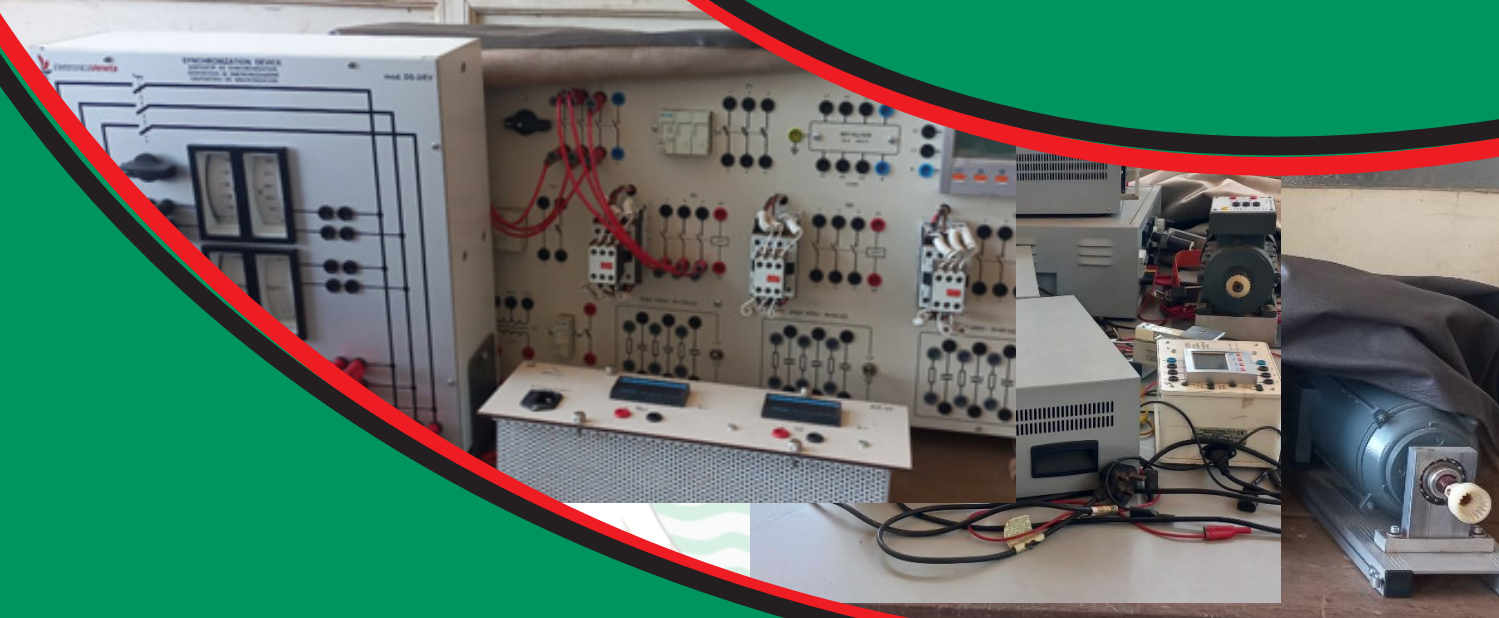
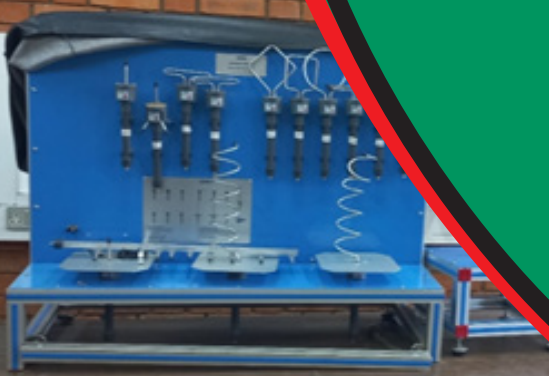




MAKERERE UNIVERSITY

SCHOOL OF OF ENGINEERING (MAK-SoEng)



FIVE YEAR

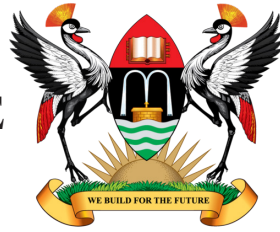
REPORT

DEPARTMENTS

1. Civil and Environmental Engineering
2. Electrical and Computer Engineering
3. Mechanical Engineering

SoEng 2018-2023

MAKERERE



UNIVERSITY

SCHOOL OF OF ENGINEERING (MAK-SoEng)

Vision

To be the Leading School in Engineering Education and Research Innovations in Africa

Mission

To educate and graduate engineers who are well founded in engineering fundamentals, blended with the highest standards of professional and ethical behavior, and are prepared to meet the market technical challenges and the needs of the society.

Goals

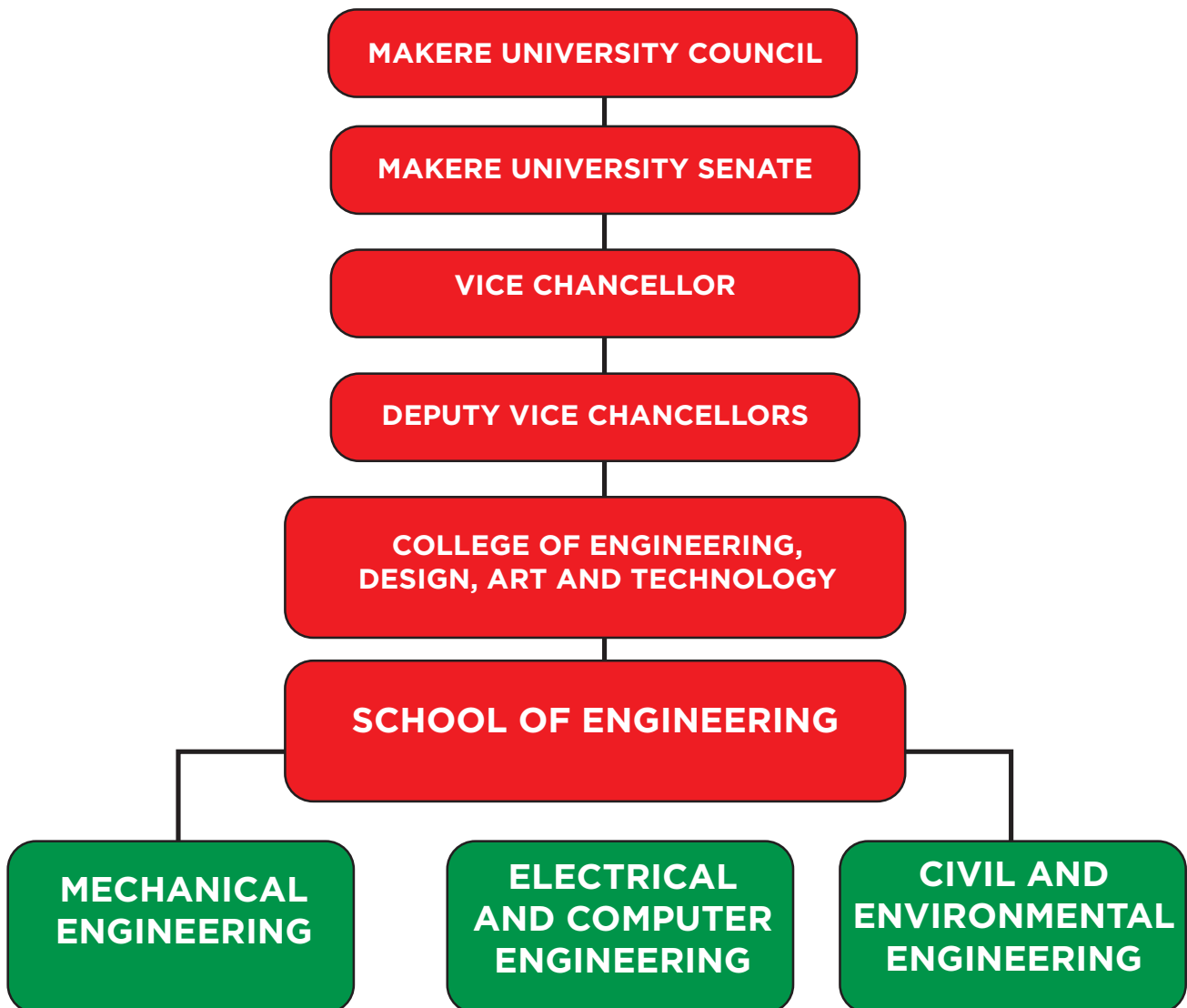
- Supporting excellence, innovation and cross-disciplinary initiatives in teaching and research.
- Encouraging opportunities for students to grow beyond their chosen disciplines by participating in industry-sponsored projects, exchange programs, and research activities.
- Providing an academic environment conducive to staff achieving the highest levels of academic and research excellence.
- Continuing to be the top engineering school in the region.
- Providing national leadership in undergraduate and graduate engineering education.

