

STRENGTHENING ENGINEERING ECOSYSTEMS IN SUB-SAHARAN AFRICA

**IDRC Grant Number: 108883-003*

College of Engineering at
Kwame Nkrumah University of Science and Technology
Ghana

By:

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Final Report

Date:

28th February, 2022

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Abstract

The consortium, led by the Kwame Nkrumah University of Science and Technology together with Feminist Data Research Canada, Engineers Without Borders USA, Safe Water Network, Ghana with AECOM as a collaborating partner identified a systemic problem in line with the World Bank and IDRC sources that point to the lack of targeted industry training and research application for students in engineering. The consortium used a scheme that involved the piloting of applied engineering research projects in the following disciplines: ICT, Sanitation (Environment and Waste Management) and Water. The process starts with a call for proposal, students respond by coming up with ideas through written proposals and pitching their proposals before a select panel. Innovative ideas piloted included innovations in data management for community water supply systems, water treatment, non-revenue water management, WASH education and ICT which are priority areas for development intervention in the United Nations Sustainable Development Goals (SDGs). The Strengthening Engineering Ecosystems in sub-Saharan Africa (SEESA) project covered a period of three years and four months from October 2018 to January 2022. During this period, the SEESA project supported a total of 31 student-led pilot projects. The projects piloted targeted solving critical developmental challenges like improving access to affordable sanitation, water supply, and energy saving while striving for gender equality (United Nations Sustainable Development Goal # 5). It has been found that the current curriculum can be enhanced if students in their final year are encouraged to work in multi-disciplinary groups partnered with the private sector with the aim of addressing specific problems in these institutions. One of the gaps identified from the pilot projects was inadequate packaging. One positive observation inferring from the total number of respondents for the calls for proposals was the interest of the students to engage in practical projects which would lead to solving problems being faced locally using the skills they have acquired in school. The inadequate packaging of some of the completed prototypes resulting from the projects did not make them attractive for purchasing or adoption. Also, the entrepreneurial attitude of the teams was not as aggressive as expected. It was observed that while engineering students have the capacity to propose workable solutions to industry challenges, their self-motivation and initiative in respect of taking the projects to the next level were low. The approach used in this applied engineering research pilot can be adopted and scaled to address the systemic problem of lack of targeted industry training and to promote stronger networks in knowledge-sharing between engineering schools and industry.

Keywords: SEESA, Engineering, KNUST, Innovation

Table of Contents

Abstract	ii
1 Research Problem	1
2 Objectives	1
3 Methodology	2
4 Project Activities	3
4.1 Activities.....	3
4.2 Project Implementation and Management.....	5
5 Project Output	7
6 Project Outcomes	10
7 Overall Assessment and Recommendations	11
8 Annexes	13

1 Research Problem

Based on extensive experience in Ghana and the overall West African region, the consortium identified a systemic problem in line with the World Bank and IDRC sources that point to the lack of targeted industry training and research application for students in engineering. This project sought to address the systemic problem of the lack of applied learning, weak networks in sharing knowledge between engineering schools and industry as well as the lack of innovation in applied research targeting industrial challenges.

2 Objectives

The objectives defined for the SEESA (Strengthening the Engineering Ecosystem in Sub Saharan Africa) project which was hosted at KNUST were:

1. Enhance the engineering curriculum at KNUST to the extent that it is better able to engage with stakeholders in the private sector to produce new knowledge for addressing social and economic problems in Ghana.
2. Assess and learn from experiences within the water and ICT sectors to understand challenges across other applied STEM fields and strengthen the engineering ecosystem in West Africa more broadly.
3. Implement applied research that is both development-driven and private sector-oriented in a targeted discipline and share the results of the research with the researcher community in Ghana and internationally through workshops, participation in conferences and publications.

All the objectives were generally met but more was done on the second and third objective where 31 applied research (student-led) projects were funded over 3 years across various STEM fields, despite COVID-19 restrictions. Various challenges in the key thematic areas were identified by the teams and innovative solutions were proposed and tried out. Participation in conferences and training overseas for the students, which was a key component of the project, was not possible due to COVID-19 travel restrictions.

