft women's ways of working, including outsourcing of non-specialised tasks, product standardisation and the use of alternative materials that are local and more sustainable. Some craft women had also started to train other women in their community with the entrepreneurial skills they had learned, creating knowledge transfer and developing role models for the next generation.

The researchers also established a business hub with the Resilience Africa Network at Makerere University, where 20 craft women were provided with digital training once a week for three months, building on their branding and online presence. This allowed them to reach a much wider pool of potential customers to help expand their businesses. Since this training, the craft women have created WhatsApp groups and Facebook pages to showcase their work online.

Future plans

There are now plans in place to expand the support for the handcraft women in Kampala. While the business hub pilot only ran for three months, the researchers are seeking funding to establish it as a more permanent information hub for the women. The researchers also acknowledge that the problems these women face are similar in many lower-income countries and refugee camps. The team has received further funding to run the same pilot with Kenyan craft women and are seeking further funding to host similar workshops in other countries, and grow their operation to an international scale.

"The project empowered me and my team to work together and create real change. As well as the amazing impact we were able to achieve together in Uganda, the project had an unprecedented impact on my life as an engineer. The collaborations I developed along the way will be lasting."

Evdoxia Viza, University of the West of Scotland

Handcraft

Funding

This 18-month project received £20,000 of seed funding from the Frontiers of Engineering for Development Programme in 2017.

84 handcraft women interviewed

20 women provided with digital training

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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Royal Academy of Engineering

Improving resilience to cyclones in Madagascar under a changing climate

GCRF
Global Challenges Research Fund

Improving resilience to cyclones in Madagascar under a changing climate

Project

The resilience of the built environment of Madagascar to cyclones in a changing climate (REBEC)

Awardee

Yuner Huang, University of Edinburgh

Collaborators

- Harinaivo Ramanantoanina, University of U-Magis
- Mark Olweny, Uganda Martyrs University
- Veronica Kiluva, Masinde Muliro University of Science and Technology
- Christopher Beckett, University of Edinburgh
- Thomas Reynolds, University of Edinburgh
- Alexandre Ganon, Liverpool John Moores University
- Massimo Bollasina, University of Edinburgh

Challenge

Madagascar is one of the most vulnerable countries to climate change in the world. It is exposed to cyclones originating in the Indian Ocean that have grown more intense with rising global temperatures. The impact of these weather patterns has been detrimental to the social and economic structures, as well as the physical and mental wellbeing, of communities. Many of the Malagasy people rely on agriculture for their livelihood and live in rural areas where basic infrastructure is susceptible to damage from weather events. For example, in 2017, Cyclone Enawo caused 81 causalities and destroyed 300,000 buildings, including 38,000 homes, and resulted in over $400 million in damage. Despite local NGOs and the Malagasy government undertaking substantial relief efforts, there is a lack of evidence about which approaches or interventions were the most effective.

Project solution

In a collaborative effort between the UK, Kenya, Uganda, and Madagascar, researchers combined their expertise to assess the resilience of Malagasy communities to these cyclones through an innovative three-pronged approach by analysing: the structural capacity of traditional homes; the adaptive capacity of local people to react to disasters; and the effect of climate

change on weather patterns. Through this holistic research method, engineers, social scientists, and climatologists were able to obtain a comprehensive understanding of local communities' ability prepare for, and react to, cyclones.

Interdisciplinary collaboration

Collaboration between the researchers and the Malagasy community was an essential part of this research. Because of the lack of appropriate labs in Madagascar, building materials were brought to the UK for structural testing. The team assessed designs from local NGOs, such as the Catholic Relief Service, who are directly involved the construction of new buildings after a natural disaster and spoke to 40 households to understand how they responded to disasters. By engaging with these key stakeholders, the researchers gained a more thorough understanding of how housing is affected by cyclones in Madagascar, which lays the foundation for future study to propose a more structurally-resilient home design that can be used by community groups.

Sustainable development goals

Impact

The team proposed a probability-based model to predict the number of houses that will be destroyed in a cyclone event and proposed practical solutions for Malagasy NGOs and government to update their guidance for building design and disaster preparation. They also offered training opportunities for young researchers in the interdisciplinary climate change resilience research methods, including four research assistants from Madagascar and two undergraduate students from the UK. The project was presented at the UK Shelter Forum in June 2018, reaching over 100 individuals and organisations involved in shelter and settlement reconstruction activities after disasters around the world.

Future plans

The multidisciplinary approach to understanding resilience to cyclones in Madagascar only marks the beginning of lasting change in the community. The project has received further funding of £537,000 over two and a half years from the Royal Society to expand their scope of work and conduct a more comprehensive survey of the three target fields of research. The team will continue to work with local stakeholders to refine and realise solutions to enhance resilience to climate change.

"The interdisciplinary nature of the Frontiers programme has been a great experience for me. Its emphasis on collaboration between different expertise has given me an opportunity to work outside my department and test other methods of research. I had never worked with climatologists before this programme but now, my research partners and I have a better understanding of each other, and I'm confident we can build this relationship up."

Yuner Huang, University of Edinburgh

Funding

This 18-month long project received £20,000 seed funding from the Frontiers of Engineering for Development programme in 2018.

Four research assistants and two undergraduate students trained in research skills

Project presented at the UK Shelter Forum in June 2018 to over 100 key stakeholders