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SoEng ADMINISTRATIVE ORGANIZATION



SCHOOL OF ENGINEERING LEADERSHIP



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Dean, School of Engineering



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*Head of Dept.
Civil &
Environmental
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Dr. Abubakar Waswa
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LIST OF ACRONYMS

CEDAT	College of Engineering, Design, Art and Technology
ICT	Information and Communication Technology
KPI	Key Performance Indicators
NCHE	National Council for Higher Education
NDP	National Development Plan
SDGs	Sustainable Development Goals
SoEng	School of Engineering
SWOT	Strength/Weaknesses/Opportunities and Threats
UN	United Nations

MESSAGE

From The Dean



It is with pleasure that I share the progress and achievements of the Makerere University School of Engineering (MAK-SoEng) during the academic years, 2018/2019 - 2022/2023. I am glad to highlight that despite the COVID-19 Pandemic interruptions, these years have indeed been fruitful with remarkable successes registered in the various areas of our work as a school.

In terms of teaching and learning, with dedicated and committed staff, we have ensured that students are taught in reasonable time, given course works and practical training. Nevertheless, there remains immense need for improvement in the teaching and learning especially with regards to industrial-oriented training of students.

The school has made big strides in terms of enhancing research in line with fulfilling the University strategy of being a research led institution. For example a number of staff have won research and innovation grants under Makerere University Research and Innovation Fund (Mak-RIF) which have been successfully implemented.

As a school going forward, we would like to be more proactive in participating in the development of Uganda through identification, design and implementation of different projects. We have plans to consolidate efforts of all the staff, through research groups and other entities, design a school research agenda and enhance research teams by bringing into use the diverse brains and individuals' abilities. The goal is to position School of Engineering as a Centre of Excellence and Innovation.

I am once again grateful to each and every one for the efforts invested in serving the institution and nation at large. We build for the future.

.....
Assoc. Prof. Dorothy Okello
Dean, School of Engineering

ABOUT SCHOOL OF ENGINEERING (SoEng)

The School of Engineering is one of the three schools that form the College of Engineering, Design, Art and Technology (CEDAT). It was formed during the formation of Colleges at Makerere University in 2011. The School of Engineering houses the three traditional Engineering Departments in Makerere University, namely; Mechanical Engineering, Electrical and Computer Engineering, and Civil and Environmental Engineering. These departments, were established at Makerere University in 1970. The school has a vision to be the leading school in Engineering Education and Research innovations in Africa. The mission is to educate and graduate engineers who are well founded in engineering fundamentals, blended with the highest standards of professional and ethical behavior, and are prepared to meet the market technical challenges and the needs of the society. The school is committed to:

- 1) Supporting excellence, innovation and cross-disciplinary initiatives in teaching and research.
- 2) Encouraging opportunities for students to grow beyond their chosen disciplines by participating in industry-sponsored projects, exchange programs, and research activities.
- 3) Providing an academic environment conducive to staff achieving the highest levels of academic and research excellence.
- 4) Continuing to be the top engineering school in the region.
- 5) Providing national leadership in undergraduate and graduate engineering education.

The School offers both undergraduate and graduate programs in various engineering disciplines consisting of civil, electrical, and mechanical engineering.

Undergraduate programs

Civil and Environmental Engineering

- Bachelor of Science in Civil Engineering

Electrical and Computer Engineering

- Bachelor of Science in Electrical Engineering

- Bachelor of Science in Computer Engineering (currently under review to be replaced by BSC Computer and Communications Engineering)
- Bachelor of Science in Telecommunication Engineering (currently under review to be replaced by BSC Computer and Communications Engineering)

Mechanical Engineering

- Bachelor of Science in Mechanical Engineering

Graduate programs

Civil and Environmental Engineering

- MSc. Civil Engineering
- PhD. Civil Engineering

Electrical and Computer Engineering

- MSc. Telecommunication Engineering (currently under review as MSc. Computer and Communications Engineering)
- MSc. Power Systems Engineering
- PhD. Electrical Engineering

Mechanical Engineering

- MSc. Mechanical Engineering
- MSc. Technology Innovation and Industrial Development
- MSc. Renewable Energy
- PhD. Mechanical Engineering



ABOUT THE DEPARTMENTS OF SCHOOL OF ENGINEERING

Department of Civil and Environmental Engineering

The Department of Civil and Environmental Engineering, formerly the Department of Civil Engineering, was established in 1970 alongside Electrical and Mechanical Engineering Departments with a specific mandate of educating civil engineers in the country to the highest international professional standards. The Department's Mission Statement is: "To provide quality education in Civil Engineering by supporting academic distinction and excellence in teaching, innovative research and technological services in the region." The major objective of the Department is to exploit the exciting nature of the Civil Engineering profession to address the most basic needs of society. This has been attained through: giving students relevant skills and knowledge; increasing awareness of latest advances in Science and Technology (S&T); and educating students on appropriate technology for national development; and inculcating professional ethics in them.

The Department's focus is on harnessing the creativity of civil engineering in conception, data collection, planning, designing, constructing, evaluating performance and maintaining physical systems that sustain human enterprise. Students are prepared for professional practice in the major areas of Civil Engineering namely: Traffic and Transportation Engineering, Highway Engineering, Water Resources Engineering (Hydraulics, Hydrology, Hydro-informatics and River Engineering), Structural Dynamics and Engineering, Public Health and Environmental Engineering, Geotechnical Engineering as well as Civil Engineering Surveying.

The Department of Civil and Environmental Engineering boasts of highly qualified human resources that train the students to the highest academic standards comparable to those of highly ranked Universities in Africa and the world. Since its inception, the Department has administered a four-year undergraduate curriculum providing a broad foundation in the above areas, leading to the award of a degree of Bachelor of Science in Civil Engineering.

The courses taught are clustered under mathematics, information & communications technology, technical drawing, technical and support courses, vocational training and design project (group and individual). The curriculum emphasizes provision of a firm theoretical and practical basis in specialty fields. It is envisaged that this leads to producing responsible and well-rounded civil engineers.

The Department also offers a two year Masters of Science in Civil Engineering in the following specialization areas: Traffic and Transportation Engineering, Water Resources Engineering (Hydraulics, Hydrology, Hydro informatics and River Engineering), Structural Dynamics and Engineering, Environmental Engineering and Geotechnical Engineering. A four-year PhD programme is also offered in all the aforementioned fields.

Department of Electrical and Computer Engineering

Electrical and computer engineers are at the heart of the smart world's rapid evolution. These engineers create, build, deploy, and maintain systems that we utilize in our daily lives. The Department of Electrical and Computer Engineering (ECE) at Makerere University strives to produce engineering graduates who will be leaders in research, innovation, and industry.

The Department also offers service courses in mathematics and engineering to the medical students pursuing Biomedical Engineering. At the postgraduate level, ECE provides one research-based Doctor of Philosophy (PhD) and three coursework-based Master's degrees. The Master of Science programs available are MSc in Power Systems Engineering, MSc in Telecommunications Engineering, and MSc in Renewable Energy (since transferred to Mechanical Engineering). A new MSc in Computer and Communications Engineering has been established to allow students to specialize in either computer or communications engineering.

ECE has highly qualified faculty members who are eager to advise students and assist them in exploring the various areas of ECE's engineering programs. Students are not only

challenged when they are asked questions, but they are also taught to ask questions of their own and to explore alternative answers. Students are encouraged to participate in the following research areas; Power Systems and Renewable Energy, Embedded Systems, Artificial Intelligence, Communications and Networks, and Biomedical Instrumentation.

Department of Mechanical Engineering

The Department of Mechanical Engineering at the School of Engineering was started in the 1970's. The Department offers one undergraduate program and three graduate programs namely; Master of Science in Mechanical Engineering, Master of Science in Technology Innovation and Industrial Development and Master of Science in Renewable Energy. The Department runs PhD and Post-doctoral programs in the areas of Materials, Nanotechnology, Industrial Engineering, Manufacturing and Production, and Energy Systems Engineering. Some of the graduate programs are offered with research and academic collaboration with international universities. The Department also covers some courses for students pursuing undergraduate degrees in Biomedical Engineering and Agricultural Engineering.

The curriculum run by the Department of Mechanical Engineering provides students with the science, technology and engineering knowledge and skills to solve engineering problems with an understanding of social, economic, and environmental implications.

Currently, the Department has the following laboratories and workshops available to its undergraduate and graduate students: Mechanical Workshop, Metrology Laboratory, Fluids Laboratory, Thermodynamics Laboratory, Materials Laboratory, Metallurgy Laboratory, and Mechanics of Machines Laboratory. The laboratories and workshop are well equipped with state-of-the-art equipment. The Department prides itself in having a State-of the-art Scanning Electron Microscope, which is one of the few in the sub-Saharan Africa on the continent. These laboratories and workshops provide a high potential for the school to address development challenges for Uganda, so they need to be utilized through innovative projects.