There were engagements with industry partners to dialogue on how to improve on the engineering curriculum and how to align them to industry needs. Female student leadership was strongly encouraged and paid off. To help improve the capacity of awardees, workshops on various topics were organised. They included such topics as:

- Gender and Development
- Project Management and Evaluation
- Gender Considerations in Proposal Development and Funding
- Health and Safety

- Presenting for Impact and Selling Your Project Ideas
- Working with Industry Partners

Some were face to face at the initial stages of the project while the others at a later stage were online(virtual).

3 Methodology

The method used in achieving the objectives are as listed below:

Objective 1

- Seminars for faculty with industry experts were organized to help achieve the objective of enhance the engineering curriculum. In addition to that a policy brief has also been presented to the College Board of the College of Engineering KNUST to help consolidate the practice.

Objectives 2 and 3

- The criteria for the selection of projects were discussed by the Consortium and the various categories of the awards as well as the thematic areas were defined before an advert for the call for proposals (Annex 1a) was sent out
- To ensure gender balance and female participation in the projects, all teams were required to have at least one female team member. Female team leads were also encouraged. This was a requirement in all calls. This requirement was informed by the gender assessment of the College of Engineering which found low enrolment numbers for females and so recommended that as a requirement to encourage female participation. In addition, the awards committee was also gender balanced and had a woman as the chair to encourage female participation in engineering.
- A project award's committee comprising members from both industry and academia were constituted to evaluate all proposals submitted and shortlist potential proposals for pitching. To ensure the involvement of the ultimate beneficiaries or their representatives in the implementation, review of results, and utilization, the awards committee had representatives from industry practitioners (Safe Water Network), Feminist Data and Research (FDR), policy makers (Ministry of Water and Sanitation) and related industry partners (GRIDCO).
- Shortlisted projects were invited to pitch their ideas and were scored by the awards committee members as per an agreed criteria approved by the consortium
- Successful applicants were given a period of 9 months to execute their projects except for the third cohort who had a shorter duration.
- To ensure the project teams were working according to schedule and also for the project management team to be abreast with their progress, periodic presentation were organised for all cohorts as well as the submission of reports at various stages.

4 Project Activities

4.1 Activities

The main activities carried out during the period of the project were:

- i. Hosting of Inception workshop for all IDRC funded projects under the Strengthening Engineering Research and Training in Africa, stream 2: Rethinking the Engineering 'Ecosystem'. KNUST was privileged to host the inception
- ii. Our consortium through FDR carried out gender and intersectionality assessment of all IDRC funded projects in this IDRC stream i.e., Applied Engineering Research from the start. This led to the development of the strategy for addressing gender equality concerns starting from the baselining to the mid-term and final stages of the project.
- iii. Calls for proposals (Annex 1) and provision of funds for thirty-one (31) successful proposal after review by the awards committee.
- iv. All three calls for proposals issued by KNUST consortium members were sent out to interested teams of students to submit proposals on an innovative idea that was seeking to solve a developmental challenge. Interested teams were asked to apply for any of the three categories: (Gold (grant not exceeding GHC25,000), Silver (grant not exceeding GHC18,000) and Bronze (grant not exceeding GHC12,000)) that were defined.

After a thorough evaluation by the awards committee, 31 projects were granted awards ranging from GHC 6,553 to GHC 25,000. Total awards given were 9, 13 and 9 in the 1st, 2nd and 3rd Calls for proposals respectively making a total of 31 projects.

The titles of the pilot projects funded by the SEESA project were:

Proposal awarded for 1st Call (2019)

- Design and Implementation of an Intelligent Energy Management Device for Energy Conservation in Air Conditioners
- Aqua-Tento-Real Time Assay of Water Bodies for Contaminants
- Lack of Centralized Data on Sanitation in Ghana
- OPTI-SAN Sanitation Technology: An Affordable and Efficient Option
- Water Tank Monitoring System Using ZigBee based Wireless Sensor Network (WSN)
- Demand-Side Smart Domestic Electrical Energy Management System
- Smart Level Monitor (SLeM) -Remote Liquid Level Monitoring in Water and Septic Tanks with Remote Pump Control Ability