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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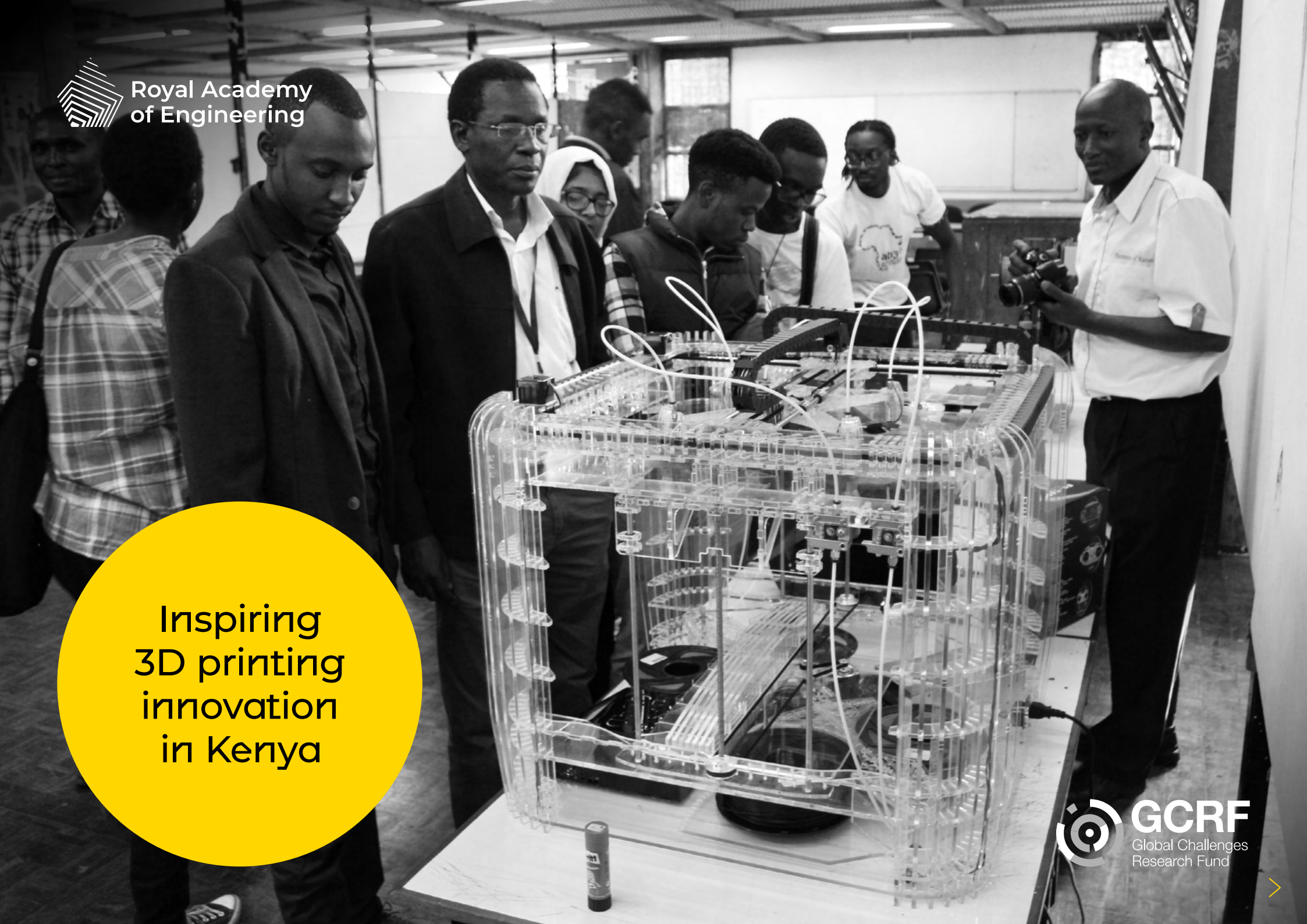
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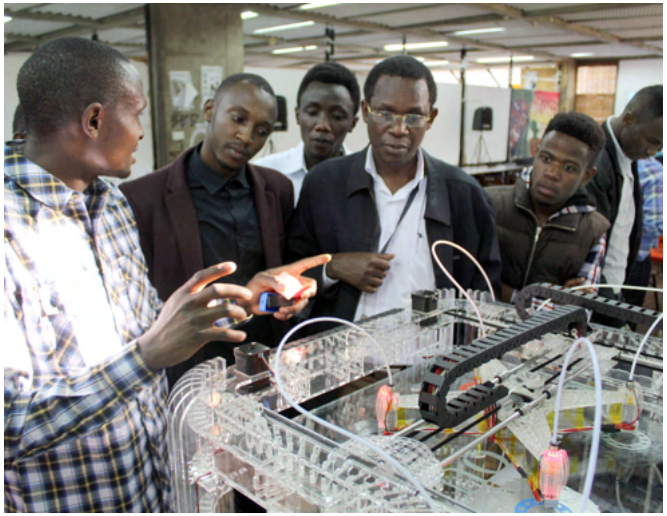
Inspiring
3D printing
innovation
in Kenya
GCRF
Global Challenges
Research Fund

Inspiring 3D printing innovation in Kenya



Project

Building 3D printing capacity in Kenya: Using a co-design approach to accelerate product development

Awardee

Timothy Whitehead, Aston University

Collaborators

- Peter Mbiria, Voltarent Engineering
- Lilac Osanjo, University of Nairobi
- Adrian Jankowiak, Nairobi Design Week
- Roy Ombatti, AB3D
- Solomon Gitau, Digital Blacksmith
- Elizabeth Rodgers, Kuumda 3D

Challenge

In much of the developed world, 3D printing has been lauded for its potential to change engineering and manufacturing industry. From open-sourced prosthetics to advanced materials, 3D printing has enabled faster and cheaper development of innovative products and designs. In developing countries, 3D printing is a pathway to international development, empowering the next generation of innovators with the technology to build their own solutions to local challenges at an affordable and timely rate. Yet, there are many unique and appropriate applications of 3D printing still to be explored.

Project solution

To inspire 3D printing innovation and support emerging economies in the field, designers, engineers and academics from the UK and Kenya partnered with local business to establish a network of 3D printing expertise. They conducted a review of the current state of 3D printing in Kenya to highlight potential opportunities for growth in the industry and found that there was a lack of access to infrastructure and knowledge.

Three steps towards these challenges were taken:

1. Engineers from Voltarent developed and manufactured a 3D printer using local materials and expertise, reducing the cost of the machine and improving access to the technology.

2 Industrial designers at Aston University developed a range of 10 product concepts to demonstrate the depth and diversity of 3D printing, these were printed using locally manufactured, recycled printers from AB3D.

3 20 students from the UK worked with students in Nairobi, providing them with training on 3D printing techniques and helping to build the engineering capacity in this area.

Interdisciplinary collaboration

The three-way partnership between students, local businesses, and academics was successful due to the collaborative sharing of expertise. Opening up access to 3D printing technology and establishing working relationships between partners enabled the development of novel uses of 3D printing. These cumulated in an end-of-project event, in collaboration with Nairobi Design Week, to showcase the design outputs and demonstrate the value of digital manufacturing and the role it can play for businesses in Kenya.

Sustainable Development Goals

Impact

Through this project, 3D printing was embedded into curriculum of the University of Nairobi, enabling staff and students to gain practical knowledge. It has been permanently incorporated into the curriculum, and printers can be used for final year projects. The industrial design department were given two 3D printers made from recycled waste, as well as workshops on how to use them. Students involved from the UK and Kenya have developed new ways of working and advanced their knowledge of 3D printing and its capabilities. Products developed during the project included a water filter, custom shoe, STEM building kit. With early exposure and enhanced knowledge, students will be able to undertake more complex designs as they progress through their careers.

