IDEAS

for better education & training for engineers

Accelerating the full implementation of the 2030 Agenda for the sustainable development at all levels through engineering education

Committee on Education In Engineering
World Federation of Engineering Organisations
October 2023

WORLD FEDERATION OF ENGINEERING ORGANIZATIONS

FÉDÉRATION MONDIALE DES ORGANISATIONS D'INGÉNIEURS

COMMITTEE ON EDUCATION IN ENGINEERING

Journal IDEAS No. 21 October, 2023

IDEAS is a publication of the WFEO Committee on Education in Engineering, addressed to engineering educators, educational officers at Universities and leaders responsible for establishing educational policies for engineering in each country. The articles it contains reflect the concern of people and institutions linked to WFEO, to provide ideas and proposals with the object of improving formation of engineers. All the issues of IDEAS were and will be partially financed by World Federation of Engineering Organizations. This issue of IDEAS was financed by the Myanmar Engineering Council.

WFEO-CEIE & Myanmar Engineering Council held an International Conference on Engineering Education Accreditation (ICEEA 2021, 2022 & 2023). The Conferences deliberations were on the themes "Quality Engineering Education towards Sustainable Development" , "*Quality Engineering Education towards Engineering the Future*" and *"Accelerating the Full Implementation of the 2030 Agenda for the Sustainable Development at all Levels through Engineering Education"* respectively. The conferences were intended to provide a scenario for the interactions among the professionals and experts from world reputed organizations to achieve the quality engineering education and accreditation. It had been launched and designated also for the purpose of deliberating on quality assurance systems, accreditation system, and the best practice in international and local engineering education.

Distinguished speakers of ICEEA 2021, 2022 & 2023 and other of international experts contributed to the IDEAS Journal (issue number 21) that ***WFEO-CEIE & Myanmar Engineering Council*** publishing in October 2023. There are around 7 papers on Engineering Education from honorable international experts in this issue.

This issue of IDEAS is financed by the Myanmar Engineering Council.

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ISBN – 978-99986-0-111-6

Prepared for printing by:

Committee on Education in Engineering Office (CEIE)-Myanmar

Myanmar Engineering Council

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Prof. José Vieira

IDEAS Journal editorial

Prof. José Vieira (October 2023)

"I was honored to be invited again to the International Conference on Engineering Education Accreditation Conference in July 2023. I am grateful again to the Myanmar Engineering Council, the current host of WFEO's Committee on Education in Engineering, and its Chair Dr. Zaw Min Aung, for hosting the ICEEA conference.

For several years, it has been a critical objective of the World Federation of Engineering Organizations (WFEO) to help achieve the harmonization and standards raising that is needed for engineers to deliver on the United Nations 2030 Agenda of Sustainable Development Goals (SDGs).

This harmonization is needed to train new generations of engineers who understand the integrated nature of challenges standing before us, and master the skills to respond to it. As tragically demonstrated through recent disasters in Morocco and in Libya, climate change mitigation and adaptation, energy and water supply, disaster risks reduction, and many others, we need urgently to train more engineers with the right skills and the ethical and professional vision that is needed to be up to the task.

Harmonizing standards and training contents is a difficult task that requires a clear vision. It requires direct contributions from engineering educators, scientists and researchers, but also takes complex negotiation and effective leadership to foster institutional cooperation at various levels. It implies improving education systems governance and improving transparency, delivering mentorship programs, coordinating national, regional and global organizations activities.

This is why WFEO contributes to reinforcing cooperation between regional and national professional engineering institutions, and with global institutions such as UNESCO and the International Engineering Alliance (IEA), and is promoting the Graduate Attributes & Professional Competencies (GAPC) jointly developed with UNESCO and IEA as a common framework from engineering education standards harmonization. Contributing to leave no one behind implies delivering the best engineering standard everywhere."

José M.P. Vieira

WFEO President

Message from President of Myanmar Engineering Council, President of Federation of Engineering Organizations of Asia and the Pacific (FEIAP), Vice President of ASEAN Academy of Engineering and Technology

Prof. Dr. Aung Kyaw Myat

"I extend my warm greetings to all research scientists, authors, engineers and colleagues. This journal is one of the successive activities of the Committee on Education in Engineering (CEIE) of WFEO. The IDEAS journal issue No.20 was already published in mid-October 2022 which reflected the excellent ideas of experts from WFEO.

We encourage the Committee for Education in Engineering to continue its efforts in promoting the integration of the United Nations 2023 Agenda of Sustainable Development Goals (SDGs) into engineering education, educational excellence and innovation and also commend the Committee for its unwavering commitment to advancing engineering education in Myanmar.

This IDEAS journal publication serves as a testament to our collective dedication and determination to enhance the quality and relevance of engineering education in our country.

Furthermore, this journal provides an excellent opportunity to highlight the importance of collaboration and knowledge sharing among educational institutions, industry partners, and other stakeholders. By fostering partnerships, we can bridge the gap between academia and industry, enabling a seamless integration of theoretical knowledge with practical application. This synergy will not only enhance the employability of our graduates but also foster innovation and promote economic growth.

MEngC maintain continuing engineering professional registration and licensing, as well as engineering education accreditation, in accordance with the Myanmar Engineering Council Law, Washington Accord guideline subscribed by IEA and we work with international organizations to promote the mobility of Myanmar professional practitioners in accordance with international rules and regulations.

I express my heartfelt gratitude to the Committee and all contributors for their valuable contributions to this journal. Thank you for your unwavering dedication and commitment to engineering education. I eagerly look forward to the publication of this esteemed journal book and the positive impact it will have on our engineering community."

Prof. Dr. Aung Kyaw Myat

President, Myanmar Engineering Council

President, Federation of Engineering Institutions of Asia and the Pacific

Vice President, ASEAN Academy of Engineering and Technology

Message from Chair of WFEO Committee on Education in Engineering

Prof. Dr. Zaw Min Aung

"I am deeply honored to announce the publication of the prestigious IDEAS Journal, Issue No. 21. This milestone is a testament to the remarkable success of the annual ICEEA conferences, a collaborative endeavor between the Myanmar Engineering Council and the WFEO Standing Committee on Education in Engineering (CEIE). These conferences have become synonymous with success, largely due to the enriching keynote presentations from esteemed academicians and industrial professionals.

During each conference, we have had the privilege of hosting approximately 20 internationally-recognized speakers hailing from renowned organizations worldwide. Their insights, shared in insightful presentations, have illuminated our understanding of the future engineering goals essential for global sustainable development.

We sought the gracious permission of these distinguished speakers to publish their groundbreaking contributions in the upcoming edition of the IDEAS Journal, which will also be accessible on the WFEO Academy Website.

The IDEAS Journals, available for download on the WFEO website, have a noble purpose — to disseminate these profound ideas to a broader audience of engineering professionals globally. By doing so, we aim to elevate the standard of engineering education worldwide. We firmly believe that knowledge shared is knowledge multiplied. Through these publications, we strive to amplify the impact of knowledge dissemination, transcending the constraints of time and place.

I wish to extend my deepest gratitude to all the contributors — the honorable international experts, the participating universities, and the supporting organizations. Your invaluable contributions have paved the way for this new initiative, expanding the horizons of learning and understanding. My heartfelt thanks also go to the dedicated members of the organizing committees of ICEEA from 2021 to 2023. Your unwavering dedication and hard work have been the driving force behind these successful endeavors.

I must acknowledge the pivotal role played by the president and members of the journal editorial board, the executive members of the Myanmar Engineering Council, the members of the Secretariat of CEIE, and the members of the Engineering Education Accreditation Committee. Your unparalleled moral, financial, and technical support have been indispensable, and we eagerly anticipate continuing this incredible journey together.

As we celebrate this achievement, we eagerly look toward the future, aspiring to organize more ICEEA conferences and publish IDEAS Journals for many years to come. Together, we are shaping the future of engineering education and contributing to a brighter, more sustainable world.

Thank you for your unwavering support and attention."

Warm regards,

Prof. Dr. Zaw Min Aung
Chair, Committee on Education in Engineering
Chair, Engineering Education Accreditation Committee

The World Engineering Day Hackathon: An Innovative Approach to Problem-Based Learning

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Abstract**–**This paper presents the rationale and delivery of problem-based learning through an international competition that engages students with advancing the UN Sustainable Development Goals while also demonstrating their skills relative to the International Engineering Alliance Graduate Attributes and Professional Competencies benchmark

Keywords–engineering students, graduate outcomes project based learning

I. INTRODUCTION

The global challenges arising from climate change and its impacts, and the imperative for sustainable infrastructure, especially for energy and water, have resulted in a compelling case for engineering education to transform. These calls have come from industry and government. Engineering education institutions are also increasingly concerned about attracting a wide range of students, balancing gender, and also from different socio-economic backgrounds and rural and urban areas. There is increasing recognition of the need for new models of engineering education that will produce engineers who will meet the challenges of today and tomorrow. At the same time, there is a recognition that the current models for engineering education do not meet the needs of industry and society and there is a need to not only change the content of engineering education programs but also the approach.