- Multi-sensor system for remote water quality monitoring
- Design and Implementation of a sensor node and data analytics platform for detecting leakages in water distribution networks

Proposal Awarded for 2nd Call (2020)

- Real-Time Low Voltage Network Visibility,
- AquaNAUT ATMs: An ATM for water service delivery in rural communities
- Removal of Fluoride from Water by Functionalized Zeolite
- Design and implementation of a real-time pipe network monitoring and actuation device with an analytics platform
- Value-Added Smart Water Monitoring System with Demand Control
- Smart Water Quality Sensing and Water Level Detector
- Smart Socket Implementation for Energy Conservation
- Production of Liquid Fuels from Plastic Waste
- Design of a Low cost Piezo-Optic Disdrometer
- Automated Hand Washing Station
- Development of Thermogalvanic cell as alternate source of energy in building construction
- Waste Tyre Activated Carbon Incorporated with Iron Oxide As Hybrid Supercapacitor Electrode
- Development of a Prototype ½ - tonne capacity Hybrid Solar - Biomass Tunnel Dryer

Proposals Award for 3rd Call (2021)

- Beneficiation and Nanosynthesis of Iron oxides from Ferrous Slags for Heavy Metal Removal from Galamsey Polluted Water
- Radio Frequency Harvesting for Low Power Applications,
- Indigenous production of high quality biodegradable sanitary pads from paper and Agro waste (plantain pseudo stem)
- Design and Development of MechCocopeat
- Treatment of Rainwater for Drinking Services Using Silver Doped Hydroxyapatite (Ag@HAp)
- Chemical precipitation and biosorbent material to remove heavy metals from polluted water

- Production of smart filter paper from paper waste and agro-waste (groundnut shells)
- Institutional Solar PV Electric Cookers with PCM
- Partial Replacement of River Sand in Concrete using Waste Materials for Sustainable Building Construction

- v. Organization of the faculty seminar as part of the Industry-Academia engagements (Annex 2)

A Seminar in which key sector players were invited to discuss the importance and benefits of industry academia collaboration were organised. These seminars were used to reinforce the importance of such collaboration to academic staff members so they can be considered during the review of programmes which takes place every four years.

- vi. Organization of Capacity Building workshops for team members of successful proposals (Annex 3).

To help address the short comings observed in the students that responded to the call for proposals, a number of workshops were organised on various topics which were expected to help the students build their capacities in those areas. Some of the topics treated during these capacity building workshops were: Project Monitoring and Evaluation, Gender Considerations in Proposal Development and Funding, Health and Safety, Working with Industry Partners, Project Budgeting and Implementation, Presenting for Impact, Selling Your Project Ideas, Taking Your Project to the Next Level amongst others.

4.2 Project Implementation and Management

The project was implemented with three core staff playing various roles in the management of the project supported by other members of the consortium. This included the Project Lead as the main person responsible for the overall administration of the project supported by the Project Engineer and the Project Accountant. The members of the consortium also played various roles including review of calls for proposals, shortlisting of applications, serving as panel members for pitching amongst others, and advising on feminist methodology and gender consideration using Gender Bases Analysis Plus (GBA+) methodology of the

government of Canada¹ as well as other tools developed for the gender analysis and gender audit.²

¹ <https://women-gender-equality.canada.ca/en/gender-based-analysis-plus.html>

² Adopted from United Nations Women, International Labor Organization

5 Project Output

In all the following were achieved:

1. Thirty-one innovative student led projects were funded

Below are prototypes developed for some projects:



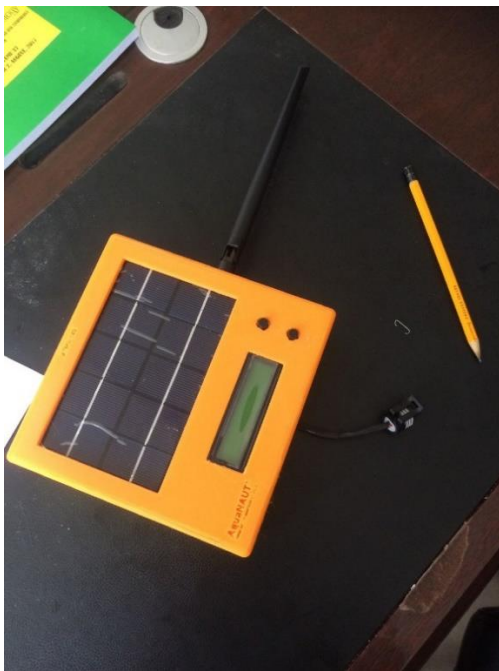
Prototype 1/2 - tonne capacity Hybrid Solar - Biomass Tunnel Dryer



Automated Hand Washing Station



AquaNAUT ATMs: An ATM for water service delivery in rural communities



Sensor Node and Data Analytics Platform for Detecting Leakages in Water Distribution Networks

2. A number of journal articles were published and submitted. Below are the references:
 1. Tabi, R. N., Agyemang, F. O., Mensah-Darkwa, K., Arthur, E. K., Gikunoo, E., & Momade, F. (2021). Zeolite synthesis and its application in water defluorination. *Materials Chemistry and Physics*, 261, 124229
 2. Affum, E. A., Agyekum, K. A. P., Gyampomah, C. A., Ntiamoah-Sarpong, K., & Gadze, J. D. (2021) Smart Home Energy Management System based on the Internet of Things (IoT). *International Journal of Advanced Computer Science and Applications*, Vol. 12, No. 2, 722-730

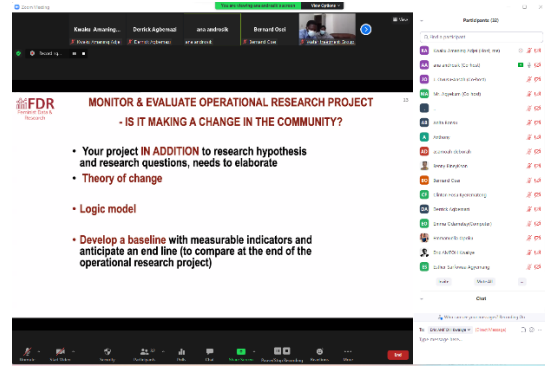
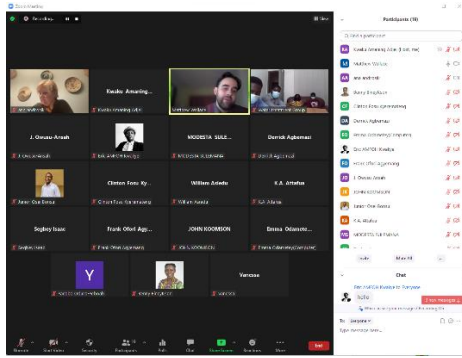
- Partnership with key industrial players has been established.



Consortium Members at a Capacity Building Workshop (Safe Water Network, Feminist Data & Research Inc, Engineers Without Borders, AECOM)

- Capacity building: the capacity of students in respect of proposal writing, pitching and transforming ideas into products has been developed as a result of this project.





5. Industry Engagements key industrial players were brought in to interact with Academic staff.



Industry Academia Engagement Held at the College of Engineering

6 Project Outcomes

- i. Through the project, female engineering students were empowered to take up leadership roles in the field of engineering
- ii. Through this project FDR and EWB made available some funds to award top three female project members. The purpose of the award was to reward well performing female team members and encourage them to aspire to higher heights.
- iii. Capacity building: the capacity of students in respect of proposal writing, pitching and transforming ideas into products has been developed as a result of this project.
- iv. Engagement with industry was improved with the aim of influencing the engineering curriculum
- v. The engagement with industry revealed the need for the involvement of industry experts in curriculum review which is one of the requirements for accreditation. This has been recommended to the College Board to ensure that this is implemented at all departments.
- vi. Innovation was identified as one of the critical skills required by industry in our graduates during the engagement with the industry experts. This observation is being addressed by the strengthening of the CoE Innovation Center and the establishment of the CoE Endowment Fund which amongst other things will support innovative projects from students.