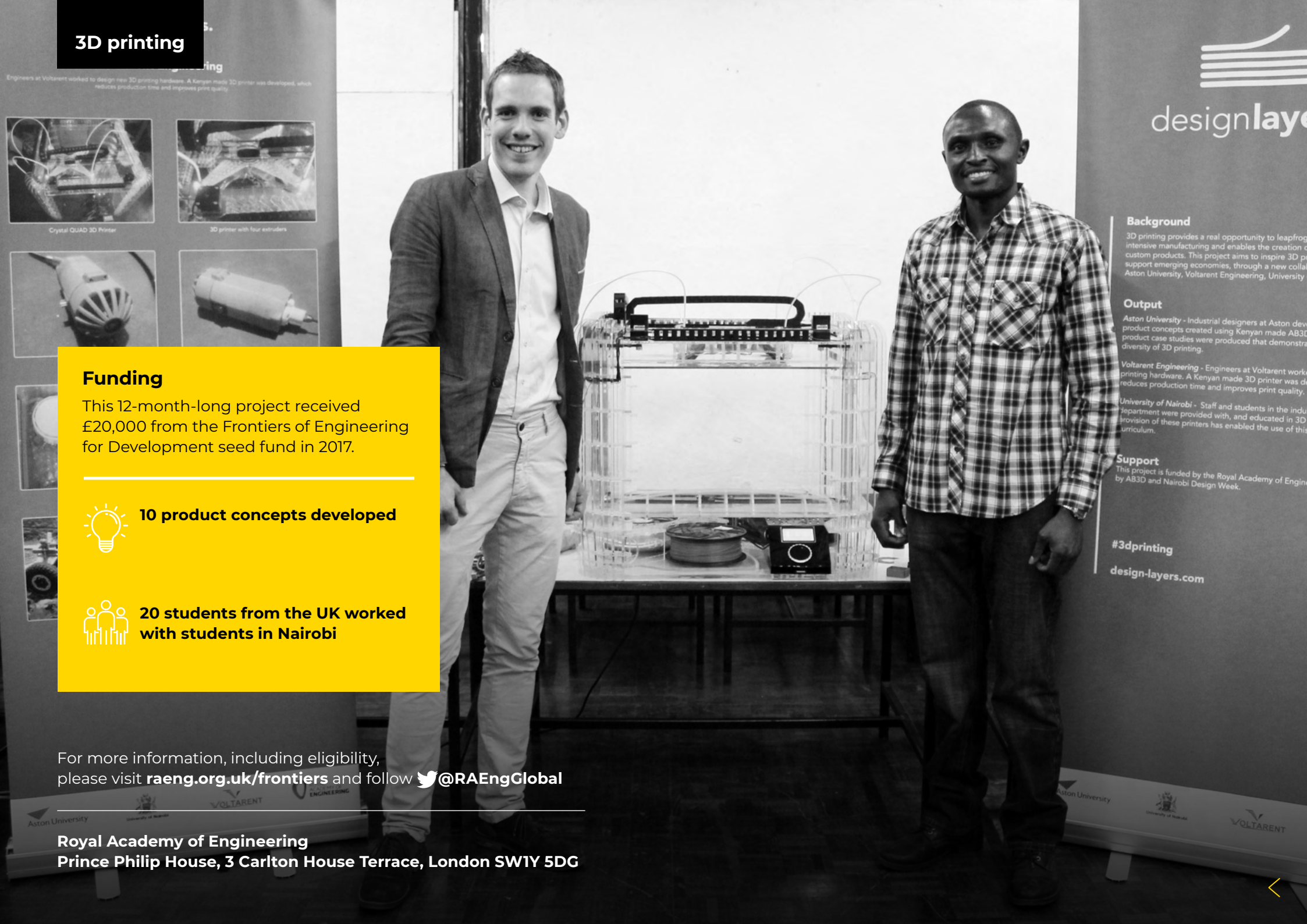
Future plans

There is still more to do to leverage the full potential of 3D printing. Dr Whitehead has received further £42,000 in funding from the Global Challenges Research Fund (GCRF) to develop a 3D printing toolkit for international development and £150,000 from the Cluster Challenge GCRF fund to investigate how plastic waste can be converted into 3D printing filament in Kenya, Nigeria and Rwanda These follow-on projects will showcase the key advantages of the technology and its potential to leapfrog developed countries. Using case studies from this project, the toolkit and further work will guide international development professionals through the use and applications of 3D printing technology in low-resource settings, and methods to develop the required skills and infrastructure.

"Without the expertise of my partners, this project would not have been the success it was. Our collaboration with each other, as well as students and staff we worked with in Kenya, meant that we were able to unlock all sorts of design possibilities that have the potential to improve the livelihoods of people in low-income countries."

Timothy Whitehead, Aston University

3D printing



Funding

This 12-month-long project received £20,000 from the Frontiers of Engineering for Development seed fund in 2017.

10 product concepts developed

20 students from the UK worked with students in Nairobi

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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Royal Academy
of Engineering
Protecting
Kenyan
aquaculture
from climate
change
GCRF
Global Challenges
Research Fund

Protecting Kenyan aquaculture from climate change

Project

Promoting climate-resilient aquaculture through shared space for co-designing adaptation measures

Awardee

Olalekan Adekola,
York St John University

Collaborators

- Margaret Gatonye, Aquaculture Association of Kenya
- Paul Orina, Kenya Marine and Fisheries Research Institute
- Bart Malaba, Larive International

1 The Star (2018). Uhuru to launch 'eat more fish campaign' in Mombasa. https://www.the-star.co.ke/news/2018-11-15-uhuru-to-launch-eat-more-fish-campaign-in-mombasa/

2 Food and Agriculture Organisation of the United Nations (2018). Impacts of Climate Change on Fishers and Aquaculture. http://www.fao.org/3/i9705en/i9705en.pdf

Challenge

The capture fisheries and aquaculture sector in Kenya plays a significant role in the economy. Fish is a staple protein of the Kenyan population, who are encouraged by the government[1] to eat more fish due to its nutritional value, to support the livelihood of more than four million people in the country that work in the sector. In recent years, however, the industry has been declining, with more than 40% of the sector's capture fisheries potential growth lost due to climate change[2]. Climate change has led to more unpredictable and extreme weather patterns, making resources scarcer and the fishing profession more challenging and less profitable. Though aquaculture offers great opportunity for fish protein provision to the growing Kenyan population, there is evident lack of coordination among local authorities, research and academia on how to cope with climate change. This has resulted in the abandonment of fish farming.

Project solution

Researchers from the UK and Kenya engaged with industry professionals to examine the impacts of climate change on the aquaculture sector and help to build its resilience. Two workshops were held in Nairobi, Kenya, bringing together more than 40 government officials, farmers, NGOs and aquaculture experts to understand how climate change has affected

their way of working from a practical perspective. The researchers also visited 15 farms in four climatic zones of Kenya and interviewed farmers and policymakers in their respective zones to gain a more holistic understanding of the specific challenges and influences at play. Through these interactions they were able to put forward measures and recommendations to enhance the industry's resilience to climate change.

Interdisciplinary collaboration

The project is the first of its kind to take an in-depth look at the effect of climate change on the Kenyan aquaculture industry and was only possible with the help of a wide range of collaborators. As well as the workshops, interviews and surveys, the team of researchers started the Climate Resilient Aquaculture in Kenya Network, a WhatsApp group of 35 stakeholders in Kenya, aiming to discuss and share resilience strategies from different parts of the sector. Working together with these industry professionals, the researchers were able to effectively access the heart of the ecosystem, improve their understanding of different problems facing each part of the aquaculture sector and integrate these perspectives into proposals for policy and infrastructure intervention.

Sustainable development goals

Impact

Through their engagement with local stakeholders, the team found that there are three major challenges facing the industry: water scarcity, prolonged droughts and floods and rising temperatures. Extreme weather patterns have meant the quantity and quality of water is poor. Farmers have resorted to using aquifers, underground layers of water-saturated rock, to supply their ponds with water, which puts additional strain on the precious water source. In other regions, extreme flooding has led to overflow in ponds, causing the expensive fish to swim away. With this in mind, the team has created a steering group of eight stakeholders who attended their workshops to raise awareness of the impacts of climate change and build local capacity to begin to adapt to these challenges. They have also prepared a policy brief that will be disseminated to the policy community to encourage rapid intervention.

Future plans

With an enhanced understanding of the impact of climate hazards there is a clear direction for the researchers to provide additional support and help farmers build resilience against climate change. The next priority is to design infrastructure, build capacity and mobilise legislation to provide support in this sector, and the team is looking for funding to do so.

"The Frontiers programme has allowed me to forge valuable relationships between academics in different disciplines. It was incredibly valuable to have different cultural and disciplinary perspectives and my relationship with my project partners has grown to a partnership that I'm sure will continue for a very long time."