The World Federation of Engineering Organisations (WFEO) has addressed these calls with a focus on ensuring that engineering education prepares future engineers to meet the challenges that lie ahead, in particular, to advance the UN Sustainable Development Goals through engineering. These Goals were declared by the United Nations General Assembly in Resolution 70/1.

In September 2015. WFEO has recognised that every one of these Goals can be advanced through engineering [1] and has developed a strategic plan to address the changes that are needed [2].

As the first step in the journey to transform engineering education to meet current and future challenges, WFEO collaborated with the International Engineering Alliance that has governance of the Graduate Attributes and Professional Competencies (GAPC) benchmark that underlies the mutual recognition of engineering qualifications to signatories of the Alliance. WFEO, and its partners in international engineering collaborated in reviewing the benchmark, the most significant change since it was first developed in the late 1980s. [3] [4]

WFEO also successfully led the proposal to declare 4th March, its founding day, as World Engineering Day for Sustainable Development. This Day has been celebrated annually since March 2020 with increasing success. It attracted nearly 60 million on social media at the celebrations in March 2023. The online celebrations attracted a global audience that exceeded 30,000, making it the largest engineering event in the world. [5]

Figure 1: Spanish, Chinese And French Translations of the International Engineering Alliance Graduate Attributes and Professional Competencies (GAPC) engineering education benchmark.

II. PROBLEM AND PROJECT-BASED LEARNING

Problem-Based Learning (PBL) has been part of engineering programs for many years. However, few programs have integrated it extensively throughout the curriculum. Among the programs that have integrated PBL across the curriculum are Aalborg, Linkoping, Roskilde and Maastricht in Europe and Worcester Polytechnic University in the US. Several engineering programs in Australia, including civil engineering at Monash and the University of Southern Queensland among others. [6]

Problem-Based Learning is an educational strategy, a learning process that engages students actively in finding answers and developing solutions themselves. The effectiveness of this strategy has been recognised for centuries, dating back to the time of Socrates and Confucius.

Parallel to the development of PBL and for a long time almost independently, a tradition of project pedagogy in engineering education emerged in response to student demands and industry that wanted improved employer-ready skills for engineers.

PBL at Aalborg can be classified into three broad categories depending upon the extent to which the learning is directed by the supervisor or by the students. In a "task-project" the engineering educator selects the subjects to be engaged and the expected modes of learning. In a "discipline-project", students select a problem within a subject area or have a choice on the method of solution. In a "problem project", students select the disciplines that they will involve in developing their solution. [7]

Generally, "task projects"" dominate in the first years of the engineering programme, "discipline projects" dominate the second and third years. "Problem-projects" are most suited to the final year where the various strands of engineering education are brought together. The World Engineering Day Hackathon is a "problem project" and provides a unique opportunity for students to demonstrate their engineering skills and attributes to develop a solution that advances one of more of the United Nations Sustainable Development Goals through engineering.

The positive outcomes that result from student participation in "problem-projects" are well documented. The process of developing options for a solution and deciding on the most appropriate one, the trial and error involved in testing the solution and developing prototypes, enables students to make connections between their solutions and their technical knowledge and competencies. Participation in project – problem based projects has also been found to result in higher levels of retention of knowledge, skill development and satisfaction compared to traditional approaches. [8]

Another aspect of the "task project "is that the complexity of the solution that is expected requires group effort, and working as a team. This results in additional benefits such as encouraging communication, engagement, project management and other team-based skills. The problem formulation directs the choice of disciplines and subject area methods. In other words, based on one work environment theme, the group can, for instance, actually work with widely different disciplines and subject methods. Students also learn to link theory and practice and consolidate their knowledge, making them work-ready and more attractive to prospective employers, as identified by the World Economic Forum. [9] This is particularly important to new technology and innovative sectors, such as Google. [10]

"Problem-project" Based Learning is therefore increasingly important to make future engineers job-ready to meet the needs of industry. Students who participate in such projects, develop strategies for project cooperation, organisation, and management, take responsibility for developing and implementing their solution, manage project timelines and outcomes, collaborate effectively and engage in a diverse learning environment. They learn to support their peers, develop empathy and connect complex ideas and develop systems thinking approaches. In addition, students develop as creative and divergent thinkers by considering multiple perspectives, reviewing and critically analysing their solution and become empowered and confident in their capabilities and develop conversational and listening skills.

III. THE WORLD ENGINEERING DAY HACKATHON – A CELEBRATION OF ENGINEERING

The World Engineering Day (WED) [11] Hackathon is a global competition for engineering students who collaborate in teams towards solve a real-world problem with a solution that advances one of the UN Sustainable Development Goals. It is a unique international competition and a "problem-project" learning opportunity, that enables students to demonstrate their engineering knowledge and skills and to win global recognition.

The competition is an essential part of the celebrations of World Engineering Day celebrated annually on 4th March, a UNESCO international day, promoting engineers and engineering. The WED Hackathon is hosted by the World Federation of Engineering Organizations (WFEO)**,** and its Young Engineers / Future Leaders (YE/FL) committee, in partnership with Engineers Without Borders International (EWB-I) [12], [13]

Established in 2022, this is an innovative opportunity for engineering students to develop sustainable engineering solutions for a global problem and demonstrate their capabilities against an internationally recognized engineering education benchmark.

Figure 2: The Home Page for the World Engineering Day Hackathon, 2022

The judging criteria

The judging criteria for the WED Hackathon are based on the GAPC Benchmark. Engineering education educators can observe how their students perform in the Hackathon, relative to the GAPC Benchmark. The WED Hackathon thus fulfils a second objective, supporting educators, by providing the framework for a project based learning opportunity. For programs that are accredited by IEA signatories, this also demonstrates the results of the institution's outcomes based education program.

The GAPC Benchmark accommodates future needs for engineering, with requirements for team work, communication, ethics and sustainability skills, in addition to core engineering skills. It requires students to develop digital and lifelong learning skills to adapt to rapidly emerging technologies and skills in using new tools such as AI and machine learning. Students also need to consider the impact of their work – technical, environment, social, cultural, economic, financial and recognize their responsibility to advance the UN Sustainable Development Goals (SDGs). Students need to demonstrate their intellectual agility, creativity, critical thinking and adaptive learning skills. Participation in the WED Hackathon is a wonderful opportunity for students to demonstrate these skills in a fun and exciting project.

The WED Hackathon Challenges

The WED Hackathon challenges relate to one of the UN SDGs. Students are required to provide a solution to a global problem in a limited time frame. The challenges are developed by young engineers from Engineers Without Borders and the WFEO Young Engineers/Future Leaders Committee and are the starting point for the learning process, directing the student's engagement and research. New challenges are developed each year.

The Challenges are practical, relevant, authentic and scientifically based. They can be analysed and solved, with an interdisciplinary approach. The solution has no specific boundaries and the solution supports diverse approaches.

Entry Eligibility and the Hackathon Process

Entries are open to undergraduate and graduate students, excluding doctoral degrees. Any student enrolled at a university, for the entire year of the challenge, is eligible to enter. Entries must be made by a group of 2 to 5 individuals working as a team with at least 50% of students enrolled in an engineering degree. An individual may only participate in a single team.

At Stage 1, the solution requires a two-page written submission. The finalists (between 9 and 12) proceed to Stage 2 and are required to submit a 5-minute video in any language with English subtitles. Only two weeks elapse between Stage 1 and Stage 2. The finalists' videos are shown globally as part of the WED celebrations. A project report is not required. Cash prizes to enable teams to progress their innovation have been provided, the total prize pool being €8,000. Every participant receives a certificate of participation from WFEO.

The Judging Process

There is a collaborative judging process that includes UNESCO, WFEO and its international partners.

For Stage 1, the judges are young engineers from the WFEO Young Engineers/Future Leaders Committee, Engineers Without Borders and SPEED (Student body of the International Federation of Engineering Education Societies). Each submission is judged by two judges and the average score is used to rank the submissions. The top scoring submissions progress to Stage 2.

Stage 2 Judges are leaders including representatives from the UNESCO Natural Sciences Division Capacity Building Section, WFEO Board, and leaders representing WFEO Partners including Engineers Without Borders, International Federation of Engineering Education Societies, International Federation of Consulting Engineers, International Network for Women Engineers and Scientists.

The Award Stage Judging Platform (third party software) is used to capture judging scores and comments to ensure robust and transparent judging and commentary, enabling international reach and scalability. The scores by the judges are moderated at each stage to discuss any scoring outliers and judges' feedback, to ensure consensus among the judges on the finalists and the winner.