ABOUT THE MAKERERE ENGINEERING SOCIETY (MES)

Makerere Engineering Society (MES) was founded in 1971 at a time when most engineering disciplines were introduced at the university and Uganda as a whole. Founded by Mr. Turyamureba in 1971, the club was the pioneer students' organisation at the then Faculty of Technology. It consisted of members from three different engineering disciplines i.e., Civil, Mechanical and Electrical Engineering that were offered at the then Faculty of Technology.

Makerere Engineering Society (MES) operates on key aspects that include creating a medium of communication between the staff and students, a worthy relationship between the students and industry and thus facilitating industrial placement of students, get in touch with practicing engineers in the field to help students broaden their technical skills through seminars and workshops hence providing free mentorship programs. It also created, and continues to encourage and perpetuate a sense and spirit of togetherness amongst engineering students and other students of the College of Engineering, Design Art and Technology as a whole.

Over the years, MES has operated and seen success in carrying out a number of activities that are highly participated in by students at the School of Engineering. For example, the Open Day and Exhibition where students show case their innovations, the MES afternoon, MES webinars, Finalists' dinner, etc. The fruits of this society have since been seen mainly because of the role it plays in shaping great men and women in the country by equipping them with interpersonal, leadership and social skills that are indispensable in the development of a successful career. The society has a rich vein of products over the years and well-placed engineers and professors as well as other professionals.

THE ANNUAL CEDAT OPEN DAY

As big as the name gets, the Open Day is an opportunity for the students at the School of Engineering and CEDAT at large to exhibit their engineering related projects. Makerere Engineering Society has the privilege of organizing this event. The CEDAT Open day is an annual historical event in the technological development that has offered a platform to ground breaking innovations such as Kiira EV, Bomb detector Robot, Kayoola solar bus project and many others which have attracted support from the Ugandan government, donor agencies, and other universities. It has always been held in celebration of the engineers' contribution in the field of innovation and we have over the years been graced by top engineers in the field and government officials. The day that is highlighted by a showcase of interesting and intriguing ideas and innovations brings in a mix of fun and learning to all the participants.

THE MES INCUBATION

The Makerere Engineering Society Incubation Program had its first edition in 2021 with over 70 students from the School of Engineering participating. The incubation program is a four-week training program that aims to accelerate and inspire innovations among the students of engineering. During the training, the students that sign up to attend it are grouped basing on what sector they are passionate about (for example, Education, Health, Energy, etc.). The students undergo different trainings in the innovation journey from problem identification to prototyping and building a Minimal Viable Product.

THE MES ANNUAL DINNER

The MES Annual Dinner is one of the most exciting events organized by the students' society because of the expectations that revolve around it. The engineers are not known to be fashionable and stylish, but events do not get as classy as the dinner. Organized annually, it has always been held in some of the most popular hotels in Uganda with the most recent being held at Sheraton Hotel. The event provides an opportunity to the students to interact with each other and connect with professional engineers. The evening of the dinner is

accompanied by really great music, meals, interactions, photography, fun and games, and a fundraiser for the society.

STUDY TOURS

Makerere Engineering Society has among its goals bridging the gap between the engineering world and students body. Academic trips are among the ways in which this objective is achieved. These tours expose the students to the life they are bound to encounter in their dif respective fields of study. They also get to encounter the practical aspects of the modules they study in the classrooms as well as fostering relationships and connections with their potential employers. Gaps in the industry are also identified from these engagements hence creating room for research and innovation. In the year 2022, Makerere Engineering Society organized tours to the National Control Centre-UETCL Lugogo, Karuma Hydro Power Plant, Ggaba Water Treatment Plant- NWSC, and the Kampala Flyover construction site. Also, in collaboration with other professional bodies such as Uganda Institute of Professional Engineers (UIPE), the students are able to take part in other tours.

CONFERENCES AND WORKSHOPS

Makerere Engineering Society also organizes interactive sessions between the various bodies it is affiliated with and the students body. From these conferences, students are able to acquire knowledge and information about how life is in the engineering field after University. These also provide opportunities to the students to engage with the professionals in the field from within their vicinity since these workshops and conferences take place within the college. In the year 2022, Makerere Engineering Society hosted Uganda Institute of Professional Engineers (UIPE) and Uganda National Oil Company (UNOC).

THE WOMEN EMPOWERMENT WORKSHOP

Across the world, March is marked as a month to celebrate the women contributing to the growth and development of our societies. Engineers are fundamental to the build-up of different development blocks in our communities and for that it is important to continually celebrate and inspire the women who contribute to this profession. As a way to celebrate the

female engineering students at the college, the Makerere Engineering Society organizes women empowerment workshops under different themes. During the event, the society hosts different female guest speakers in the field of engineering. On 26th March, 2022, MES hosted Eng. Ziria Tibalwa the Executive director at the Electrical Regulatory Authority (ERA) as the main speaker.

THE MENTAL HEALTH WORKSHOP

Mental health is an integral aspect of our overall well-being. It encompasses our emotional, psychological, and social well-being, affecting how we think, feel, and behave. However, the demands of academic life and the pressure to excel can put a strain on students' mental health. In fact, studies show that students in engineering programs are particularly vulnerable to stress, anxiety, and depression.

To address this issue, in 2023, Makerere Engineering Society organized a mental health webinar for its engineering students. The webinar aimed to promote well-being and resilience among students by providing them with tools and strategies to manage their mental health effectively. The webinar covered various topics, including stress management, coping strategies, and self-care. The speakers emphasized the importance of taking breaks, seeking social support, and practicing mindfulness. They also provided practical tips for managing academic stress, such as breaking down tasks into smaller, manageable steps, and prioritizing self-care activities.

Overall, the mental health webinar was a valuable resource for engineering students at Makerere University. To ensure that students continue to receive support and education on mental health, it is recommended that such webinars be held regularly. Additionally, mental health resources and services should be readily available and easily accessible to students, promoting a culture of self-care and well-being.

THE CEDAT SPORTS GALA

The gala, composed of several competitive games both on field and indoor games, is one of the annual activities that the society participates in. The society presents students from the School of Engineering, with students participating in different games. Some of the field

games include football, basketball, netball, volleyball and athletics. Indoor games played during the gala include chess, scrabble to mention but a few.

THE JOURNEY OF RESILIENCE DURING COVID-19 PANDEMIC

The School of Engineering was resilient throughout the COVID-19 pandemic. Despite numerous presented challenges, the pandemic also accelerated the integration of technology and innovative teaching methods. This led to a more resilient and adaptable system for teaching and engagements at the school.

The pandemic saw the School of Engineering strengthen online teaching in order to ensure continuity of learning. Online teaching provided greater flexibility for both lecturers and students. Recorded lectures and asynchronous learning options allowed students to study at their own pace, accommodating individual learning styles and personal schedules. Additionally, online teaching increased access to education for individuals who previously faced geographical or physical barriers.

Online teaching encouraged lecturers to incorporate multimedia content, such as videos, interactive quizzes, and simulations, into their lessons. This multimedia approach made learning more engaging and helped cater to diverse learning preferences.

The shift to online teaching prompted lecturers to develop new digital skills and enhanced opportunities for learning soft skills and effectively use them. This provided an opportunity in that the University was able to invest and promote a virtual learning environment which increased uptake of ICT-Based teaching and learning with hybrid teaching methods and which became part of the School instruction methods.

Use of the social media platforms has elevated the interaction with heads of departments within the SoEng for any request and messages needed, and increased participation by the different staff. With introduction of Zoom/IT, etc., one can multi-task using online

engagements and bring about the whole aspect of promoting Technology for Development (TFD).

The approach has greatly improved partnerships globally. It has opened spaces globally without physical meetings. This global reach has facilitated the exchange of knowledge and ideas on a broader scale.

RECENT COLLABORATIONS OF SCHOOL OF ENGINEERING

- 1- Students of Civil Engineering have access to the full suite of Prokon modules latest version, following an agreement between the department of Civil and Environmental Engineering and Prokon South Africa. Civil Engineering students therefore have unlimited access to one of the leading structural analysis and design softwares in the world. The Computers available in the laboratories are not enough for the engineering students.
- 2- Makerere University Signed an MOU in 2022 with China Communications Construction Company (CCCC) in the area of Construction.
- 3- CEDAT signed an MOU in 2022 with Electricity Regulatory Agency (ERA) and the area of collaboration is in Electricity regulation
- 4- The School of Engineering is spearheading a project, Higher Technical Education in Africa for a Technical and Innovative workforce (CFIT III), which is an initiative by UNESCO with support from the People's Republic of China.

KEY PLANED STRATEGIES OF SCHOOL OF ENGINEERING

- ✓ To align the school programs to Vision 2040, NDP III, and Makerere University Strategic Plan
- ✓ Align the school research aspirations to Makerere University Research Agenda
- ✓ Work closely with alumni through Makerere Convocation to harness resources for advancing research and innovations
- ✓ Globally to link with institutions/agencies with similar objectives.