Olalekan Adekola, York St John University

Aquaculture

Funding

The 12-month long project received £20,000 funding from the Frontiers of Development programme in 2018.

Over 40 stakeholders engaged in workshops to understand impact of climate change on aquaculture

Steering group of eight stakeholders to raise awareness and build local capacity

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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Bottle houses: using waste materials for sustainable homes

GCRF
Global Challenges Research Fund

Combatting water scarcity and sanitation with sustainable solutions

Project

Developing local capacity for building affordable, self-sufficient homes

Awardee

Muyiwa Oyinlola, De Montfort University

Collaborators

- Amal Abuzeinab, De Montfort University
- Timothy Whitehead, Aston University
- Boksun Kim, Plymouth University
- Yewande Akinola, Laing O'Rourke
- Farukh Farukh, De Montfort University
- Karthikeyan Kandan, De Montfort University
- Fatai Anafi, Ahmadu Bello University

1 UN News (2017). Affordable housing key for development and social equality, UN says on World Habitat Day. https://news.un.org/en/story/2017/10/567552-affordable-housing-key-development-and-social-equality-un-says-world-habitat

Challenge

Access to safe and affordable housing is a global challenge with more than 1.6 billion people worldwide living in slums, informal settlements or inadequate homes1. In Nigeria, homes of low-income communities are often low quality and made of mud bricks, which can fall down after several years. Such communities are also plagued by plastic and agricultural waste that is not cleared due to a lack of waste collection services. The waste is often incinerated, leading to a further reduction in living standards. This project offered an opportunity to address both problems at the same time and develop local capacity to construct low-cost, sustainable homes in such communities.

Project solution

A team of engineers and architects from the UK and Nigeria explored the possibility of upcycling materials to use as a low-cost building material in residential construction in the low-income community of Paipe, Nigeria. The team looked at materials such as plastic bottles and agricultural by-products, which are usually thrown away as waste. The engineers tested the structural potential of local waste and investigated the energy and water components required for a self-sufficient building. They also engaged with local members of the community and stakeholders to understand the specific

requirements of housing within the community. Through this engagement the team was able to design and build a prototype self-sufficient home made from locally engineered materials.

Interdisciplinary collaboration

A significant portion of the project was dedicated to collaborating with stakeholders and involving them in the design and construction of homes. The researchers understood that it was paramount that the prototype home was socially accepted by the local community. As such, they conducted interviews and focus groups with 11 households in the community, including residents, local builders and the community chief. Participants were also invited to feedback on prototype designs. By engaging the various expertise of academics, policymakers, community members and construction workers, the researchers were able to co-design a universally beneficial model for a home and raise local awareness of sustainable construction methods.

Sustainable development goals

Impact

The team has built a prototype home using upcycled plastic bottle walls and integrated in-house electricity generation and water purification systems, at 35% of the cost of a conventional building. The researchers also offered training opportunities for young engineers, bringing 20 students and three academics from the UK to Nigeria on a capacity building trip. The team worked with two local academics, eight construction workers and 10 local students during the engineering process to build local knowledge about sustainable construction methods. The design has been widely accepted by the community and the prototype has been visited by over 200 people, including the Housing Committee Chair, Electricity Agency and representatives of the Federal Ministry of Science and Technology. Through this engagement the researchers gave the people of Paipe a solution that can be used time and time again.

Future plans

Following such a positive response from the community the researchers are now seeking funding to enable them to further improve the design of the prototype. As well as making the houses fire retardant and safer, the team is now looking to create eco-bricks made out of plastic bottles that will be shaped like conventional bricks. This would make the designs more accessible to a larger number of construction workers and enable many more community groups to use such materials for their homes.

"The Frontiers project has been highly instrumental in progressing my research career. It has connected me to people who are also committed to applying their work in developing countries, and I have developed close relationships with many of them."

Muyiwa Oyinlola, De Montfort University

Bottle Houses

Funding

The eight-month long project was awarded £20,000 by the Frontiers of Engineering for Development Programme in 2016.

Three academics and 20 students from the UK went to Nigeria on capacity building trip

The prototype home has been visited by over 200 people, including Housing Committee Chair, Electricity Agency and representatives of the Federal Ministry of Science and Technology

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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MAPwater: combatting water scarcity and sanitation with sustainable solutions

GCRF
Global Challenges Research Fund

Combatting water scarcity and sanitation with sustainable solutions

Project

MAPwater: mapping availability and pollution of water resources

Awardee

Mirella Di Lorenzo, University of Bath (PI)

Francesca Pianosi, University of Bristol

Rodolfo Rueda, Fomento Mexicano

Collaborators

- Jannis Wenk, University of Bath
- Thomas Kjeldesen, University of Bath
- Elias Martinez Hernandez, Instituto Mexicano del Petroleo
- Alfonso Duran, Universidad Autonoma de Madrid
- Claire Edward-Collins, University of Bath

Conagua

- Consejo Consultivo de Agua,
- Engineers without Borders, Isla Urbana, Saya

Challenge

Water scarcity affects every continent across the globe and climate change and overpopulation has only exacerbated the issue. In Mexico, lack of available drinking water is a widely acknowledged problem. This is partly because water management and infrastructure are not well developed, but also because the country depends on aquifers for drinking water, underground layers of rock saturated with water. These have been overexploited through urbanisation and do not adequately replenish during the rainy season. In the rural communities of Mexico, water scarcity is even more severe. For example, in Llano Grande, a community on the outskirts of Mexico City, no households are connected to a public water supply and only 59 households out of 110 have sanitary installations. There is no running water for cleaning, cooking, or domestic consumption, and drinking water is collected from a well and a natural spring, which are both located far away from the settlement.

Project solution

A group of UK academics collaborated with Mexico-based NGO Fomento Mexicano, local stakeholders from NGOs, government bodies and water companies to develop an effective water management and resilience strategy for rural Mexican communities, focused on Llano Grande. They gathered historical data on water

availability and quality from academic literature and government reports and hosted a workshop about sustainable water provision to foster open discussions between experts in rural water availability. The researchers also engaged with residents of Llano Grande to gain insight into the challenges they face when obtaining safe water.

Interdisciplinary collaboration

To understand the issue of water availability in the country, the researchers built a collaborative network of water experts from academia around the world. Their expertise was combined with the input from key Mexican stakeholders to enable an open discussion on the issues of water availability, quality and treatment in rural Mexican communities. Engagement with the community of Llando Grande was critical to understanding the end-user perspective of the water challenge. The team worked closely with local NGOs who had intimate knowledge of the culture of rural communities. Overall, the researchers gained a thorough understanding of both top-down and bottom-up perspectives of water security, which was key to developing impactful strategies.

Sustainable development goals

Impact

Through their research, the team found that rainwater harvesting is one of the most viable solutions for water scarcity in the area. Working with the local NGO, Isla Urbana, they installed a rainwater harvesting and purification system at the local school, Miguel Angel de Quevedo, that has a capacity of over 450,000 litres per year and can provide more than 65% of the community's water needs. A school activity called 'Escuelas de Lluvia' was developed with another NGO, Saya, to educate young people and their families on the importance of water safety and raise awareness of sustainable water use. As part of this activity researchers trained a small committee of parents, teachers and students on the maintenance of the rainwater harvesting and purification system to build local capacity and ensure that the system can be used for many years to come. This activity has so far been used by over 200 students and teachers and the researchers hope to bring these activities to other rural schools.