WED Hackathon 2022

The Challenges for WED 2022 were developed around UN SDG #12 – "Responsible Consumption", for solutions for the innovative use of materials to reduce of non-biodegradable waste. Challenge #2 related to UN SDG #9 – "Industry Innovation and Infrastructure", requiring a solution that used Biomimicry for an engineering solution for healthy and improved living. Challenge #3 involved SDG # 6 – "Clean Water and Sanitation", for solutions for climate-resilient, safe water access. The solutions also had to be consistent with the theme for WED 2022, *"Engineering a Sustainable Future".*

There were more than 1000 pre-event registrations, with 125 teams from 23 countries. Stage 2 had nine teams from six countries: Australia, Canada, China, India, Kenya and the Philippines 40 young engineers from 16 countries volunteered as judges for Stage 1 and there were five judges, form UNESCO, WFEO, and its international partners.

The winner of the WED 2022 Hackathon developed a water treatment process using recycled PET bottles that are chemically transformed into metal organic framework adsorbents, addressing Challenge #1, developed by an all-female team from Batangas State University, Philippines.

In 2nd Place, a mobile rain water harvesting system for use by remote Canadian indigenous communities, addressing Challenge #2, was developed by a team from The University of British Columbia, Okanagan, Canada.

In 3rd Place, the team from Egerton University, Kenya developed a biodegradable alternative to single use plastic product using a problematic water weed, addressing Challenge #1.

WED Hackathon 2023

The challenges for WED Hackathon 2023 related to UN SDG #2 "No Hunger", for sustainable food access. Challenge #2 related to UN SDG # 6 "Clean Water and Sanitation", for a solution for clean water access in scarce and polluted situations. Challenge #3 related to UN SDG #3 – "Good Health and Wellbeing" for improved city design and infrastructure. The solutions had to be consistent with the WEC 2023 theme, "*Engineering innovation for a more resilient world*".

Social media promotion for WED Hackathon 2023 reached more than 6.4 million with more than 1000 pre-event registrations resulting in 150 team entries in Stage 1 from 23 countries.

27 young engineers judged Stage 1. Five judges from UNESCO, WFEO and its international partners judged the Stage 2.

The winner of the 2023 WED Hackathon was Team Sponge, Ateneo Naga University, The Philippines who addressed Challenge #3 with an innovation to repurpose waste materials to produce a permeable road surface that can absorb rainwater runoff, reduce flooding and improve catchment health.

In 2nd place, Team Aquam Soils, University of British Columbia – Okanagan Canada, addressed Challenge #2 with a low-cost, portable water treatment device for use in areas hit by natural disasters.

In 3rd place, Team Aqua-Smart, University of Mauritius, developed an innovative solution for water treatment for remote and rural areas.

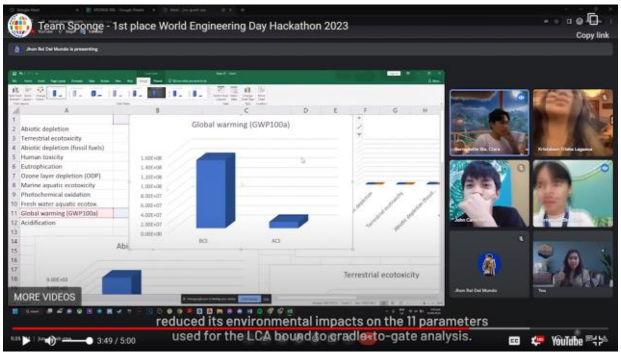

Figure 3: Team Collaboration to develop a solution for the World Engineering Day Hackathon 2023

IV. OUTCOMES FOR STUDENT LEARNING

More research is required on the outcomes for student learning for those who participate in the World Engineering Day Student Hackathon. It is expected that participation will result in higher levels of engagement in engineering programs as the relevance of the curriculum will become more apparent. In addition, participation challenges students to direct their own learning because projects are open ended, requiring them to critically evaluate multiple solutions and justify their decisions; requiring a higher degree of thinking.

Participation in the Hackathon is also expected to result in the development of employability skills including complex problem solving, critical thinking, creativity and emotional intelligence. The Hackathon is an effective way for to gain these skills and to demonstrate these to a global audience.

Another expect outcome is improved academic performance as the Hackathon promotes self-discovery, develops problem-identifying and problem-solving skills, leading to deeper understanding of the students' engineering skill and abilities. More research will be done in the future to assess the impact of the project on student learning outcomes.

The Hackathon also supports engineering education programs with a contemporary and globally relevant project that supports the development of essential skills relating to communication, team work, critical thinking and lifelong learning.

V. CONCLUSION

The Hackathon competition is a unique tertiary level challenge that provides engineering students with the opportunity to integrate their knowledge and skills, to address a global sustainability problem in an exciting global competition.

The judging criteria are based on the International Engineering Alliance (IEA) Global Graduate Attribute and Professional Competencies Framework, the international benchmark for engineering education that develops technical and essential skills relating to communication, team work, critical thinking and lifelong learning. The judges are representatives of international engineering organizations, for a truly global challenge. The outcomes showcase the achievements of engineering education programs and the success of educators in developing future engineers.

For participating engineering students, the WED Hackathon is a project supports their personal development, with learning outcomes that develop employability skills. They are exposed beyond their university campus and gain an international perspective on the context of their engineering skills.

The Hackathon has attracted diverse student teams from developed and developing countries with the winners from developing countries in 2022 and 2023: The Philippines (2), Kenya, and Mauritius. It shows that intellectual capacity can be developed anywhere and engineers with limited resources can develop innovative solutions to address the world's most pressing problems.

Women have participated in significant numbers with an all-female winning team in 2022. This demonstrates the capacity of women to contribute equally to engineering solutions and provides further empowerment for them.

The Hackathon is scalable and transferrable, delivered at no cost across all countries, every university in the world can participate, in an inclusive global competition.

The power of the finalist's videos that are shown around the world inform the community and prospective students about the power of engineering, and how it provides the essential skills that can be applied anywhere in the world without barriers to make a difference for a better world.

The Hackathon is therefore not only educational and empowering for the students but for educators, industry and the community. It shows that the universal language, systems and skills of engineering can be applied anywhere in the world without barriers and engineers can make a difference for a better world.

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The Role of Accreditation in Assuring the Profession of Engineering

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Abstract–This paper provides a brief overview of the system of assurance that is employed by the profession of engineering to earn the confidence of the community. It places accreditation of engineering education programs at the centre of the assurance chain, being the link between professional practice and education. In this role, accreditation is the foundation for mutual recognition of qualifications and registration across international borders.

Keywords–accreditation, registration, assurance, confidence, quality, trust

I. INTRODUCTION

There have been some suggestions that program accreditation, in taking on some of the characteristics of quality assurance, has the simple purpose of assuring the 'quality' of the education program – this would be described as esteem value, 'displaying a certificate on the wall'. This viewpoint inaccurately treats engineering education as a closed system. But just as no quality system 'does quality' for the sake of quality, so education has a clear purpose beyond the boundary of the classroom experience: to prepare graduates for the rigour of the profession. Accordingly, accreditation sets out to systematically verify that the education program achieves that purpose. As businesses understand, at a fundamental level quality is not something that they put into a product or service – it's what the user gets out of it.

II. AIM

The aim of this paper is to highlight and briefly explain the role of accreditation in the assurance of the profession of engineering, through its provision of a critical link between the comprehensive verification processes at multiple levels of the education sector and the verification processes implemented by a professional member organisation. The purpose of this system of assurance is to earn the confidence and trust of the community allowing it to function as a self-regulating profession.

III. ACCREDITATION AND REGISTRATION

Accreditation is an evaluation and review process to determine if an education program meets defined and agreed professional education standards that assure a comprehensive educational basis for entry to the practice of engineering. The standards are in the form of threshold criteria that must be individually met, and are expressed as outcomes-oriented attributes required of a graduate at a level that allows the appellation 'engineer' at the completion of the education program. Note that this appellation (lower case) is not a formal title and is distinct from the formal title 'Professional Engineer' (or similar) which indicates registration – which may also be called licensing – and which is achieved only after an appropriate period of experiential learning in the engineering workplace.

The evaluation process of accreditation is applied to education programs and confirms whether or not they are capable of producing the target graduate attributes, but graduates themselves are not systematically evaluated for evidence of the attributes (although some partial spot checks may be done for additional assurance purposes). In comparison, registration is applied to individual persons. The International Engineering Alliance (IEA) in its statement of graduate attributes and professional competences [1] defines the development of an engineering professional as an ongoing process in two stages: 'The first stage is the attainment of an *accredited educational qualification*, the graduate stage. The fundamental purpose of *engineering education* is to build a knowledge base and attributes to enable the graduate to continue learning and to proceed to formative development that will develop the competences required for independent practice. The second stage, following a period of formative development, is *professional registration*.' This description helps to place accreditation in the bigger picture of assurance of the profession.