- vii. Lack of understanding of industrial problems by academia was raised as one of the major problems inhibiting industry academia collaborations. This is currently being addressed by industrial visits by staff to selected industries each semester and especially new staff going on industrial attachments during long vacation.
- viii. It has been found that the current curriculum and the training of engineering graduates can be enhanced if students in final year are encouraged to work in multi-disciplinary groups partnered with the private sector with the aim of addressing specific problems in these institutions.
- ix. Industry is willing to collaborate with academia to find solutions to some of the challenges they encounter, however industry is unwilling to contribute funds and resources in finding solutions to these problems.
- x. Engineering students have the capacity to propose and develop innovative and workable solutions to industry challenges which was learnt through the responses to the call for proposals.

7 Overall Assessment and Recommendations

The SEESA project has made significant contribution to the way call for proposals for innovative projects are handled in the College of Engineering. One of our flagship projects the Water ATM is currently being piloted by the national agency responsible for rural water development, Community Water and Sanitation Agency, Ghana. We hopeful a lot more projects will be piloted by other agencies. However, access to funds to upscale some of the projects which were largely prototypes was limited and hence, some awardees have not been able to move the prototypes to the next level. The project itself was worth every effort as it gave a lot of student awardees the opportunity to implement their innovative ideas. It also allowed them to try targeted applied research aimed at solving industry and societal problems. Networking opportunities for the students, staff and industry partners has been greatly enhanced.

Due to COVID-19 pandemic some activities planned as part of the project could not be executed such as overseas student exchange. This component would have exposed the students to innovation that would have influenced their career greatly. It would have been good if those activities were shifted to a future date instead of them being scrapped. Planned visits to the University of Guelph, Canada and Arizona, USA could have happened on line.

A key lesson learnt during the project was that order to improve the success rate and quality of project outputs, an intensive capacity building workshop should be implemented for awardees. In addition, there should also be closer collaboration and engagement with industry partners during the project implementation for each team which in our case was not very effective due to COVID-19.

The focus of the project was to help improve employment opportunities for student awardees of the project. Largely this was achieved through the skills the students acquired by working on the projects resulting in most of them getting employed right after national service resulting in the mentors having to look for a new team to continue the project.

Another key lesson was that the ownership of the ideas was centered on students with the mentors guiding the teams. Following from this project, future projects should consider faculty led projects with the students working as mentees so that the projects can be worked on by multiple teams and continued to the end.

Funding was a challenge for some successful projects to continue and so some seed funding should be budgeted for as part of the innovation development process to fund the consolidation and commercialization of the innovative ideas/projects in the early stages.

An 8-to-12-month period was observed to be short for some projects as the product and innovation required a much longer time to develop and pilot. A 12-to-24-month period will be more ideal to enable awardees to consolidate their gains.

8 Annexes

Annex 1a: Advert for Call for Proposal



2ND CALL FOR PROPOSALS

Strengthening Engineering Research and Training in Africa (SEESA)

The College of Engineering KNUST and the Regional Water and Environmental Sanitation Center Kumasi (RWESCK) with the support of IDRC are now accepting proposals for funding on innovative initiatives that will seek to improve employment opportunities in the formal and informal sectors for graduates of the college of engineering. The purpose of the Innovation Fund is to offer seed funding for initiatives or assist in the implementation of endeavors with clear time frames that align with the thematic areas and specific industrial problems below. Activities that will be funded shall be innovative, entail an upscaling potential, be cost-effective, sustainable and show local ownership. It must fall under these thematic areas or address one of the specific problems:

Thematic Areas

Broad Themes

- Water and environmental sanitation
- ICT for Smart Waste Management
- ICT for Smart Energy Conservation

Specific Problems (in Partnership with Safe Water Network)

Water ATM:

An automated water vending machine to replace the usual tap. Water credit is bought and stored on a consumer's chip. The tap is activated to dispense water when the chip engages the tap. While water flows, its value is deducted from the stores water credit on the chip. The following features are essential:

- Consumers must be able to know their credit easily as they fetch
- Data on the units must be accessed remotely
- Consumer consumption data should be accessible