Future plans

By working with local communities and key stakeholders, the team has mobilised government bodies to find more sustainable solutions to water scarcity in rural Mexico. However, the team acknowledge that there is still much to do. The outcomes of this project can be applied to other communities where access to safe water is critical and the team is now looking for further funding to expand the scope of the project and help bring a sustainable clean water supply to other communities that need it.

"When working with vulnerable communities it is essential to build a relationship of trust, and this could not have been possible without the knowledge and experience of NGOs and other academics that I met through Frontiers. The ability to collaborate with people around the world, and in the community itself, really made all the difference to this project."

Mirella Di Lorenzo, University of Bath (PI)

MAPwater

Funding

This nine-month project received £20,000 in funding from the Frontiers of Engineering for Development programme in 2017.

School activity on sustainable water use has been used by 222 students

Committee of eight parents, students, and teachers trained to maintain the rainwater harvesting and purification system

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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Royal Academy of Engineering

Developing low-cost hand prostheses for patients in need

GCRF
Global Challenges Research Fund

Developing low-cost hand prostheses for patients in need

1 Access Prosthetics (2017). 15 Limb Loss Statistics that May Surprise You https://accessprosthetics.com/15-limb-loss-statistics-may-surprise/

2 WHO (2005). Guidelines for Training Personnel in Developing Countries for Prosthetics and Orthotics Services https://www.who.int/medical_devices/publications/guide_prosthe_ortho_train/en/

3 Alturkistani R, A K, Devasahayam S, Thomas R, Colombini EL, Cifuentes CA, Homer-Vanniasinkam S, Wurdemann H, Moazen M. 2020. Affordable passive 3D-printed prosthesis for persons with partial hand amputation. Prosthetics & Orthotics International, 44:92-98. https://doi.org/10.1177/0309364620905220

Project

Development of an affordable hand prosthesis

Awardee

Mehran Moazen,
University College London

Collaborators

- Helge Wurdemann, University College London
- Shervanthi Homer-Vanniasinkam, University College London
- Esther Luna Colombini, University of Campinas
- Carlos Cifuentes, Colombian School of Engineering Julio Garavito
- Raji Thomas, Christian Medical College
- Kavin Alagesan, Christian Medical College
- Suresh Devasahayam, Christian Medical College

Challenge

The loss of all or part of a limb is a traumatic and life changing event. Globally, there are over one million limb amputations every year[1]. The World Health Organization estimates that 30 million people need a prosthetic or orthotic device[2]. Significant advances in technology in recent decades mean that there are solutions that can assist amputees in their daily life. However, many of these technologies are unavailable to people from disadvantaged backgrounds or low- and middle-income countries, where hospitals may not have the tools or expertise to provide prosthetics and patients often lack the means to afford treatment and rehabilitation. This is especially true for partial hand amputees, whose amputations are more unique and complex than other body parts so there is far less expertise in this form of rehabilitation.

Project solution

To help address this problem, three teams of engineers from Colombia, Brazil, and the UK worked with clinicians at the Christian Medical College (CMC) in India to design and create low-cost upper limb prostheses that can be offered to patients in need. The teams designed and manufactured 3D-printed patient-specific prosthetic hands using moulds and information about the patients from the clinicians at the hospital[3]. The team also hosted a student

competition in all three countries to design non-3D-printed hands, as an alternative to 3D-printing, using recyclable materials and easily accessible manufacturing procedures.

Interdisciplinary collaboration

Partial-hand amputations can differ widely and must be reviewed and treated on a case-by-case basis. With teams in four separate countries around the world, close collaboration between clinicians and engineering teams was crucial in delivering functional prostheses. Images and 3D moulds of patients' hands were shared among the team to develop 3D printed and non-3D printed designs. During two capacity- building trips to India, researchers and students from the UK, Columbia and Brazil met with patients to test the prosthetics and further refine them based on their feedback.

Impact

At the end of this project, three 3D-printed hand prostheses and three non-3D-printed ones were tested on the patients, using the GRASP Taxonomy test to examine the functionality of the prosthetic devices. The 3D-printed prostheses outperformed the non-3D-printed ones and the researchers received positive anecdotal feedback. The team trained local clinicians and researchers in India in the research methods and prosthetic design process, as well as students in their respective countries. A further 60 students from the UK, Colombia, and Brazil participated in the student competition and were taught non-3D-printed prosthetic design and manufacturing, building their engineering capacity and research skills. The team identified ways to further improve the functionality of the 3D-printed devices and have continued working in this area through student projects[4]. Finally, the team identified that one of the key challenges for the CMC was access to manufacturing facilities to create the prostheses. The team is currently working on providing the hospital with access to 3D printers to enable them to create their own designs and support their patients.

Future plans

Following positive initial results, the team is working to establish continuity for the project and attract further funding to expand its reach, aiming to help more patients get the care they need. Scaling up this project could give local hospitals a sustainable means of providing accessible and functional prostheses to their patients.

"The driving force behind this project was our motivation to have a tangible impact on the people in need. I've worked on many projects over the course of my career, but to me, this project has been one of the most positive ones. Even though we all come from a diverse range of backgrounds and expertise, we were united by this common goal to make real impact to the communities of India."

Mehran Moazen, University College London

Sustainable development goals

4 Shi G, Palombi A, Lim Z, Astolfi A, Burani A, Campagnini S, Loizzo FGC, Lo Preti M, Marin Vargas A, Peperoni E, Oddo CM, Hardwicke J, Venus M, Homer-Vanniasinkam S, Wurdemann HA. 2020. Fluidic haptic interface for mechano-tactile feedback. IEEE Transactions on Haptics, 13:204-210. https://doi.org/10.1109/TOH.2020.2970056

Funding

The 12-month project was rewarded £20,000 from the Frontiers of Engineering for Development programme in 2017.

Three 3D-printed hand prosthesis and three non-3D-printed ones developed and tested

60 students from the UK, Colombia and Brazil participated in student competition to design a non-3D-printed prosthetic

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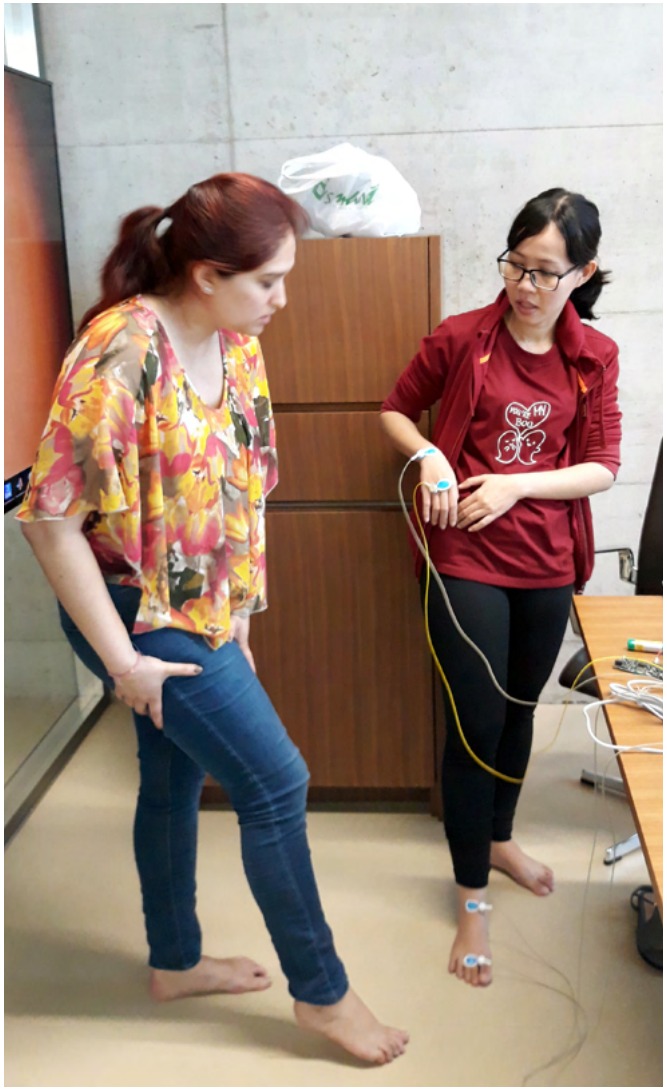
Royal Academy of Engineering