IV. TRUST AND CONFIDENCE IN THE PROFESSION

A profession can only operate with independence within a society if it merits the trust of that society. Trust is the willingness to be vulnerable to the actions of others based on positive expectations of their future performance [2]. To merit trust, the profession is obligated to operate transparently in certain ways with appropriate competency and accountabilities so that society provides its tacit consent for it to operate. The obligations placed on a profession necessitate advanced knowledge and training, in conjunction with appropriate experience and judgement, that is, professional competence. It also requires adherence to ethical standards; competence and ethical practice together are essential to maintaining the continuing trust of society.

Professionals publicly vow to adhere to a code of ethics (or code of practice) when exercising professional judgement. A code of ethics is developed in response to community expectations that engineering outputs should be: fit for purpose; safe to own and operate; and, environmentally responsible. The ultimate accountability of the professional is to the community, through the medium of a professional body that collectively defines and manages the code of ethics. According to the reference [3], 'it is inherent in the definition of a Profession that a code of ethics governs the activities of each Profession … They define and demand high standards of behaviour in respect to the services provided to the public and in dealing with professional colleagues.'

A professional code of ethics considers the effect of a professional's actions on others, on society and on the physical environment by taking into account a set of fundamental principles that can be expressed as:

- Respect the inherent worth of the individual
- Act on the basis of a conscience informed by competence
- Act in the interest of the community

In addition to the code of ethics, the profession of engineering provides competency and development standards that support professional performance, leading to accreditation of education programs and registration or licensing of individual professionals. By these means, the profession of engineering seeks to merit the trust of the general community in the execution of all its activities.

V. ASSURANCE OF THE PROFESSION

Assurance of the profession to earn the trust of the community relies on multiple assurance instruments: accreditation, registration (or licensing), code of ethics and performance standards. Registration has its foundations in accreditation which assures knowledge and skills of new entrants to the profession, and constructs workplace experiential learning on that foundation to provide assurance that the knowledge and skills are properly applied to create outcomes that are at a professional standard.

Accreditation itself is built on three assurance mechanisms: certification of the higher education provider (university level), usually by a government regulator; certification of the qualification type, usually in the form of a national qualifications framework, and backed up by regular internal self-assessments by the education provider; and a system of verification by the education provider where each student is subject to a systematic assessment throughout each and every year of the study program, usually resulting in a total in excess of 100 assessments in the form of examinations and an assortment of assigned tasks. Together these constitute a system of verification that is so comprehensive and thorough that no external agency such as a professional member organisation can hope to match it, and to attempt to do so would be unnecessary and indeed wasteful. What the professional organisation can do, and does do, is to insist that these education programs meet certain professional accreditation standards, expressed in the form of graduate attributes or competencies such as those expressed by the IEA in reference [1]. Accreditation is the assurance link between the profession and the education sector and is critical in the assurance chain for that reason.

Accreditation is summative in an educational sense, but in professional purpose it is forward looking as it contributes to the assurance that professionals are able to meet their future obligations. It is the nature and purpose of higher education to enable graduates to extrapolate their learning beyond their existing knowledge base; in the terminology of [1], 'Can extend beyond previous experiences by applying principles-based approaches'.

Distinct from accreditation, registration assesses the accumulated experience levels of engineers in the workplace much of which is in the form of tacit knowledge (which largely cannot be assessed) and also explores matters of professional competence and judgement. It presumes accreditation as a prior verification and cannot and does not attempt to reproduce it. Experience-based learning occurs in-depth at discrete points in the knowledge and learning space and is valuable in its own right, but it does not provide a verifiable capability to safely extrapolate beyond that base in the way that principles-based learning does, hence its reliance on accreditation.

Standards in the form of regulations for professional work are mostly developed for specific industry sectors (for example, aeronautical, civil construction, nuclear, medical instruments, rail, electrical power, etc) and these are legally applied to the enterprises that facilitate the engineering works. The enterprises then devolve responsibility for compliance with those standards to the engineering team. Apart from some very useful contributions (see reference [4]), there are no universally-accepted standards that apply generally across all engineering disciplines in a manner similar to professional competences.

The baseline for the profession to earn the trust of the community is a history of reliable performance in the past, yet it is only a 'necessary but not sufficient condition' for future performance. Trust is future facing, being a positive expectation of the intentions of others [1]; it is earned by the profession through the key assurance instruments provided by the education sector on the one hand, and code of ethics, professional credentials (denoting registration or licensing) and standards on the other hand, and where accreditation is the critical link between education and the profession.

ACKNOWLEDGEMENTS

Ms Bernadette Foley, Engineers Australia

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INDUSTRY, ACADEMIA, GOVERNMENT AND ENGINEERING REGULATORY BODIES' COLLABORATION TO EMPOWER ENGINEERING EDUCATION

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Abstract– *This paper investigates the role that industry, academia, government and engineering regulatory bodies' collaboration should play in empowering engineering education. These partnerships are enshrined in the 17 Sustainable Development Goals (SDGs), which are integrated; SDGs are global goals that United Nations adopted in 2015 as a universal call to eradicate socio-economic challenges. Nations are expected to align their political policies and agendas for 15 years to ensure the realisation of these goals by 2030. Engineering and technology are vital for achieving the 17 SDGs. Engineering education is key for addressing most SDGs and is essential in integrating humanitarian, social and economic development. In this context, the Engineering Council of South Africa (ECSA) evaluates and recognises the education programmes offered by higher education institutions through accreditation. It can be beneficial for key role players to consider a partnership model that would empower engineering education. This paper recommends that the industry, academia, government and engineering regulatory bodies promote, invest and support engineering education studies to develop pedagogy, teaching and learning; research for innovation; technology; and faculty training. Furthermore, it suggests improving and strengthening science, technology, engineering and mathematics (STEM) education in schools.*

Key Words– Accreditation, collaboration, education, engineering, regulation, sustainable development goals

I. INTRODUCTION

The engineering industry continues to face several challenges despite its continued achievements and success. Some of these challenges include technological advancements, industry changes, a lagging education system and the developing needs of engineering professionals. These challenges call for key role players to partner with and empower the engineering industry through engineering education.

The collaborations among industry, academia, government and engineering regulatory bodies open portals of opportunities, not only for engineering professionals but also for members of the public. On 25 September 2015, world leaders met at the United Nations (UN) in New York, where they adopted the SDGs (United Nations, 2015). These 17 goals and 169 targets set out an agenda for sustainable development for all nations that embraces economic growth, social inclusion and environmental protection.

These SDGs are the result of what the UN has described as the largest consultation in its history. However, these efforts will be fruitless if key role players fail to collaborate effectively to ensure they are fully implemented. As a framework, the SDGs extend the previous Millennium Development Goals (MDGs) in many ways, particularly by seeking to link the social, economic and environmental aspects by 2030.

The 17 SDGs are: 1 – no poverty, 2 – zero hunger, 3 – good health and well-being, 4 – quality education, 5 – gender equality, 6 – clean water, 7 – affordable and clean energy, 8 – decent work and economic growth, 9 – industry, innovation and infrastructure, 10 – reduced inequality, 11 – sustainable cities and communities, 12 – responsible consumption and production, 13 – climate action, 14 – life below water, 15 – life on land, 16 – peace and justice strong institutions and 17 – partnerships to achieve the goal.

II. AIM

One of the SDGs is to foster partnerships by sharing knowledge in education as the stepping-stone to reaching equal civil societies worldwide. Therefore, the aim of this paper is to investigate the role that academia, industry, government, and regulatory collaboration would play in empowering engineering education.

III. PROFESSIONAL LIFECYCLE

A. *Engineering Education*

The professional engineering lifecycle begins with engineering education. The engineering education system is a pipeline, whereby the pipeline stages start with formal education and an accreditation programme, training and experience, ending with practice. From the point of view of formal education, the journey toward professional engineering should be considered from primary school. To increase intake, it is pivotal that all stakeholders in the value chain of the STEM subjects from primary school through to industry understand and ensure that they make these subjects attractive and intriguing to students.

Engineering education in South Africa is provided by institutions of higher learning (universities, colleges for Technical and Vocational Education and Training, and Further Education and Training). These institutions' qualifications must conform to the ECSA Graduate Attributes for the degree to be accredited. ECSA evaluates and recognises the education programmes offered by higher education institutions through accreditation. Accreditation of a programme means that the programme satisfies the prescribed criteria and can continue to produce graduates who meet the criteria for a defined period of up to 5 years.

Accreditation for professional registration has been a powerful tool for academic quality and relevance after qualification as an entry route to the engineering profession. This is a rigorous endorsement of a critical element of a student's pathway toward becoming a registered person who demonstrates the required outcomes.