Data Loggers:

Device to be installed at standpipes (as well as any other point) to enable us know how much water has passed through the standpipe from a remote location and in real time

Funding

Duration of Project

The duration of all project shall not exceed the end of September 2020

Grants will be awarded in three categories:

- Gold Category (Three Awards with an award not exceeding GhC25,000)
- Bronze Category (Five Awards with funding not exceeding GhC18,000 each)
- Silver Category (Six Awards with funding not exceeding GhC12,000 each)

Eligibility Criteria

- Team members must be postgraduate or undergraduate students (Second, Third and Fourth Years)
- The lead applicant must be from the College of Engineering.
- The team (3-5) should include at least one female, however a gender balanced composition is preferred. Teams with female leads are also encouraged.
- The proposal must be co-signed by a lecturer at the College of Engineering who will be the mentor of the team.
- Interdepartmental applications are highly encouraged

Application

Project proposals can be submitted electronically until 29th February 2020 by e-mail via seesaknust@gmail.com | For further information or enquiries contact Ing. K. A. P. Agye-kum (0204001004) or Dr. K. A. Adjei (0249588470)

Structure of Proposals

All applicants MUST use the SEESA Proposal Template which can be downloaded from: rebrand.ly/seesatemplate

Project budget

The budget should cover only project expenses including travels, data collections production of prototypes, laboratory cost etc.

Allowances and purchase of items like laptop, mobile phone, external hard disk, usb drives etc. are not allowed.

Incentive

A maximum allowable amount of GhC1,500.00 may be budgeted for as stipend or accommodation for vacation stay for the whole duration of the project.

Signing

The proposal has to be signed by the main applicant and his/her project mentor from the College of Engineering.

Assessment

The submitted projects will be assessed according to the following criteria:

- The project fits with the theme(s) of the call and CoE educational vision.
- Team composition is gender balanced
- The project has a clear aim and problem description.
- The project is innovative with respect to solving a societal problem (new teaching method, new tool, application of existing tool to new context, etc.).
- The design of the project is suitable and feasible.
- The project outcomes are clear
- The project outcomes can (easily) be applied to other domains, departments or contexts.
- The application has a suitable dissemination and/or sustainability strategy
- There is a link to industry or a sector

Fund Management

The project funds will be assigned under the responsibility of the project mentor who must be a lecturer at the College of Engineering.

Timeline

What	Responsible	Deadline
Submission of proposals	All	29th February 2020
Reviewing proposals	Committee	March 2020
Selection of proposals	Committee	March 2020
Awarding project funds	Provost & RWESCK	March 2020
Kick off meeting for projects	Projects	March 2020

Partners



Annex 1b: Pictures from Pitching





Strengthening Engineering Ecosystems in Sub-Saharan Africa (SEESA)

FACULTY SEMINAR: FECE

*Industry-Academia partnership and its impact on
engineering education and innovation*

1. New trends in industry which should be incorporated in training of our graduates.
2. How can we improve industry-academia partnership?

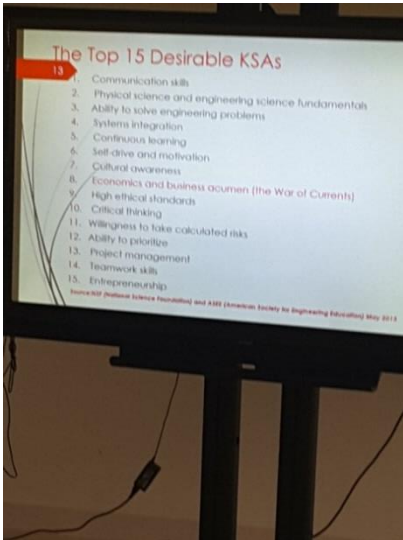
POTENTIAL SPEAKERS: VODAFONE, GRIDCO

DATE: **30.05.19** TIME: **10:30A.M.**

VENUE: **ANTARTIC
CONFERENCE ROOM**



Annex 2b: Faculty Seminar Pictures



Annex 3a: Capacity Building Workshop