Improving care for critical dengue patients through bio-impedance

GCRF
Global Challenges Research Fund

Improving care for critical dengue patients through bio-impedance



Project

Bio-impedance for detection of fluid status in dengue

Awardee

Louise Thwaites, Oxford University Clinical Research Unit

Collaborators

- Walter Karlen, ETH Zurich
- Nguyen Van Vinh Chau, Hospital for Tropical Diseases

Challenge

Dengue is an infectious disease that affects an estimated 390 million people every year in tropical regions[1]. While most cases of dengue are mild, patients can occasionally develop severe dengue, where fluids leak from blood vessels to the surrounding tissue causing hypotension and shock. The maintenance of a patients' body fluid level is a critical component of severe dengue care and early detection of the disease progression and access to proper medical care lowers the fatality rate to below 1%. However, in many low- and middle-income countries, there is limited resource to diagnose and monitor patients. At the Hospital for Tropical Diseases in Ho Chi Minh City, Vietnam, thousands of patients are admitted every year with dengue. Assessing fluid status in such large numbers of patients can become difficult and costly. The development of new technology offers an opportunity to provide low-cost solutions to monitor patients and improve the quality of care they receive in such environments.

Project solution

To improve the quality of treatment for dengue patients, clinicians from the Hospital for Tropical Diseases in Vietnam worked with engineers from ETH Zurich to create a device to monitor fluid leakage in patients. Prior to this project, engineers at ETH Zurich had already developed

1 WHO (2020). Dengue and Severe Dengue. www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue

a device that measures bio-impedance, a body's resistance to electric current, to monitor dehydration in children. Bio-impedance has been shown to correlate the fluid levels and water accumulation in a patient's body, but there has been little data to support these claims. This device was adapted to be more appropriate for dengue patients, and further developed and improved through two workshops with stakeholders. Preliminary patient data was generated using the wearable device to support future trials. The final device, named D~AMBICA sensor, proves to be an easy-to-use and non-invasive solution for medical professionals.

Interdisciplinary collaboration

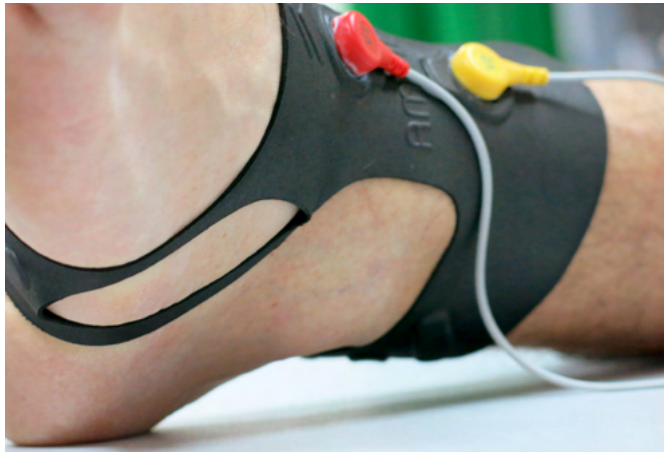
The technical requirements for such a medical device are very specific, and it was critical that both teams were able to understand how the device would be used. A week-long workshop was conducted in Ho Chi Minh City, bringing together Vietnamese and international stakeholders, including clinical trial staff, engineers, and doctors, to discuss the needs and specification for non-invasive dengue management. This workshop allowed stakeholders to share expertise regarding the pathophysiology of dengue and the principles of bio-impedance, simultaneously facilitating opportunities to build working relationships for the project and understanding of the setting in which the device will be used.

Impact

The D~AMBICA Sensor has been demonstrated to be a low-cost, wearable bio-impedance device for continuous monitoring of fluid status in patients with dengue. It measures body bio-impedance every 10 minutes by passing a small electric current through the body, and initial tests show that it is accurate and safe to use. These results were presented at the second workshop at ETH Zurich, where a protocol for clinical trials were developed. This protocol has since been approved by the relevant institutions and regulation authorities.

Future plans

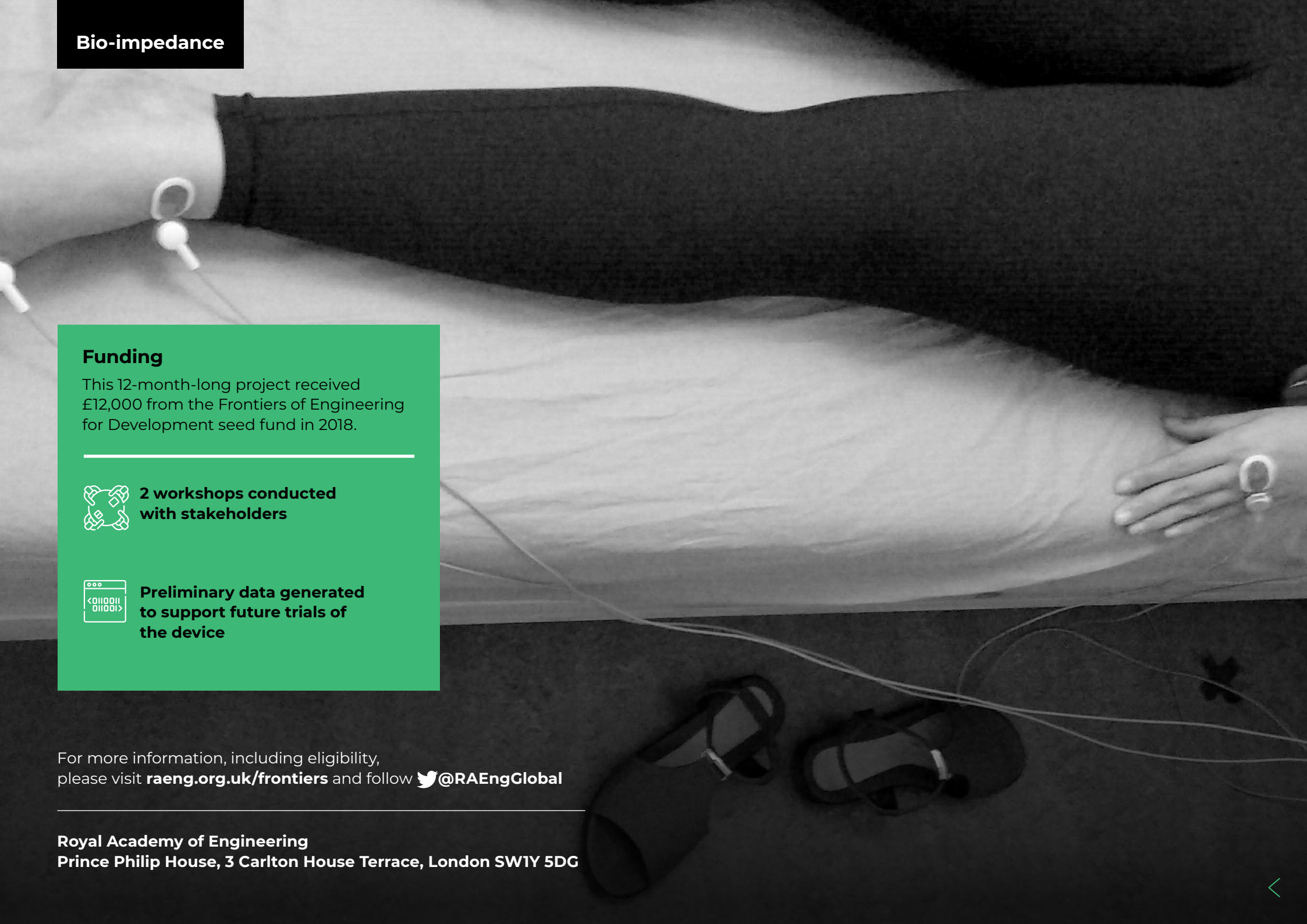
The team has separately secured further £4,000,000 in funding from the Wellcome Trust Flagship Award programme for three years, combining biomedical engineering and computer science innovation to improve the management of critical patients in low-resource settings. While the D~AMBICA is a small proportion of this, the team will continue device development and testing, and investigate its potential use for sepsis and septic shock, as well as other infections.