The accreditation system assures the public, students, employers, funder, and other stakeholders of the following:

- The programme fulfils its key purpose, which is to provide graduates with the educational foundation for engineering in a stated role at the professional level. The educational foundation refers to a coherent body of knowledge, skills and attitudes preparing a graduate for undertaking training and experience toward attaining competence for independent practice.
- Teaching, learning and assessment processes are effective.
- Programmes are internationally comparable with the International Engineering Alliance agreements (educational accords, i.e., Washington, Sydney and Dublin Accords) to which ECSA is a signatory.
- Programmes are of the highest quality.

According to Indeed Editorial Team (2021), an engineering role relies heavily on experience, knowledge and training. Engineers in training may perform some engineering work under the direction and supervision of a professional engineer. Any work they perform requires their supervisor's approval and signature. Being an engineer in training allows candidates to gain practical experience in engineering work after graduation before they officially enter the workforce or complete projects independently.

B. *Professional Categories*

ECSA registers engineering professionals under the following categories: Professional Engineers (Pr Eng), Professional Engineering Technologists (Pr Tech Eng), Professional Certificated Engineers (Pr Cert Eng) and Professional Engineering Technicians (Pr Techni Eng).

These categories of professionals are differentiated by the degree of complexity of the work they carry out. Pr Eng are expected to solve complex engineering problems; these require in-depth, fundamental and specialised engineering knowledge that facilitates an analytical approach from first principles. Pr Eng Tech and Pr Cert Eng are expected to solve broadly defined engineering problems; these require coherent and detailed engineering knowledge underpinning the applicable technology area. Pr Eng Techni are expected to solve well-defined engineering problems, mainly solved by practical engineering knowledge underpinned by related theory.

Registered persons are required by the Rules and Code of Conduct to practise strictly within their area of competence and to maintain and enhance their proficiency. Therefore, registered persons are responsible for keeping abreast of developments and continuously improving their knowledge in their areas of expertise to maintain their competence. In addition, registered persons should strive to advance the body of knowledge in the field in which they practise and in the engineering profession in general. In all engineering categories, whether business, education, professional practice, the public sector or any other engineering environment, the competencies needed to function effectively as a registered person continue to evolve, change and expand engineering knowledge. Registered persons in all categories are confronted by increased expectations to display professional knowledge and skills in this ever-changing environment. Therefore, maintaining and continually developing professional competence is critical in meeting new engineering challenges.

IV. ENGINEERING EDUCATION ROLE PLAYERS

According to Chandu and Chandu (2020), engineering institutions have well-established practices and processes performed efficiently over several years to customer satisfaction. However, engineering education has remained stagnant; lectures, textbooks and oral and written examinations have remained the same over decades in many countries, which implies a need for digital disruption in engineering education. Such disruptions are an opportunity to solve existing problems and engineering institutions and educators would largely benefit.

To implement a disruption, engineering institutions need successful and timely innovation in the processes leading to employable skills transfer. If institutions cannot do it alone, synergy should occur among several organisations working for the same purpose. Academia, industry, government and engineering regulatory bodies should partner to empower engineering education and the profession. Industry and academia partnerships provide academia with the necessary funds for academic research where there is a lack of funding from government due to various funding challenges and competing government projects. Both sides thus benefit greatly from forging long-term collaborations over once-off projects.

A. *Benefits for Industries*

There is a mutually beneficial relationship between industry and academia, as the industry seeks qualified candidates to add to its workforce academia. At the same time, the brightest minds enrol in academia with the hope of gaining industry preparedness and employment in the labour market. Academia customises and alters the curricula to prepare students for challenges after graduation and suit the industry's needs.

There is a need to strengthen the industry-academia relationship; Harazi (2022) highlights the following benefits:

- The industry gets access to state-of-the-art research facilities and equipment.
- Academia is a hotbed of fresh ideas, perspectives and talent for corporate finance management.
- The research support academia receives can translate into funding and support for initial-stage start-ups.

- Academic research impacts the industry and sometimes receives funding from companies.
- Academia is better aware of industry trends than ever before.
- It reduces the skills mismatch between graduates and industry.
- It benefits, research findings and academic output in an area that require investigation.

B. ***Benefits for Universities***

With competing priorities for policies and funding, government research funds are reduced and diversified among various sectors. Therefore, academia relies on the industry to bridge the gaps. Additionally, Harazi (2022) highlights that the academia and industry partnership allows academia access to more resources to fund its research and expand its research areas. It also receives industry feedback and guidance on its inventions helping it to improve further. Industry partnerships also allow universities to expose students to real-time industry jobs. Most students involved in incubator projects are offered a role within the company after graduation because they have had time to adjust to the company culture.

Partnerships can be a powerful public relations tool; this tool is used by academia for students who can be placed in full-time employment in industry. The higher the placement numbers, the more likely it is for academia to persuade potential students and industry partners.

C. ***Benefits for Engineering Regulatory Bodies***

The benefits of engineering regulatory bodies are realised through the fulfilment of their mandates prescribed by government. Some of the benefits for engineering regulatory bodies are as follows:

- To ensure public safety and the improvement of skills.
- To play a role in the accreditation of programmes offered by academia.
- To ensure that students meet the needs of the economy and reduce unemployment.
- To ensure relevancy by meeting government priorities.
- To ensure the Code of Practice, Code of Conduct and Continuing Professional Development.

Through signing a memorandum of understanding with the industry, the regulator can strengthen its partnership with the industry by establishing academy programmes.

D. ***Benefits for Government***

Through policy measures such as incentives and penalties, government can encourage the industry to introduce programmes to strengthen partnerships with academia.

The Tambal (2017) outlines the following as the government's role in promoting collaboration:

- **Research partnership agreements** are collaborative efforts on research projects between two or more institutions. These projects can be for exploratory purposes, targeted for a specific task or to produce a marketable product.
- **Educational agreements** develop programmes that educate personnel in a way that satisfies the missions of all parties involved. Examples of this are fellowships, internships, co-ops and training programmes designed to help those involved gain valuable experience they otherwise would not have had the opportunity to obtain.
- **A consortium** brings together a group of institutions to pool their research and expertise to tackle an issue that would be beyond the scope of any one member.

V. CONCLUSION & RECOMMENDATIONS

The role of industry, academia, government and engineering regulatory bodies in empowering engineering education and achieving the SDGs established by the UN has been highlighted in this paper. However, there is a long journey to achieve these global goals since collaboration among these key role players is not fully implemented in many nations.

The following recommendations should be considered:

- Governments should increase the focus on interdisciplinary curricula, sustainable development and professional competencies, combining them with funding models that support these needs.
- Industry, academia, government and engineering regulatory bodies should promote, invest and support engineering education studies to develop pedagogy, teaching and learning; research for innovation; technology; and faculty training.
- Governments should reward institutions developing new systemic student-centred blended learning models. These include engineering institutions working to change the curriculum and learning approaches by creating comprehensive, blended educational models developed in cooperation with industry and other societal actors. Such models use real-world complex problems and projects, including regarding sustainable development.
- Government should improve and strengthen STEM education in school.
- Government and academia must improve educational leadership for educational change.
- Industry and engineering regulatory bodies should encourage academia to be agents of change.
- Engineering regulatory bodies should ensure compliance with continuing professional development.
- Industry, academia and engineering regulatory bodies must ensure that engineering programmes are designed so that students reskill themselves at convenient Intervals with intermittent employment.

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Empowerment Teaching: A Model for Successful International Knowledge Transfer In Engineering

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Abstract *– Around the world, an excellent education is believed to be the key precondition for individual wealth, economic prosperity, and environmental protection. Especially in engineering education is the fundamental basis to reach the Sustainable Developing Goals and to meet the global challenges we all have to face.*

In emerging countries, the potential of highly motivated students and young academics is often diminished by a lack of ability to apply their knowledge. Therefore, it is essential to implement capacity-building measures to promote and accelerate the transfer of knowledge and technologies from developed countries to emerging countries. The main focus has to be the development of local academic expertise.

But: How can we effectively transfer our knowledge from country A to country B? What are the prerequisites especially in applied sciences like engineering?

Having given numerous lectures around the world during the last twenty years, the authors are convinced that participatory teaching methods can be an ideal answer to these questions. The main aim is to empower the learner to meet the challenges of the future in theory and in practice. Participatory teaching methods enable the learner to develop knowledge, skills and attitudes. They are very useful to overcome cultural barriers between the international lecturers and their students. This can create a win-win situation for both sides.

The authors have developed a 7-phase model based on their practical teaching experiences, which can be applied to secure the effectiveness of an international knowledge transfer.