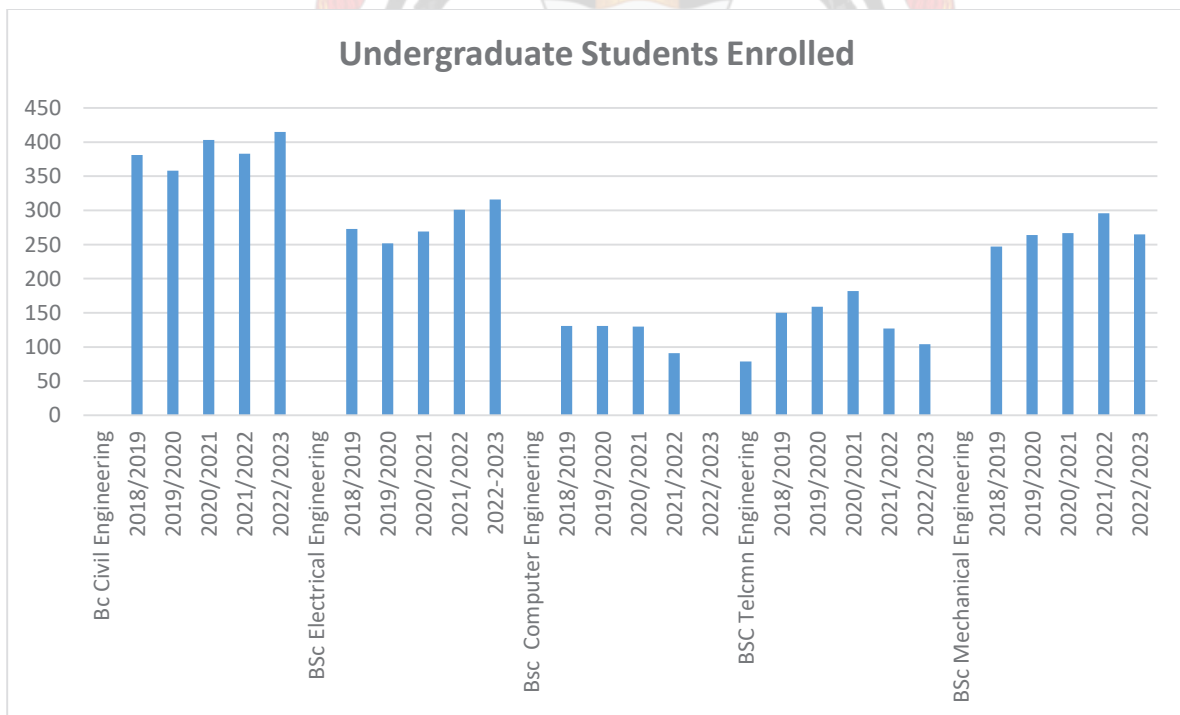


TEACHING AND LEARNING

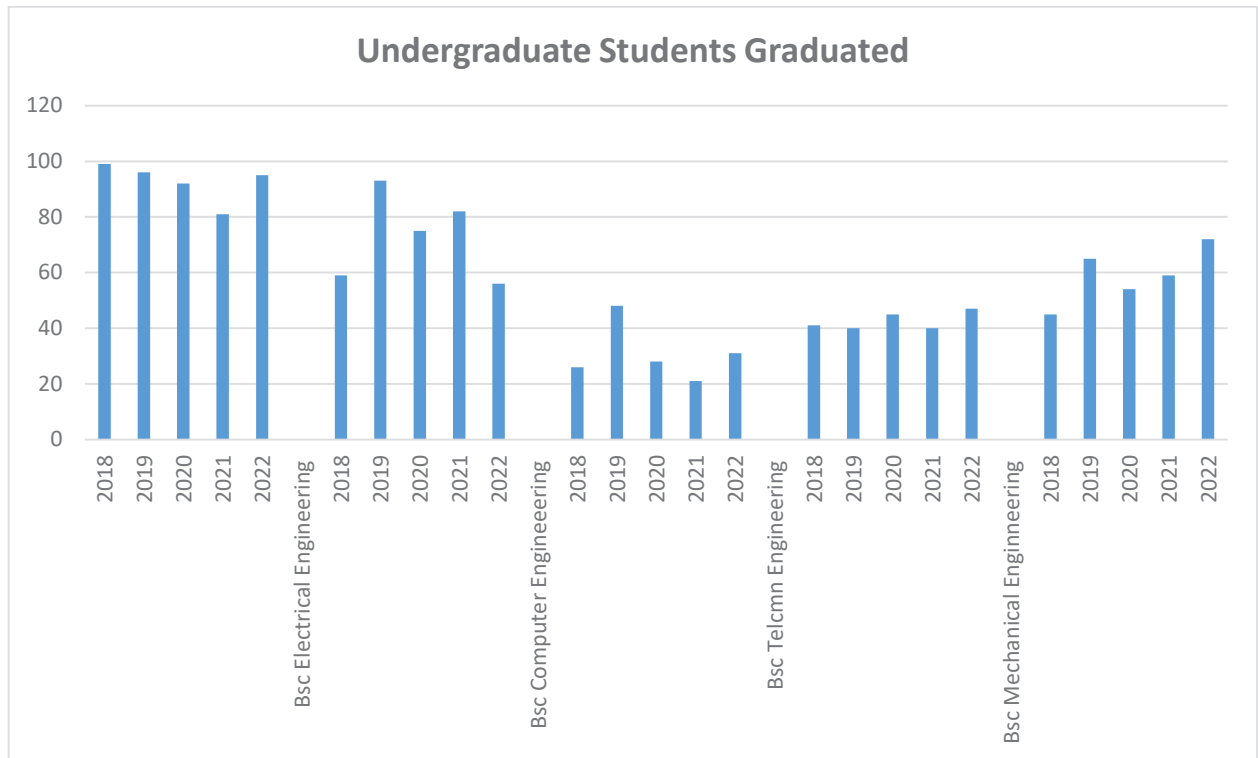
During the academic years 2018/2019- 2022/2023, the dedicated and experienced staff at the School of Engineering ensured that students were taught in time, given course works and were properly guided to learn. Teaching was done according to the allotted load and the Heads of Departments ensured that the students were taught and given work to research about and expound their understanding. Students’ full participation was encouraged. Below are the key highlights.