"The Frontiers programme has been a really valuable experience for me and, without it, I'd never be doing what I am today. I really appreciated how it brought professionals from different backgrounds together, and our collaboration helped me understand how our disciplines can work together more generally."

Louise Thwaites, Oxford University Clinical Research Unit

Sustainable Development Goals



Bio-impedance

Funding

This 12-month-long project received £12,000 from the Frontiers of Engineering for Development seed fund in 2018.

2 workshops conducted with stakeholders

Preliminary data generated to support future trials of the device

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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Royal Academy
of Engineering
Makazi:
emergency
shelters that
foster social
empowerment
in Africa
GCRF
Global Challenges
Research Fund

Makazi: emergency shelters that foster social empowerment in Africa

Project

Circular design of emergency sheltering for Africa: a holistic approach

Awardee

Francesco Pomponi,
Edinburgh Napier University

Collaborators

- Gama Sibanda, Biomimicry South Africa
- Abimbola Windapo, University of Cape Town
- Taghried I.M. Abdel-Magid, Sudan University of Science and Technology
- Bernardino D'Amico, Edinburgh Napier University
- Susan Snaddon, Friend of the Arup Education Trust
- Lara Alshawawreh, Edinburgh Napier University

1 www.unhcr.org/uk/figures-at-a-glance.html
2 www.unhcr.org/uk/africa.html

Challenge

Over 79.5 million people worldwide had been forced out of their homes because of conflict, violence, or natural disasters by the end of 2019[1]. Sub-Saharan Africa hosts over a quarter of displaced people, and the number is growing due to ongoing crises[2]. Emergency shelter relief efforts have been substantial, but even the best solutions are often only intended to be temporary. In many cases, however, emergency shelters become semi-permanent homes in refugee camps, providing inadequate housing for generations of displaced families. There is an opportunity to engineer more effective solutions that can be instantly deployed but also easily adapted by the residents as a long-term solution.

Project solution

A team of experts from the UK and South Africa worked together to develop a solution for post-disaster and conflict sheltering for communities across Africa. They conducted an extensive review of relevant academic work and currently available shelter solutions and found that there are insufficient options available for the transitional period between the immediate aftermath of a disaster and permanent housing.

With this in mind, they hosted one online and two in-person workshops with a panel of engineers, architects, NGOs, humanitarian

professionals, and other relevant stakeholders. The workshops systematically assessed the performance of existing solutions across four sustainability dimensions: environmental impact, social suitability, economic viability, and technical performance. After reaching a consensus on the best performing solution on the market, they hosted exercises to improve the design using principles of the circular economy, and created a new prototype solution. This pre-manufactured building was named Makazi, after the Swahili word for home. Structural analysis of the building was performed to ensure its safety.

Interdisciplinary collaboration

Sheltering solutions are highly context-dependent. To design an adequate solution that would meet the cultural needs of the community, the natural constraints of the environment, as well as the cost requirements of humanitarian organisations, many factors had to be considered. The disciplinary diversity of the group allowed them to consider these challenges from many academic angles, as well as from the practical experiences of participating NGOs who work on the ground with displaced people. Together, the experts were able to combine their unique perspectives to develop a solution that delivered all of the requirements.

Sustainable Development Goals

Impact

While the Makazi prototype building that the team created is slightly more expensive than other solutions currently on the market, it is easily transportable and can be customised to meet long-term housing and social needs. The panels of their design can be flat-packed for quick deployment to where they're most needed, and its walls can be reinforced with natural materials and decorated with traditional designs. Such a customisable design provides dignity and comfort to affected people, respects local culture and tradition, and helps them move towards long-term social empowerment. Makazi won the Design, Innovation and Creativity category at the UK RISE awards in 2019.

Future plans

The team has received further funding from the Royal Academy of Engineering Frontiers Follow-On Grants scheme to build a 1:1 prototype of Makazi and conduct full-scale testing, including monitoring for humidity, temperature, and user comfort. They will also host four similar design workshops in Kenya, South Africa, Jordan and Zimbabwe, working with NGOs and refugees on emergency shelter design.

In the meantime, members of the team are remaining active in humanitarian projects across sub-Saharan Africa and the Middle East, and hope that their work will prove to be impactful in aiding the millions of individuals displaced from their homes.

"It's been an incredibly rewarding experience. I met so many wonderful people at the Symposium and through the collaboration, experienced cultures and made a good group of friends. My team and I will be continuing our collaboration in the follow-on project, and I'm really excited to be working with them in the future."

Francesco Pomponi,
Edinburgh Napier University

Makazi

Funding

This 12-month project received £30,000 from the Frontiers of Engineering for Development seed funding programme in 2018.

Mazaki won a 2019 UK RISE Award

3 workshops conducted with stakeholders

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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Royal Academy
of Engineering
Improving
understanding
of sand dams
to tackle water
scarcity
GCRF
Global Challenges
Research Fund

Improving understanding of sand dams to tackle water scarcity

Project

Re-engineering Kenyan sand dams by biological design

Awardee

Cindy Smith, University of Glasgow

Collaborators

- Alison Parker, Cranfield University
- Ruth Quinn, Cranfield University
- Africa Sand Dam Association
- Excellent Development

Challenge

It is estimated over 785 million people around the globe lack access to basic drinking water[1]. In parts of Africa there are serious difficulties in securing fresh water supply and the threats of water security are growing due to climate change. Low-technology solutions such as sand dams promise to alleviate some of these issues. Consisting of a reinforced concrete wall built across a seasonal sandy river, they trap some of the water flowing downstream and rainwater run-off from the land. When the dam fills up with sand and sediment, it can store water in the gaps between sand particles[2]. The sand can also act as a natural bio-filter, protecting the water from contamination as well as improving water quality through filtration. However, there has been little research into this technology and insufficient evidence to support large scale investment in building sand dams. There is a need for greater understanding of the microbiological quality of water sourced from sand dams to ensure that the dams are biologically safe and offer an appropriate solution to water scarcity.