Keywords– *international knowledge transfer, participatory teaching methods, 7-phase model*

International Excellence through Know-How Transfer

Around the world, an excellent education is believed to be the key precondition for individual wealth, economic prosperity, and environmental protection. Therefore, our world should be in excellent shape since ninety percent of all scientists who have ever lived are living today; the largest number of scientists in a generation of all time (Kretschmann/Plien 2014). Nevertheless, how can we apply a successful international know-how transfer as know-how is created in such an immense amount? As today know-how is mostly published through the internet and high-ranked journals in a one-way street of know-how transfer. But one-way communication alone is not enough to secure long-lasting effects on science, society and, politics (Kretschmann 1990).

In emerging countries, the potential of highly motivated young academics is diminished by a lack of ability to apply this know-how. Therefore, it is essential to implement capacity-building measures to promote and accelerate the transfer of know-how and technologies from developed countries to emerging countries. Expertise from abroad can bring know-how and motivation to these countries, but the main focus has to be the development of local academic expertise. A key element to this merging process is the cooperation between universities from different countries. On a face-to-face level the scientific community can try to motivate and enhance the capacities of the highly qualified academic talents in the emerging countries. By exchanging the acquired know-how and transferring personal expertise of senior researchers and highly experienced executives from developed countries, know-how will be accessible and easy to process for future researchers, managers and leaders in emerging countries (Kretschmann/Plien 2014).

Participatory Teaching Methods for Know-How Transfer

In conventional lectures the teacher defines what is to be taught and the methods to be used (PRIA 2002). This also corresponds to a strongly deductive teaching style, which Felder and Silvermann (1988) describe as the prevailing method where teaching starts with principles and "fundamentals" (Felder and Silvermann 1988: 677) and only later proceed to the applications. This approach of lectures is traditionally based on the idea that the lecturer knows everything, while the students know nothing (deficit orientation). The lecturer defines the particular set of what students need to learn and how these learning needs can be met. Students do not have any active roles during this process. The lecturer becomes the central point, around whom the entire process revolves. In applied sciences, this method cannot be regarded as state-of-the-art. The success of communication (teaching) depends on the listener not on the speaker. Because of this effective teaching requires a change of the lecturer´s role from being a mere sender of knowledge (teacher) to a coach, then to a motivator, and finally, to a mentor. Participatory training methods are based on an empowerment-orientated approach. They promote learner-centered development through training and learning. Participatory training methods help learners by enabling them to develop knowledge, skills and attitudes individually and to share perceptions so that they can actively contribute to renewal and improvement (Nguyen 2011). They aim to increase the potential of the learner (potential orientation). Empowerment teaching thus boosts confidence of learners which impacts on motivation of learners (Graham et al. 2013).

In practice, active application of participatory teaching methods also implies a change of perspective for the lecturer as the seats are arranged in a semi-circle or circle to create a closer contact between participants and the lecturer (Paukens et al. 2008). Regarding training materials, diverse tools and other materials such as white board, moderator box and contents, sheets of AO paper (flipcharts), notebooks, projector and screen, etc. can be used. Beside of this lecturer should use materials such as photos from incidence in practice or/and video clips to visualize the theoretical inputs (Kretschmann/Nguyen 2014). This will help students to remember the detailed information, more than only listening to the trainers, or reading documents or books (Kretschmann 2000). Additionally, posters, related statistical data, and charts can contribute to a better understanding (Kretschmann/Nguyen 2014). Most important, however, are lecturer’s attitudes and mindsets of intelligence and abilities: studies have shown that an open, non-fixed belief about intelligence may influence students‘ performances in exams (Canning et al. 2019), their persistency in college and students’ motivation (Canning et al. 2019, Rattan et al. 2012).

Moreover, lecturers’ attitudes and mindsets may also convey and facilitate a sense of belonging to engineering applied sciences (Rattan et al. 2018, Killpack & Mélon 2016) as this may be an important factor to further pursue this field academically or professionally (Hrabowski 2011; Wilson et al. 2015).

If participatory training methods are applied during the teaching programs the lecturer can motivate and mentor the learners´ initiative roles in learning, and encourage them to contribute more at work; such as finding out disadvantages and how to improve the situation themselves. Learners should understand that the details can be seen in work place by the directly involved staff, not by the management board. Participatory teaching methods promote learner-centered development through learning and practicing. Therefore, teaching should be multi-sectoral, interactive and focused on group work. Participatory teaching is learner-centered as it recognizes, evaluates and seeks to build on the existing knowledge of the learners.

7-Phase Model for an Effective International Know-How Transfer

During multiple teaching courses the authors have developed a 7-phase model for an effective international know-how transfer from developed countries to emerging countries with an emphasis on the education in the mining sector.

1. **Start-up Phase**

At the beginning it is important to establish a common basis. The lecturer has to explain the framework and the rules he expect to be followed in the course of the lecture. It must be kept in mind that learning is set within a frame which incorporates many cultural differences (Hofstede 1986). Most importantly, know-how cannot be transferred when teacher and student do not speak the same language. One language, mostly English, has to be defined as the classroom language. A strict application of this rule has to be enforced in order to keep everyone on the same level if students are coming from different countries.

After formal aspects of the training course have been defined by the lecturer, the participants should be asked to introduce themselves, sharing briefly their experiences and expectations of the content of the lecture. The aim of this first short introductions sequence is to overcome students´ hesitancy to speak. To make students talk is a first step to empowerment. The lecturer and the students get to know each other and facilitate the know-how transfer by creating a friendly and cooperative atmosphere. Cultural characteristics have to be acknowledged. In Asian countries for example, it is important to overcome the hesitancy of mentioning the ego (I – myself) as a performance of politeness and the reluctant of showing the individual and preference of the group. Due to the high respect for older people and lecturers it will always be a challenge for the lecturer to implement participatory teaching methods, which emphasize individuality and flat hierarchies. A side effect of the short introduction by the students is that the lecturer familiarizes themselves with the names of the participants. This is especially challenging when dealing with names from completely unfamiliar cultural contexts. But in order to generate a friendly learning atmosphere this task should to be completed by the lecturer as soon as possible.

During the whole training course it is imperative to welcome questions as this gives the students the chance to participate and actively contribute to the learning success of their fellow students.

2. Warm-up Phase

After the introduction it is necessary to quickly "break the ice" between lecturer and students!

At first the "big picture" of the lecture should be explained in simple comprehensive language as the lecturer cannot assess the languages skills of his class at this point of the course. If possible the creation of an emotional bond based on trust and sympathy should start right now. The warm-up phase has to be regarded as a core element of the 7-phase model as communication has a social dimension and is therefore the result of the interactive behavior between the lecturer and the learners (based on their culture and experiences). In the process of an active know-how transfer two levels of teaching are present. On the content level the objective information is emitted but on the process and relationship level sympathies, emotions, expectations and fears are transferred in the way people speak to each other. Communicative relationships – like the ones between lecturer and student – are influenced predominantly by emotional feelings and only to a much lower extent by rationality (Schulz von Thun 2015).

Lecturers and students should understand each other on the content level and on the relationship level. That is why during this phase the lecturer should evaluate potential barriers like shyness, restraint and poor language skills in order to further adapt the course. In this process the role of the lecturer as a team leader with social competences and emotional and social intelligence is crucial for the success of his lecture. The lecturer should try to enforce the students´ willingness and abilities. Moreover, consoling or comforting struggling students is not helpful but tends to demotivate students as Rattan et al. (2012) have found regarding students' math abilities. Instead, an open mind of the students' ability to grow and develop may essentially make a difference. Though a main aim of the lecturer should be to motivate the students to talk and listen – it is their task to be the best listener in class. Student's acknowledgments of the learning progress should be given and contributions in classroom should be valued. In this way students will feel optimistic about their abilities to learn, enhance creativity and decision-making skills which keep the intrinsic motivation high and leads to a better learning effort.

3. Learning and Experiencing Phase

Phase 3 initiates the learning and experiencing process of the students and enables the learner to develop their potentials, knowledge, skills and attitudes. Central are methods which are often labelled as "active learning" as they engage students in the learning process, by "actively processing and applying information in a variety of ways" (Wieman 2014: 8319) and thereby prompting students to "think about what they are doing" (Prince 2004: 223). This may include many different teaching methods such as collaborative learning in small groups, cooperative learning between individuals and longer phases of problem-based learning (Prince 2004), which have been found to positively influence student performance in general and in science, technology, engineering and mathematics in particular. Freeman et al. 2014 studied the impact of active learning on student performance and found that average exam scores improved by 6% while students in classes with active learning were less likely to fail. The teaching methods have to be outlined and explained to the students comprehensively. Time should be given to the students as they probably do not know the new teaching methods that will be applied during the course.