A. Undergraduate programs

(a) Undergraduate Student enrolment



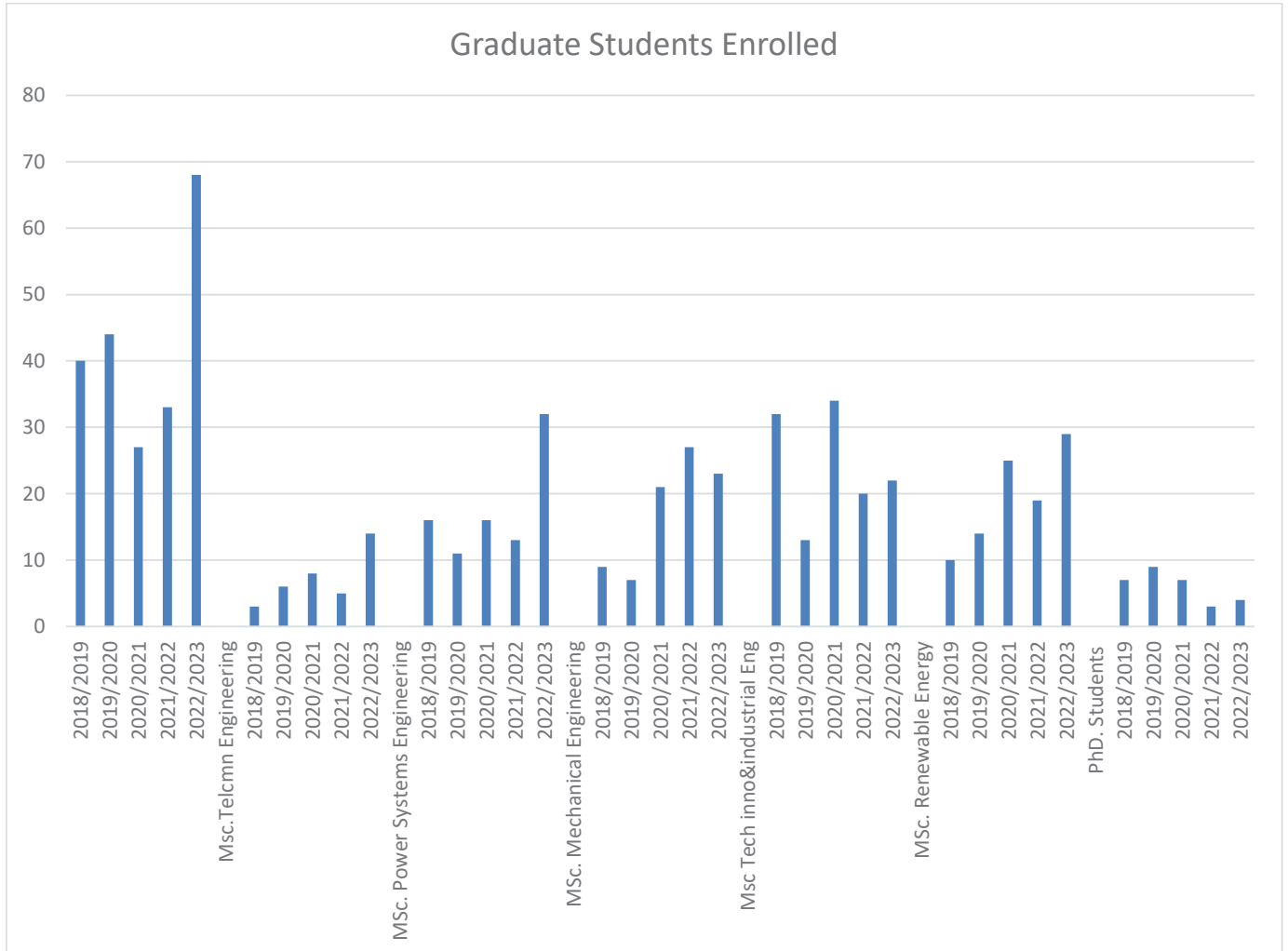
(b) Undergraduate Students graduated



B. Graduate training

(a) Graduate programs

Graduate Student enrolment



2

RESEARCH AND INNOVATIONS

School of Engineering (SoEng) endeavours to address the university agenda of being a research led institution and has made significant strides in this direction. SoEng has plans to enhance research by bringing into use the diverse brains and individuals' abilities from different research groups. The aim is to position School of Engineering as a Centre of Excellence and Innovation.

This initiative will put the school research portfolio to a higher level in terms of quality of research, projects and innovations. It will also make the SoEng research agenda to be more competitive nationally and globally through being more focussed and well-coordinated.

(a) SoE Research Equipment

Key Research Equipment at Civil & Environmental Engineering Department – Structure Laboratory

No.	Major Research Equipment	Capacity	Purpose	Subject specialty of application
1	Universal/ Compression testing machine	2500KN Functional	Testing for Compressive and Flexural/ Bending strength	Materials' strength
2	Compression testing machine	1200KN Functional	Testing for compressive strengths	Materials' strength
3	Stone cutting/ Trimming machine	Functional	Trimming Rock cores, concrete cores, etc	Trimming/ Shaping

No.	Major Research Equipment	Capacity	Purpose	Subject specialty of application
4	Core drilling machine	Functional	For drilling rock cores,etc	Material drilling
5	2kg Mortar mixer	Functional	Mixing cement mortar	Material mixing
6	Concrete mixer-Winget Ltd Rochester Kent England (Engine driven)	Functional Capacity 1M ³	Mixing concrete	Material mixing
7	Concrete mixer Capacity <0.5 cubic meters (Electrical power)	Functional Capacity 0.5M ³	Mixing concrete	Material mixing
8	Slump cone	Functional	Testing for workability	Material testing
9	Flow table testing apparatus	Functional	Workability-Cement mortar	Material testing
10	Vibrating Machine	Functional	compacting	Compaction
11	3no.Vicatronic apparatus (ASTM)	Functional	Consistency and setting times for cement	Cement testing

Research Equipment at Electrical & Computer Department

No.	Major Research Equipment	Capacity	Purpose	Subject specialty of application
1	Advanced double bus bar system	Double souse of three phase	Power Transmission demonstrator	Transmission lines
2	Synchronization Unit	Phase displacement with lights.	Phase balancing	synchronizer
3	Multifunctional Digital instrument	Power parameters measurement with digital display State: Working	Measurement, and storage of data	Measuring instrument

No.	Major Research Equipment	Capacity	Purpose	Subject specialty of application
4	Reactive power compensator	Total power, Active power and reactive power.	Power correction	Power factor correction unit
5	Variable resistive load	From ohms to mega ohms load. Working sate	Load selection	loads
6	Variable capacitive loa	All pico, nano and micro farads	Loads selection	loads
7	Variable inductive loads	Milli henries and henries	Loads selection	Loads
8	Single phase transformers	Low capacity of up to 240v	Windings transformation	Power transfer
9	Automatic motor winding machine	Small capacity of up to three phase one horse power.	Motor winding	Motor winding machine
10	Automatic transformer winding machine	Small capacity transformers - single phase of up to 500VA	Transformer winding	Transformer winding machine
11	Digital Workbench	Basic equipment	Electronic circuits	Formation and measurement
12	Radio transmitter	Basic AM/FM transmitter	Transmitter training module	Teaching transmission principles
13	Radio receiver	Basic AM/FM receivers	Receiver training module	Teaching of receiver principles
14	Control and measurement equipment	Control engineering	Control training kit	Control engineering principles
15	EMF equipment	Microwave training	Microwave trainer	Microwave learning
16	Digital television Trainer	CRT Technology	Television trainer	Repair of Electronic communication equipment

No.	Major Research Equipment	Capacity	Purpose	Subject specialty of application
17	Antenna kit	Antennas	Antenna training	Antenna principles
18	3 node simulation and deep learning cluster (wit gpus)	AI, Scientific Computing	AI workloads, adhoc simulations	AI, all computational courses
19	2 portable ultrasound machines	Biomedical imaging research	Ultrasound screening research	Electrical engineering, biomedical engineering courses

Key Research Equipment at Mechanical Department

No.	Major Research Equipment	Capacity	Purpose	Subject specialty of application
1	Scanning Electron Microscope	Capacity: 500 μ to 5nm Resolution	Material Characterization	Materials science
2	XRD	Under installation	Material structure Characterization	Material science
3	High Temperature Furnaces	Capacity: 0 to 1200 degrees	Material Characterization	Material science and energy
4	Fourier Transform InfraRed machine	Functional	Material Characterization	Material science
5	Spark Arc Spectromter	Capacity: Can detect up to 0.0001% concentration	Material Characterization	Material science
6	Universal Testing Machine	Capacity: 0- 300KN	Material Characterization under load in tension and compression	Material science
7	Rockwell and Superficial Tester .	Capacity: Multi-function -Brinell and Rockwell l scales 0 – 60HRC	Material Characterization	Material science
10	Torsion Testing machine	Capacity: 0-50NM	Material Characterization under cyclic loading	Material science

No.	Major Research Equipment	Capacity	Purpose	Subject specialty of application
12	Bomb calorimeter	Capacity: Detection range 0 – 100 MJ	Energy quantification	Material science and energy
13	Computerized Thermographic analyzer (TGA)	Capacity: Detection Up to 0.001%	Material degradation under heat	Material science and energy
14	Computer controlled CHS analyzer	Capacity: Detection Up to 0.001%	Material Characterization	Material science and energy
15	Sample homogenizer	Capacity: Grind up to 100 microns	Material preparation	Material science and energy
18	Tubular Furnace	Functional	Material carbonization and activation	Material science and energy
19	Carbon activator	Capacity: Produce up to 20g per run	Material activation	Material science and energy
25	CNC lathe machine	Capacity : Max diameter is 200mm	Product production	Production
26	CNC MACHINE CENTER	Capacity : Max diameter is 200mm	Product production	Production
27	Lathe machines	Functional	Product production	Production
28	Tool grinding machine	Functional	Product production	Production
29	Pelton Turbine	Functional		Energy

(b) Research Projects and Grants of SoEng Involvement

Sample of research Projects in the department of Civil & Environmental Engineering

No.	Staff	Project Title	Partners/ Funders
1	Assoc. Prof. Charles B. Niwagaba	Water, Behaviour Change and Environmental Sanitation (WABES): Sustainable Solutions to Research, Knowledge and Professionalization – Integrated Water, Sanitation and Solid Waste Services (INTEGRATE).	Swiss Development and Cooperation, through Eawag; Switzerland

No.	Staff	Project Title	Partners/ Funders
		RECLAIM of nutrients - digitalisation of a collaboration game for resource recovery in sanitation.	FORMAS (Swedish Research Council), Sweden
2	Prof. Umaru Bagampadde	Collaboration for Active Mobility in Africa (CAMA) under the program Partnerships for sustainable solutions in sub-Sahara Africa from 2021 to 2024	Karlsruhe University of Applied Sciences, Germany/ DAAD (German Academic Exchange Service) and BMBF (Federal Ministry of Education and Research)
3	Dr. Robinah Kulabako	Sustaining urban low-cost water supplies and sanitation systems in Africa (AfriWatSan Project)	University College of London (UK), Université Cheikh Anta Diop (Senegal), University of Nairobi (Kenya), Makerere University (Uganda)/ UK Royal Society - DFID
		Beyond the networked city: Building innovative delivery systems for water, sanitation and energy in urban Africa (Off Grid Project)	University of Bristol (UK), Loughborough University (UK), University of Capetown (South Africa), Sierra Leone Urban Resource Centre (Sierra Leone) & Makerere University (Uganda)/The Global Challenges Research Fund (GCRF)
		Collaborative Research between KCCA and Makerere University, College of Engineering, Design, Art and Technology (CEDAT) to establish and share scalable Models and Technologies for enhancing Citywide Inclusive Sanitation (CWIS) Services (KCCA-MAK- CWIS Project)	Kampala Capital City Authority

No.	Staff	Project Title	Partners/ Funders
		Development of Zeolite-Based Nanocomposite Filters for Drinking Water Treatment in Uganda	Makerere Research and Innovations Fund (Mak-RIF) - Call 3
		Development of Iron Oxide Nanoparticles from steel waste for Applications in Drinking Water Treatment	Science, Technology and Innovation – Office of the President (STI-OP)
4	Dr. Swaib Semiyaga	Transfer of the Delft-based programs and courses in Sanitation as part of the project “Transfer of the New MSc Program in Sanitation to South Asia and Sub-Saharan Africa – Global Sanitation Graduate School (GSGS)	Bill & Melinda Gates Foundation.