Project solution

Researchers from the UK partnered with two NGOs in Kenya to conduct the first comprehensive assessment of water quality in sand dams. They conducted a microbiological

1 UN (2019). Report of the Secretary-General, Special edition: progress towards the Sustainable Development Goals https://undocs.org/E/2019/68

2 Excellent Development. What is a Sand Dam. www.excellentdevelopment.com/what-is-a-sand-dam

survey of three sand dams in south-east Kenya at the beginning and end of the dry season, testing various sites within the sand dam. 72 samples were brought back to the UK where they were sequenced and analysed.

Interdisciplinary collaboration

This project was a collaboration between researchers specialising in water and sanitation in low-income countries and water microbiology. By partnering with local NGOs, the Africa Sand Dam Association and Excellent Development, the researchers were able to gain access to sand dams used by local communities. Their findings can promote and support the use of sand dam technology in semi-arid regions of Africa.

Impact

The results indicated that water from sand dams is safe to drink, but the quality can be compromised by the method of collection. Water is commonly extracted from sand dams through wells with a hand pump, or by digging a hole and scooping out the water. A greater diversity of microorganisms was found in the scoop holes. This is likely because of the unsanitary nature of extracting water by hand from an unprotected open source exposed to humans and animals.

An objective of the project was to build research capacity, which was undertaken in three ways. Firstly, two Masters students from Cranfield University were trained in fieldwork techniques and travelled to Kenya assist with the data collection and two Masters students at Glasgow were trained in the complex sequence data analysis. Also, a secondary school student undertook a work placement at the University of Glasgow to support the research project. Thirdly, a lecture on sand dams has been incorporated into the MSc in Water and Sanitation for Development course at Cranfield University to further build knowledge about the techniques that are used for water harvesting around the world.

Future plans

These results will be used as a starting point for future research into the water quality of sand dams. The team is preparing a manuscript on the finding from the work funded by the RAEng. Dr Parker received further funding from NERC partially to work on sand dams, and will also be continuing her research into sand dams by studying how salinity affects people's choice of water sources, working with a EPSRC Centre for Doctoral Training student on this topic.

"The nature of Frontiers really facilitated collaboration. Getting everyone together at the conference, having seed funding on the table, and the fast turnaround on our proposals meant that we were able to turn an idea into something real. Our collaboration has led to a strong working relationship that will last for many years."

Cindy Smith, University of Glasgow

Sustainable Development Goals

MAPwater

Funding

This 12-month-long project received £20,000 from the Frontiers of Engineering for Development seed fund in 2017.

72 water samples collected and analysed

2 master's students trained

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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Royal Academy of Engineering

Inspiring the younger generation with circular economy

GCRF
Global Challenges Research Fund

Inspiring the younger generation with circular economy

Project

EduKid-CE (Educational platform for kids in circular economy)

Awardee

Anna Bogush, University College London (now Coventry University)

Collaborators

- David Greenfields, Circular Economy Club
- Adrian Jones, University College London
- Zeinab El Maadawi, Cairo University
- Levit Barry Nudi, Notonlab, Kenyatta University
- Burcu Karaca Ugural, Ege University
- Jamal Mohammaed Hassan, ShambaIntel Africa Limited
- Semih Erden, Ege University

1 www.un.org/development/desa/en/news/population/world-population-prospects-2017.html

2 wwf.panda.org/?307230/Earth-Overshoot-Day-2017-is-August-2

Challenge

The world's population grows by approximately 83 million people every year[1]. With increasing industrialisation across the world over the last century, the human population is currently using Earth's natural resources 1.7 times faster than ecosystems can regenerate[2]. As a result, many people are rejecting the 'take, make, and waste' system, where products are disposed once they no longer fulfil their intended use, and moving towards the circular economy approach. In this closed-loop system, unwanted products and infrastructure are recovered for use in another process or application, minimising the use of new resources and the creation of waste, pollution, and carbon emissions. Young people need to be educated about the concepts of the circular economy to encourage future innovation in the field, which will help this approach reach its full potential of conserving Earth's natural resources.

Project solution

A team of specialists from the UK, Kenya, Turkey, and Egypt worked together to create a free educational platform to promote the concept and value of the circular economy to children aged four to fifteen. They hosted a series of 24 country-specific interactive workshops in breakfast and after school clubs, with six workshops in each country. The children learned about issues such as recycling, biomimicry,

climate change, and pollution through hands-on activities including games, research and artwork. These workshops were enriched by use of free and open online educational resources, as well as traditional learning tools. In addition, games were co-created for key concepts and definitions, including an app called BinMatch that matched waste materials to their correct recycling bin.

Interdisciplinary collaboration

Because of the unique barriers to implementing a circular economy at large in each country, the workshops were tailored to fit their respective cultures and traditions. Using their own multidisciplinary and diverse areas of expertise, the team was able to create relevant learning materials and case studies for each country. For example, in Kenya, workshops were conducted in the two of the largest informal settlements in Nairobi, Mathare and Kibera, where the waste collection infrastructure is poor and children often gather waste materials themselves to sell. Understanding that this mode was their best point of access, the workshop focused on how waste materials can be converted to products to use or earn money for food.

Sustainable Development Goals

Impact

The project successfully shared knowledge about circular economy with almost 500 children and their parents through the workshops conducted. Children who were involved with the club not only learned about the concepts of circular economy, such as the six Rs (Rethink, Refuse, Reduce, Reuse, Recycle, and Repair), but they also made new friends and learned about different cultures. These transferrable skills and knowledge will empower students to find better ways of creating future job opportunities.

The impact of the workshops was not limited to the children who attended them. They were also able to change their parent's views on protecting environment and sustainable development. Through anecdotal evidence, the researchers saw children begin to teach their parents how to sort waste. In a concluding workshop, 25 delegates from academia, NGOs, and circular economy professions participated in a roundtable discussion about how principles of circular economy can be further disseminated with the public.

Future plans

The team is planning to expand the circular economy club for children and are seeking further funding to do so. They also want to introduce concepts of the circular economy into the educational curriculum, develop materials and show how the circular economy can be incorporated into various subjects. Further development of the project will be required, and they hope to partner with institutions and organisations that share similar visions and objectives.

"It's been an amazing collaborative experience. I learned a lot from my partners and the communities we worked with, and I hope they learned a lot from us and our project. My partners and I speak to each other often and hope to expand the project so we can share our work with the rest of the world."

Anna Bogush, University College London

EduKid-CE

Funding

This 12-month project received £30,000 from the Frontiers of Engineering for Development programme in 2018.

Almost 500 children reached

25 stakeholders attended final workshop

For more information, including eligibility, please visit **raeng.org.uk/frontiers** and follow **@RAEngGlobal**

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