The course has to be designed by distributing learning in intervals, there has to be enough time for discussions and repetitions. For the long-term learning effect it is essential that the students have the opportunities to make their own experiences by guessing, trying, and speculating on new ideas and techniques. While transferring knowledge and applying this new method of teaching the trainer has to constantly encourage the students to actively use the classroom language.

In the theoretical inputs sessions, participants should share their own ideas and experiences. When learners get used to speaking out loud, they gain self-confidence to contribute more (Kretschmann/ Nguyen 2014). The lecturer leads by setting the framework and planning the learning process. He acts as a moderator when the students provide their own ideas, knowledge and techniques. He helps the learners to understand the content of the lectures leading Q&A sections and discussions (Nguyen 2011).

Keeping in mind different learning styles (Hawk et al. 2007) as well teaching styles especially in engineering education (Felder & Silverman 1988), lecturers use different approaches to engage the students and enhance the active pursuit of new knowledge. It is also important to acknowledge Felder & Silverman's (1988: 680) assessment, that most engineering students prefer visual, sensing and active learning styles, whereas most engineering education is auditory, abstract and passive. A different teaching approach as it is advocated here may therefore enhance student performance and students' motivation. Theoretical input sessions should be systematic, scientific, updated, and realistic. The systemization of knowledge and techniques helps participants better obtain new knowledge and skills. The scientific features are illustrated by up-to-date achievements, can become persuasive evidence to the students. Students are free to contribute to the achievement of the group and ask questions to get a better understanding of the practical relevance of the theoretical input. The lecturer should play the role of a motivator and a mentor when facilitating and supporting participants' knowledge development (Koki 1997). Participants can exchange experiences, share reactions and observations, reflect upon implications and consequences, and discuss theoretical input with responsible people in practice. Subsequently students can develop practical and conceptual understanding (PRIA 2002).

The main goal during this phase should be that the students are eager to come to class and learn as they have been inspired by the transmitted new ideas and learning processes. Due to the possibility to contribute to class in a two-way-learning-process (which increased their acting competence) a trust and belief in their competencies is enhanced more and more which contributes to an increasing self-efficacy and self-esteem. This could also impact on the students‘ belief of intelligence and abilities – studies have shown that students' fixed growth mindsets (fixed abilities and intelligence) are predictors of their academic performance (Blackwell et al. 2007).

4. Practical Phase

In general, people remember about:

- 10% of what they read
- 20% of what they hear
- 30% of what they see, but
- 50% of what they see and hear
- 80% of what they say or write
- 90% of what they compile and execute themselves (Kretschmann/ Plien 2014).

The aim of the practical phase is to learn with all senses and to develop skills ant attitudes. Learning is often not done with the head alone, but with the hands (touching), the heart (emotions), the skin (heat, coldness) and sometimes with the whole body (very strenuous work). Therefore it is important that theoretical input sessions are accompanied by field trips, practical sessions or discussions with people in practice. In applied sciences know-how should not be generated and transferred in small academic circles, but should be used to improve the outside world. Therefore, the theoretical input has to be transferred into real life to make the world a better place by realizing improvements. Applied science is based on every day's challenges everybody has to face everywhere around the world, big challenges like climate change, deforestation or conserving the global fresh water supply; as well as other smaller problems like implementing safe working conditions in coal mines. Therefore, a sustainable understanding should be transferred to the students that every challenge is important and every question should be addressed. Teaching applied science should make the students able and willing to use their know-how for improvements.

The practical phase has to imprint the fact that engineering is an applied science. In order to achieve this, students must be given space to realize self-effectiveness and competence. The lecturer has to foster acting competence in practice. He should encourage teamwork and demand students' contribution by actively asking questions, sharing experiences and observations, reflect implications and consequences and leading the discussion with people in industry. To sum this up the students must test themselves in order to become future researchers, decision-makers and team players. Sometimes best cases or role models can be adapted and implemented. But, applied science in the real world usually does not carry out one-size-fits-all-solutions. To solve the challenges of a real case and apply suitable solutions should be the focus of this phase. That is why the lecturer should set the goals and rules, give orientation and lead the learning process! Most importantly they have to create a positive learning atmosphere with the aspiration in mind – yes, we apply! The learners should be aware they are not learning for their exam primarily, but for their and others´ future lives.

5. Wellness Phase

Courses designed as block seminars with additional field trips can enhance the learning process of the students tremendously when the lecturer designs a friendly and creative atmosphere outside the classroom as well. Planned distraction like trips to cultural sites or even touristic places will first of all shape the group cohesion and support the creation of a student network, which is especially important if students in the courses come from different countries and universities. These extracurricular activities help to overcome cultural barriers between the lecturer and the students and among the students themselves. Enjoying free time transports joined positive experiences into the classroom. The aim is that the lecturer creates “happy moments” (and hundreds of photos by the learners) to show the learners that lecturers can be good company. The learners sometimes will remember these happy moments for the rest of their lives.

6. Exam Phase

A lecturer has to actively let his students apply their know-how during this phase that will summarize the learning efforts of the students. In the course of the exam the lecturer has to be the mentor and coach who encourages the students to transfer their know-how learned by the participatory teaching methods back to the audience in form of the audit committee. By creating a positive and challenging atmosphere the lecturer should guide the student through the exam. It is imperative to be fair and avoid surprises by asking questions out of the transferred know-how curricula. Handwritten papers might be allowed to support the student in the exam. It has to be made clear beforehand that the amount of personal notes should be kept to a manageable limit.

7. Final Phase

After the exams are completed the final phase concludes the course. The importance of this phase should not be underestimated as it will have a long-lasting impact on the students. As they have hopefully all passed the exams, all students should be asked to (anonymously) evaluate the course. Student evaluation of teaching (SET) is an acknowledged instrument of evaluating teaching effectiveness in institutions of higher education worldwide (Spooren et al. 2013). Though there might be problems applying this instrument it can give valuable insights into students’ reception to further refine and develop the lectures (Gezign 2011). Giving meaningful feedback is also a strong motivation for students’ participation in teaching evaluations (Chen & Hoshower 2003) thus taking students’ opinions and feedback may also strengthen the relationship between lecturer and students.

Overall, it is the final and most important task for the lecturer to encourage the students to be proud of themselves. In order to strengthen the emotional bond and build a trustful and long-lasting future relationship the class and staff of the institution which supported the course could jointly celebrate the end of the course. This will close the whole course in an appropriate way. It will probably be done by the students intuitively but the lecturer should not forget to take photos to value the time he or she has shared with their students.

Implementation of Empowerment Teaching in the Study Course Mineral Resource and Process Engineering - MRPE

Flexible, know-how orientated and international, these are the objectives which are addressed with the new master program Mineral Resource and Process Engineering at TH Georg Agricola. Offered are the two focus areas Mineral Resource Engineering or Process Engineering. Flexibility is implemented as students can arrange their own semester program out of a pool of summer semester modules, winter semester modules and year-round modules. Furthermore, the master program can be studied full-time or part-time. Know-how orientation is matched by a high degree of self-studies, blended learning, teaching in an activating manner and by research orientated modules. The set-up of the program is international; it can be studied either in English or in English and German. The international requirements of e.g. the Society for Mining, Metallurgy & Exploration (SME) and the Accreditation Board for Engineering and Technology (ABET) are fully met[1].

The overall objective or learning outcome of the master program Mineral Resource and Process Engineering is to qualify the graduates for a leading position as an engineer in mining or process engineering. In the beginning, the students enhance their professional knowledge. To prepare the students for a leading role in the industry the professional knowledge is complemented by management skills. In addition to knowledge, the learning objectives competences and skills are fostered in the courses. The students are enabled to define, to structure, to plan and to execute complex projects. They take into consideration the global, economic, ecological and societal context. Furthermore targeted is a problem solving attitude. Students shall be qualified to identify problems and to generate solutions self-dependently. In activating courses, the students learn to act in a team, to lead a team and to communicate the results of their work.

Empowerment Teaching

[1]http://www.abet.org/wp-content/uploads/2015/05/E001-15-16-EAC-Criteria-03-10-15.pdf sowie http://www.abet.org/wp-content/uploads/2015/10/T001-16-17-ETAC-Criteria-10-16-15.pdf

The curriculum of MRPE consists out of 50% contact courses (lectures, labs, practial training) and 50% self-studies. To communicate with students and to provide all kind of course material the online platform Moodle is used. When planning the courses special focus was on the methods of empowerment teaching as described above. As examples for teaching in an activating manner the two modules Case Study Mining Project and Publication Contest are presented below.

During the Case Study Mining Project the students plan self-organized a full-scale mining project in teams of 5 students under realistic conditions (see **Error! Reference source not found.**). Provided are drilling data, topography and information on surface infrastructure. During the course of the semester the students have to work on all aspects of a Feasibility, starting from deposit modelling, mine design and production planning and ending with equipment selection, staffing and financial modelling. Each team has a supervisor and has to prepare a pre-feasiblity-study and a presentation at the end.