Sample research Projects the Department of Electrical and Computer Engineering

No.	Staff	Project Title	Partners/ Funders
1	Assoc. Prof. Dorothy Okello	Open Source Design of a Decontamination Device for Personal Protective Equipment	NRF, South Africa
		Development of an Efficacious Patient Management System for Uganda using Machine Learning Techniques.	Mak RIF
		Integrating Resilience and Sustainability in the planning for infrastructure projects in Uganda (RESULTS)	Royal Academy of Engineering
2	Dr. Jonathan Serugunda	Machine Learning-guided Screening of COVID-19 using Point-of-Care Ultrasound in Uganda	Mak RIF
4	Andrew Katumba	ICT Platform for the Pathogen Economy	STI secretariat
		Machine learning- aided screening of tuberculosis from chest X-rays	MAK RIF

No.	Staff	Project Title	Partners/ Funders
		End-to-End Artificial Intelligence (AI) and data systems for targeted surveillance and management of COVID-19 and future pandemics COAST Project	IDRC
		A computer-aided diagnosis system for cervical cancer from colposcopic images	Mak RIF
		Building NLP Text and Speech Datasets for Low Resourced Languages in East Africa	Bill and Melinda Gates Foundation, Google.org and Rockefeller Foundation
5	Cosmas Mwikirize	Deep learning-based detection of COVID-19 from lung ultrasound images	IDRC (COAST Project), MAK RIF-2
		Automated recognition of suspicious lesions in breast ultrasound images	Carnegie Corporation (SECA), UNESCO TWAS
		A smart portable ultrasound for guidance of minimally invasive procedures	MAK RIF
		Automated Screening of Prostate Cancer from Multi parametric MRI Sequences	MAK RIF
6.	Edwin Mugume	Urban Heat Island: Spatiotemporal Patterns and Implications for Human Thermal Comfort in Kampala	MAK RIF
7	Jane Namaganda Josephine Kakande	Integration of on-grid and off-grid decentralized renewable energy systems in Uganda	MAK RIF
8	Ronald Kizito	A Luganda Neural Text-to-Speech system for Health promotion and Accessibility.	MAK RIF

Sample research Projects in the Department of Mechanical Engineering

No.	Staff	Project Title	Partners/ Funders
1	Prof. John Baptist Kirabira	Development and production of medical and biomedical plastic supplies in Uganda	STI-OP
		Evaluation of nanoscale materials as candidate adjuvants and delivery systems for SARS CoV-2 sub unit vaccine in humanized mice	PRESIDE/STI-OP
		MAPRONANO ACE – various	World Bank/GoU

No.	Staff	Project Title	Partners/ Funders
		Extraction Of Saponins from Locally Available Plants for Vaccine and Drug Delivery	GoU
		Valorization of Cassava Peels for Abatement of Active Pharmaceutical Contaminants from Water Systems in Uganda	MakRIF
		Design Review and Development of a Self-Disinfecting Glove	MakRIF
		Scaling: Valorization of Cassava Peels for Abatement of Active Pharmaceutical Contaminants From Water Systems in Uganda	MakRIF
		Inclusive Markets for Energy Efficiency in Uganda (IMEU)	Sida/Swedish Embassy
2	Dr. Michael Lubwama	Enhanced Flame Retarding of Bio composite Plastic Developed with Rice husks and Clay fillers	Volkswagen foundation
		Bio photier Development from agricultural remainder in Uganda	Swedish Research council
		MAPRONANO-ACE	World Bank
4	Assoc. Prof.Peter. W. Olupot	Metallization of Ugandan Iron Ores	Science, Technology and Innovation, Office of the President of Uganda
		Iron oxide-based Nanocomposite bio-adsorbents for water treatment	EPFL- Switzerland/EXAF
		Renewable Energies for Africa: Effective Valorisation of Agri-food Wastes- REFFECT AFRICA	University of Jaen Spain and 28 other partners/European Commission Horizon 2020
		Optimisation of Recirculating Water Treatment Process for a Smart Communal Hand Washing System	University of Kassel, Germany/Volkswagen Foundation
		Technology for application of activated carbons from rice husks in water treatment	RIF/ Makerere University
5	Dr. Betty Nabuuma	TUM-SEED PROJECT with Technical University of Munich, Germany.	DAAD
6.	Dr. Hillary. Kasedde	Inclusive Markets for Energy Efficiency in Uganda	Swedish Embassy
		LEAP-RE	EU
7	Dr. Norbert. Mukasa	Green Synthesis of Graffin using Agro-waste	Makerere University RIF Fund

(c) Selected publications by School of Engineering

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2. Arineitwe, F., Serugunda, J., & Okello, D. (2022, January). Development of the Protocol for Inter-Autonomous Systems Routing in Software Defined Networks. In 2022 IEEE 11th Annual Computing and Communication Workshop and Conference (CCWC) (pp. 0414-0422). IEEE.
3. B. Andrew, K. A. Buyondo, H. Kasedde, J.B. Kirabira, P. W. Olupot, A. A. Yusuf. Investigation on the use of reclaimed asphalt pavement along with steel fibers in concrete Case Studies in *Construction Materials* 17 (2022) e01356. <https://doi.org/10.1016/j.cscm.2022.e01356>.
4. Yiga, V. A., Pagel, S., Lubwama, M., Epple, S., Olupot, P. W., & Bonten, C. (2020). Development of fiber-reinforced polypropylene with NaOH.
5. Fenekansi Kiwumulo, H., Muwonge, H., Ibingira, C., Kirabira, J. B., & Tamale Ssekitoleko, R. (2022). A systematic review of modeling and simulation approaches in designing targeted treatment technologies for Leukemia Cancer in low and middle income countries.
6. Jjagwe, J., Olupot, P. W., Menya, E., & Kalibbala, H. M. (2022). *Journal of Bioresources and Bioproducts*.
7. Kayiwa, R., Kasedde, H., Lubwama, M., & Kirabira, J. B. (2022). Mesoporous activated carbon yielded from pre-leached cassava peels
8. Kayiwa, R., Kasedde, H., Lubwama, M., & Kirabira, J. B. (2022). Mesoporous activated carbon yielded from pre-leached cassava peels.
9. Lubwama, M., Yiga, V. A., Ssempijja, I., & Lubwama, H. N. (2022). Thermal and mechanical characteristics of local firewood species and resulting charcoal produced by slow pyrolysis. *Biomass Conversion and Biorefinery*, 1-16.

10. Lubwama, M., Yiga, V. A., Wanambwa, S., Bbosa, D., & Lubwama, H. N. (2022). Pyrolysis kinetics and combustion characteristics of local firewood species and charcoal produced by slow pyrolysis. *Biomass Conversion and Biorefinery*, 1-10.
11. Lukanga, R., Ayebare, G. K., Najjuuko, C., Mugume, E., & Okello, D. (2022, May). Leveraging TV White Spaces for Rural Broadband Connectivity. In *2022 IST-Africa Conference (IST-Africa)* (pp. 1-8). IEEE.
12. Lwanyaga, J. D., Kasedde, H., Kirabira, J. B., Shemi, A., & Ndlovu, S. (2022). Process Design and Economic Evaluation for the Recovery of Halite and Co-products from Lake Katwe Brine. *Process Integration and Optimization for Sustainability*, 1-16
13. McConville, J.R., Kvarnström, E., Ahlström, M., Niwagaba, B. C., 2022. Possibilities for changing to resource recovery in Kampala's on-site sanitation regime. *Resources, Conservation and Recycling*, 181, Article 106275; Pp 1-12.
14. Mugala, S., Okello, D., & Serugunda, J. (2022, May). Coverage and Rate Analysis of a UAV Enabled Heterogeneous Network. In *2022 IST-Africa Conference (IST-Africa)* (pp. 1-10). IEEE.
15. Nayebare, J. G., Owor, M. M., Kulabako, R., & Taylor, R. G. (2022). Faecal contamination pathways of shallow groundwater in low-income urban areas: implications for water resource planning and management. *Water Practice and Technology*.
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18. Odongtoo, G., Ssebuggwawo, D., & Lating, P. O. (2022). Water Resource Management Frameworks in Water-Related Adaptation to Climate Change. In *African Handbook of Climate Change Adaptation* (pp. 993-1006). Springer, Cham.

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20. Ogwang, I., Kasedde, H., Nabuuma, B., Kirabira, J. B., & Lwanyaga, J. D. (2022). Characterization of Biogas Digestate for Solid Biofuel Production in Uganda. *Scientific African*, 12, e00735
21. Olupot, P. W., Menya, E., Jjagwe, J., Wakatuntu, J., Kavuma, T., Wabwire, A., ... & Kalibbala, H. M. (2022). Development and appraisal of hand wash waste water treatment system for water recycling as a resilient response to COVID-19. *Journal of Environmental Chemical Engineering*, 9(5), 106113.
22. P. W. Olupot, E. Menya, F. Lubwama, L. Ssekaluva, B. Nabuuma, J. Wakatuntu. Effects of sawdust and adhesive type on the properties of rice husk particleboards. *Results in Engineering* 16 (2022) 100775. <https://doi.org/10.1016/j.rineng.2022.100775>.
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24. Semiyaga, S., Nakagiri, A., Niwagaba, C.B., Manga, M., 2022. Application of Anaerobic Digestion in Decentralized Faecal Sludge Treatment Plants. In: Meghvansi, M.K., Goel, A.K. (eds) *Anaerobic Biodigesters for Human Waste Treatment*, pp 263–281. *Environmental and Microbial Biotechnology*. Springer, Singapore. https://doi.org/10.1007/978-981-19-4921-0_14. ISBN 978-981-19-4920-3.
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28. Ssekatawa, K., Byarugaba, D. K., Wampande, E. M., Moja, T. N., Nxumalo, E., Maaza, M., ... & Kirabira, J. B. (2022). Isolation and characterization of chitosan from Ugandan edible mushrooms, Nile perch scales and banana weevils for biomedical applications. *Scientific Reports*, 11(1), 1-14.
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35. Wesonga, R., Kasedde, H., Kibwami, N., & Manga, M. (2022). A Comparative Analysis of Thermal Performance, Annual Energy Use, and Life Cycle Costs of Low-cost Houses Made with Mud Bricks and Earthbag Wall Systems in Sub-Saharan Africa. *Energy and Built Environment*.
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43. Yiga, V. A., Lubwama, M., Pagel, S., Olupot, P. W., Benz, J., & Bonten, C. (2022). Optimization of tensile strength of PLA/clay/rice husk composites using Box-Behnken design. *Biomass Conversion and Biorefinery*, 1-27.



STRATEGIC RESEARCH LABORATORIES AND SERVICE CENTRES

Key Laboratory space at Civil & Environmental Engineering Department

No.	Name of laboratory	Type of laboratory	
		Undergraduate	Graduate
1	Public Health and Environmental Engineering Lab (Old CEDAT Building)	✓	✓
2	Public Health and Environmental Engineering Lab (New CEDAT Building)	X	✓
3	Structures/materials Laboratory	✓	✓
4	Geotechnical Engineering Laboratory	✓	✓
5	Engineering Surveying	✓	✓
6	Highway laboratory	✓	✓
7	Hydraulics Laboratory	✓	X
8	Water Resources Modelling Laboratory	✓	✓



No.	Name of laboratory	Type of Laboratory	
		Undergraduate	Graduate
1	Electronics laboratory	✓	✓
2	Telecommunication s laboratory	✓	✓
3	Power (machines) Laboratory	✓	✓
4	Control measurements and instrumentation laboratory	✓	✓
5	Renewable energy lab (CREEC)	✓	✓
6	Net labs	✓	✓
7	Marconi Lab	✓	✓
8	iLabs	✓	✓
9	ARMS	✓	✓

Key Laboratory space at Mechanical Engineering Department

No.	Name of laboratory	Type of laboratory	
		Undergraduate	Graduate
1	Engineering Materials Lab (Old CEDAT Building)	✓	✓
2	Engineering Materials/Energy Lab (CEDAT Building)	✓	✓
3	CNC Machine Laboratory (CEDAT Building)	✓	✓
4	Fluids Mechanics Laboratory (CEDAT Building)	✓	✓
5	Training Workshop (CEDAT Building)	✓	✓
6	Thermodynamics / Energy Laboratory (CEDAT Building)	✓	✓



ADMINISTRATIVE, HUMAN CAPACITY IMPROVEMENT AND SUPPORT

Academic positions per Department

Department of Mechanical Engineering

Faculty in the Department of Mechanical Engineering as of August 2022

Rank/Position	Name	Gender	Highest Qualification	Speciality and Research Interests
Professor	Kirabira, John Baptist	Male	PhD	Nanomaterials and product development
A/Professor	Okure, Mackay A.E	Male	PhD	Dynamic systems and Energy
Senior Lecturer	Olupot, Peter W.	Male	PhD	Materials Science and Engineering Applications
	Lubwama, Michael	Male	PhD	Materials Science and Energy
Lecturer	Kaconco, James	Male	M.Sc.	Operations Research and Production Planning
	Nabuuma, Betty	Female	PhD	Computer Aided Engineering, Energy
	Mukasa, Nobert	Male	PhD	Production Planning and Automatic Control
	Kasedde, Hillary	Male	PhD	Computer Programming, Materials, Energy
Assistant Lecturer	Arineitwe, Ndemere J.	Male	M.Sc.	
	Tumusiime, Edmund	Male	M.Sc.	
	Ayor Andrew Ssemakula	Male	M.Sc.	
	Sembatya, Martin	Male	M.Sc.	
	Mujuni, Francis	Male	M.Sc.	
	Kiseka, Gerald	Male	M.Sc.	
	Mpagi, Edmond	Male	M.Sc.	

Technicians in the Department of Mechanical Engineering as of August 2022

Position	Name	Gender	Highest Qualification	Speciality and Research Interests
Chief technician	Wabwire Andrew	Male	Masters	Materials/energy
Principal technician	Okello innocent	Male	Degree	Materials
Senior technician	Mubangizi Moses	Male	Degree	Automobile
Technician	Akaali Soweed	Male	Degree	Electrical Engineering
	Basalirwa Charles	Male	Diploma	Agriculture Mechanization
	Mafuma Wilson	Male	Diploma	Mechanical Engineering
Technician II	Kasakye A. Phillip	Male	Advanced Cert	Fitter
	Richard	Male	Diploma	Production Engineering

Department of Civil and Environmental Engineering (DCEE)

Faculty in the in the Department of Civil & Environmental Engineering as of August, 2022

Rank/Position	Name	Gender	Highest Qualification	Speciality and Research Interests
Professor	-	-	-	-
A/Professor	Charles B. Niwagaba	Male	PhD	Environmental Engineering
	Umaru Bagampadde	Male	PhD	Highway Engineering
Senior Lecturer	Dr. Robinah N. Kulabako	Female	PhD	Environmental
Lecturer	Katukiza Yasoni Alex	Male	PhD	Environmental
	Matovu Moses	Male	PhD	Structures
	Kalibbala Herbert Mpagi	Male	PhD	Environmental
	Nyenje Mayanja Philip	Male	PhD	Water Resources
	Musenze Ronald	Male	PhD	Environmental
	Mugume Seith	Male	PhD	Water Resources
	Sempewo Jotham Ivan	Male	PhD	Water Resources
	Namutebi May	Male	PhD	Highway
	Tumwesigye Emmanuel	Male	PhD	Water Resources
	Kigobe Max	Male	PhD	Water Resources
	Kasangaki Gilbert	Male	PhD	Geotechnical
	Semiyaga Swaib	Male	PhD	Environmental
	Bakamwesiga Hilary	Male	PhD	Management
Assistant Lecturer	Rucukye Anthony	Male	M.Sc.	Structures
	Meri Carlos Tony	Male	M.Sc.	Structures
	Ngyero Felixson	Male	M.Sc.	Structures
	Jjuuko Samuel	Male	M.Sc.	Geotechnical
	Okodi Allan	Male	M.Sc.	Structures
	Buregyeya Apollo	Male	M.Sc.	Structures
	Tumutungire Martin	Male	M.Sc.	Water Resources
	Kaddu David	Male	M.Sc.	Highway
	Muyonjo Geoffrey	Male	M.Sc.	Management
	Atukunda Michael	Male	M.Sc.	Geotechnical

Technicians in the Department of Civil and Environmental Engineering as of August 2022

Position	Name	Gender	Highest Qualification
Chief technician			
Principal technician	Namusoke Josephine	Female	Masters
Senior technician	Besigye Jimmy	Male	Degree
Technician			
Technician II	Luswa Yunus Kigongo	Male	Advanced Cert
Laboratory attendants / Assistants	Rita Nakazibwe	Female	
	Joseph Kanamwanje	Male	
	Kule Mujungu Wilson	Male	

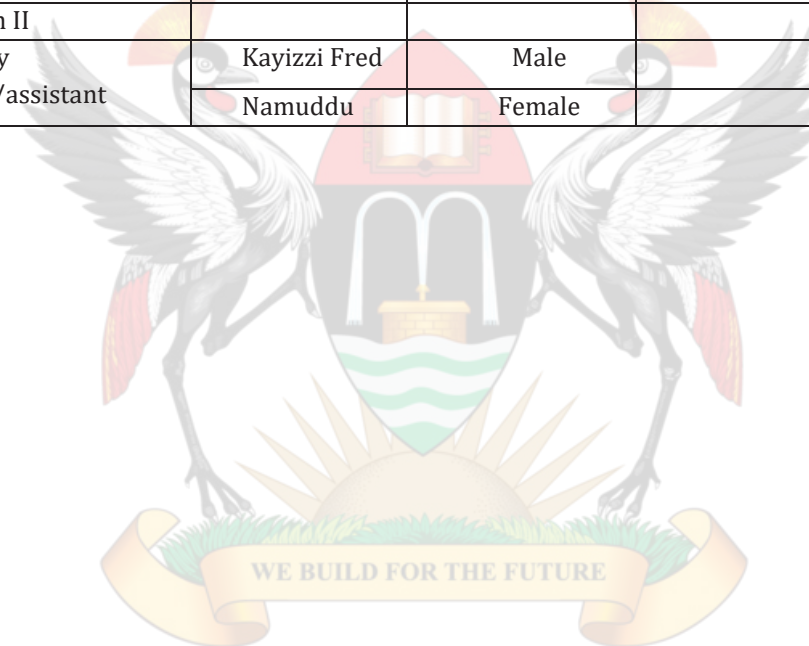
Department of Electrical and Computer Engineering
Academic positions

Faculty in the Department of Electrical and Computer Engineering as of August 2022

Rank/Position	Name	Gender	Highest Qualification
Professor A/Professor	Dorothy Okello	F	PhD
	Peter Okidi Lating	M	PhD
Lecturer	Abubaker Matovu Wasswa	M	PhD
	Emmanuel Miyingo Wokulira	M	PhD
	Ronald Kizito	M	PhD
	Roseline N. Akol	M	PhD
	Jonathan Serugunda	M	PhD
	Edwin Mugume	M	PhD
	Andrew Katumba	M	PhD
	Jane Namaganda Kiyimba	F	PhD
	Milton Edimu	M	PhD
	Geofrey Bakkabulindi	M	PhD
	Cosmas Mwikirize	M	PhD
	Mr. Derrick Sebaale	M	MSc.
	Mr. Kenneth Kahuma	M	MSc.
	Ms. Dativa Tizikara K	F	MSc.
	Ms. Carol Ovon	F	MSc.
	Ms. Sheila Mugala Ndoboli	F	MSc.
	Ms. Josephine Nakato Kakande	F	MSc.
Mr. Paul Bogere	F	MSc.	
Mr. Geoffrey Mark Kagarura	F	MSc.	
Mr. David Martin Amitu	F	MSc.	
Ms. Donna Lillian Namujju	F	MSc.	
Ms. Agatha Turyagyenda Kagina	F	MSc.	
Ms. Margret Nanyonga	F	MSc.	
Mr. Gordon Ariho	M	MSc.	
Peterson Mwesiga	M	MSc.	
Mr. Innocent Oketch	M	MSc.	

Technicians in the Department of Electrical & Computer Engineering as of August 2022

Position	Name	Gender	Highest Qualification
Chief technician			
Principal technician	Phillip Mujaasi	Male	Degree
Senior technician	Ntege Robinson	Male	Higher Diploma
	Gitta Robert	Male	Higher Diploma
Technician	Daniel Muzuula	Male	Higher Diploma
Technician II			
Laboratory attendant/assistant	Kayizzi Fred	Male	
	Namuddu	Female	



6

CONCLUSION AND RECOMENDATIONS

(a) Conclusion

This report shows that significant achievements have been realised on the plans set by the school. The rewards for efforts invested by each and every member in implementing activities of the school are reflected in the key achievements registered among others. Throughout the five years we obtained positive results in all the school program areas evidenced by commitment of teaching and non-teaching staff, enhanced research and innovations. Key achievements include:

- ✓ Enhanced team work and coherence in the school
- ✓ Increased partnerships:
- ✓ Improved community outreach and practical training
- ✓ Enhanced research and innovations
- ✓ Enhanced use of ICT and online teaching and engagements

(b) Recommendations

- 1) **Establish Research and Projects Coordination Unit:** There is need to consolidate and coordinate research and innovation efforts by staff and stakeholders. These efforts should be well coordinated and support to generate high impact projects of advancement of the country development.
- 2) **Graduate students:** There is an acute need to designate sitting space for graduate students (MSc and PhD) in all departments. The Timetabling committee needs to timetable MSc lectures for the 3 departments to optimally use the available space and avoid inconvenience to students and staff. There is a need to audit the space in the school so as to identify areas to be occupied by graduate students for lectures and research.

- 3) **Graduate research**: Departments need to evaluate areas/ specialties, where there is limited or no active research and purposely pursue a guided approach on human resource and related infrastructure capacity development.
- 4) **Enhance Staffing (Academic and Technicians)**: The new staff should be based on the specialties under-represented at the school. This will help to boost research and graduate supervision in these areas.
- 5) **Enhance Equipment**: Departments need to identify additional equipment requirements to boost research and innovation activities.
- 6) **Maintenance**: For sustainability of equipment operation, there should be cost-sharing arrangements through levies of user/bench fees for students from different departments.
- 7) **Obsolete equipment**: Technical staff of the departments need to check and identify the obsolete equipment that are no longer in use.
- 8) **Certification of Laboratories**: The school should carefully review and identify an appropriate certifying agent to ensure that laboratories get certification.
- 9) **Opening up the SoEng to communities**: The school should open up to the outside communities to ensure public view and can use the facilities for various services. A key in point are the labs. CEDAT Open Day must not an enclosed event exclusively for the university community, but instead made a public event for people to appreciate, copy and replicate the ideas learnt and seen during the open day.

10) Student Support

- The need to devise committees mandated to do specific tasks
- Need for focused career guidance for students which is a bit specialized is needed to avoid scenarios where a student's studies a particular engineering course reaches midway realizes that is not what he/she needed.
- Even programs on mental health should feature in the school to enable students prepare their minds as the go out of the university

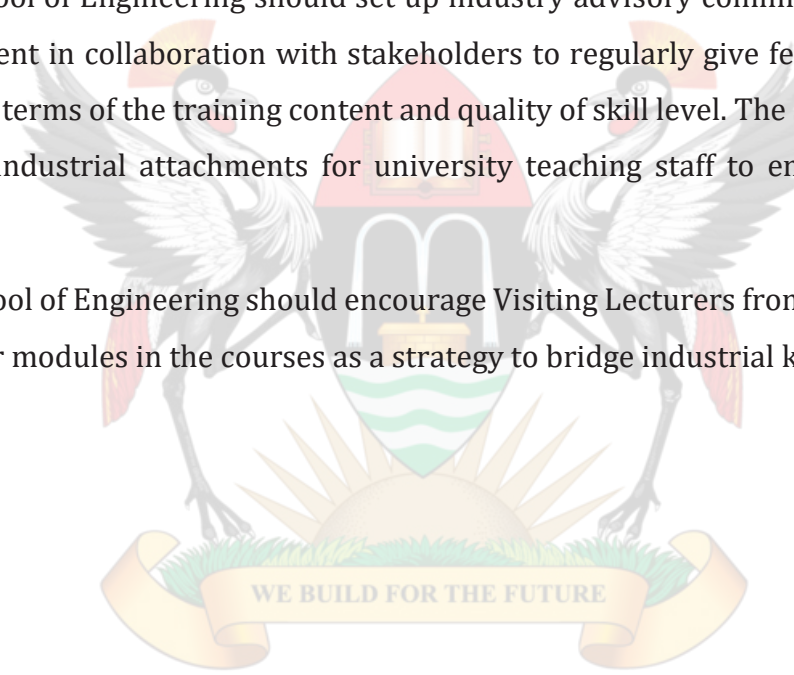
Career mentorship and modelling should be enhanced to allow for proper placement and choices for under graduate and graduate students. Student Support Services The School of

Engineering should assign mentors (Students-through Makerere Engineering Society) and staff members (from the requisite department) or industry (through the alumni networks and the Uganda institution of Professional Engineers) to students on a voluntary basis. Peer Assisted Study Support (PASS) schemes ran by students in upper years, should be set up and supported by the School of engineering.

11) Collaboration with Industry

-The School of Engineering should set up industry advisory committees for each Department in collaboration with stakeholders to regularly give feedback to the school in terms of the training content and quality of skill level. The School should arrange industrial attachments for university teaching staff to empower them further.

-The School of Engineering should encourage Visiting Lecturers from the industry to deliver modules in the courses as a strategy to bridge industrial knowledge.



PICTORIAL