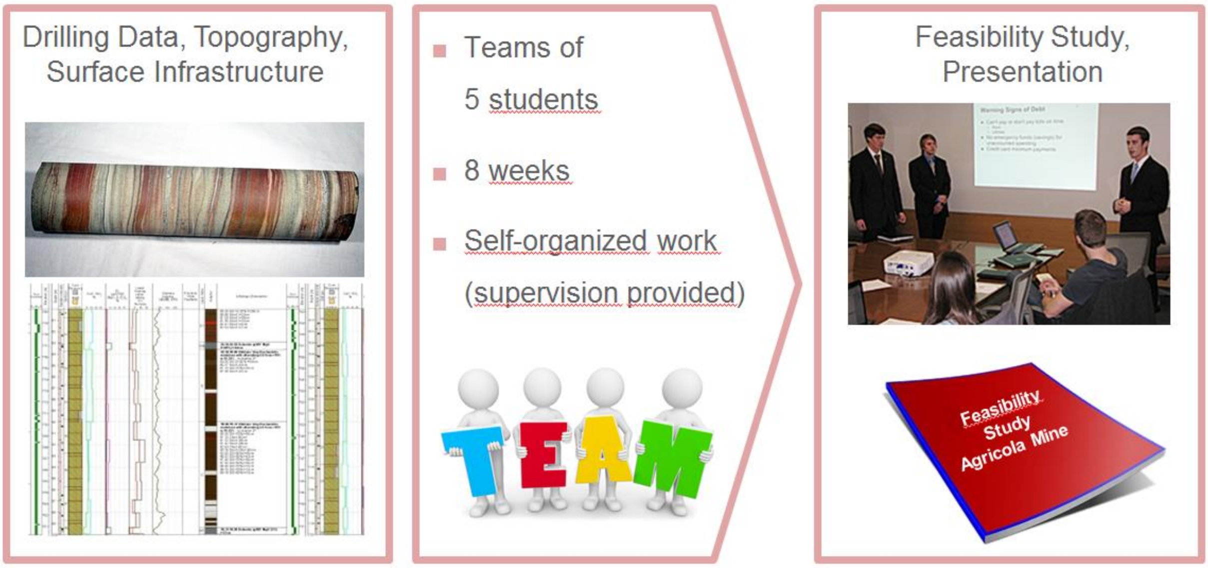

Figure 1: Case Study Mining Project.

The publication contest introduces scientific writing and publications to the students in an interactive way. Based on real authors' guidelines and coached by a lecturer the students prepare a paper on a topic of their own choice. The paper is peer reviewed and feedback is given. (see Figure 2).

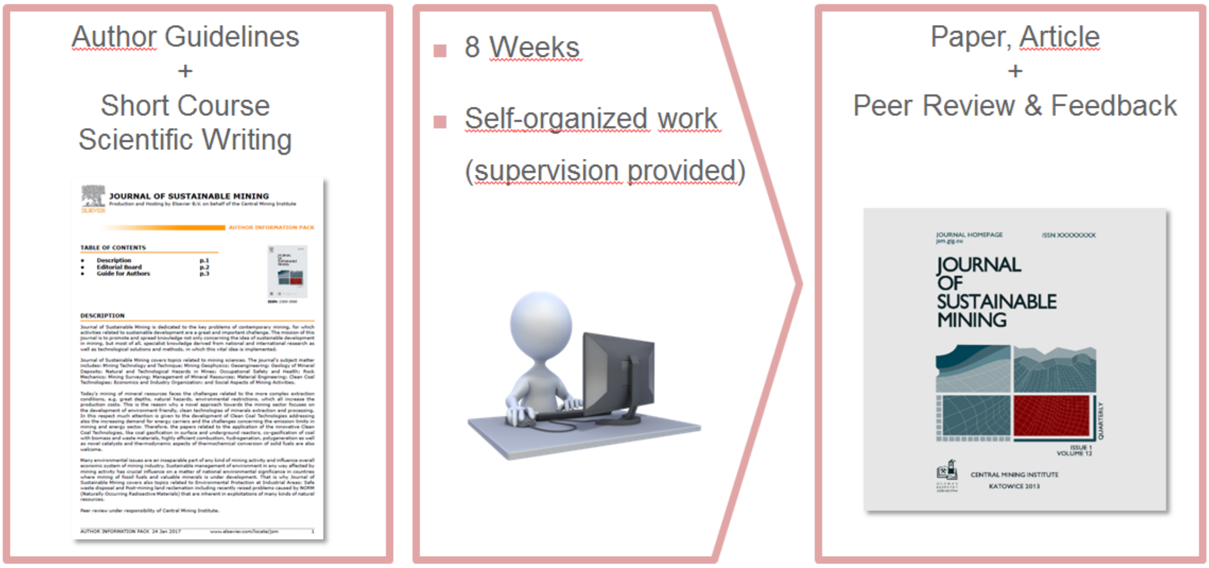

Figure 2: Publication Contest.

Conclusion

Potential orientated participatory teaching methods can improve the effectiveness of an international know-how transfer. The following equation summarizes the authors' vision of such a transfer:

$$a + 2h = c$$

a = I am (a valuable person, lovely, nice, competent, unique characteristic, individual, somebody special, human)

h= I have (knowledge, aims, competencies) I have (friends, a team who will help, people who like me)

c = I can (apply my know-how, solve problems, bear burden, meet challenges, undertake responsibilities, …)

When implementing this equation by using participatory teaching methods lecturers will realize the tremendous learning effort of their students as the biggest advantages of this method compared with the classical "top-down teaching." If international lecturers insist on playing the center role in the class/seminar room, transfer of know-how might be possible, but it is not as effective as possible and denies cultural barriers that might exist. Lecturers should therefore give the participants the initiative in learning, sharing and applying their know-how playing the roles of the coach, motivator and mentor. If lecturers want to teach successfully all over the world, they need excellent language skills, high motivation, humanity, respect, excellent time management, huge emotional engagement and a great passion to their profession. Participatory teaching methods applied effectively can overcome cultural barriers and create win-win situations for both, lecturers and students. This experience will enrich their lives and bring them joy and happiness!

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The Implementation of Soft Skills in the Higher Studies of Engineering to achieve the 2030 Agenda for the Sustainable Development Size

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Abstract*–The European Higher Education Area (EHEA) initiated the development and subsequent implementation of new Study Plans which established the inescapable requirement of the acquisition by future engineers of the so-called Soft Skills.*

These Soft Skills were considered to facilitate the free movement of university students and graduates in Europe and access to an increasingly globalised labour market. Since the implementation of EHEA in 2010, European engineering universities have addressed, in one way or another, the commitment to students to ensure their training and evaluation regarding the Soft Skills that each degree should contemplate. These Soft Skills are related with communication, problem-solving, organization, leadership, teamwork, adaptability, creativity and interpersonal skills and emotional intelligence. And the way each university proceeds has been very diverse, resulting in models of greater or lesser scope of goals and more or less successful results.

The objective of this conference is to promote the implementation of new Soft Skills to achieve the 2030 Agenda for the Sustainable Development seeking to end poverty and hunger, realizing the human rights of all, achieving gender equality and the empowerment of all women and girls, and ensuring the lasting protection of the planet and its natural resources.

How to implement these new Soft Skills and the need to do it, are the backbone of a new way of teaching the new generation of engineers, guaranteeing their teaching and assessment.

Keywords *- Soft Skills, EHEA, 2030 Agenda, Sustainability.*

I. INTRODUCTION

Integrating soft skills into higher studies of engineering is essential for achieving the 2030 Agenda for Sustainable Development. The United Nations´ 2030 Agenda includes 17 *Sustainable Development Goals* (**SDGs**) that address a wide range of global challenges, such as poverty, inequality, climate change, and sustainable economic growth. Engineers play a crucial role in achieving many of these goals, and the development of soft skills can enhance their effectiveness in contributing to these objectives. In this paper, there is going to be a explanation on how soft skills would be implemented in engineering education to support the 2030 Agenda:

- **Communication Skills**: Engineers need to effectively communicate complex technical information to diverse audiences, including non-technical stakeholders. Teaching communication skills can help engineers convey the importance of sustainable practices and technologies to policymakers, the public, and other stakeholders.
- **Teamwork and Collaboration**: Many of the SDGs require interdisciplinary and international collaboration. Teaching engineering students how to work effectively in diverse teams and across cultural boundaries can help them contribute to global sustainable development efforts.
- **Problem-Solving and Critical Thinking**: Engineers often encounter complex and multidisciplinary problems in the context of sustainable development. Encouraging critical thinking and problem-solving skills helps students analyze and develop innovative solutions to sustainability challenges.
- **Ethical and Social Responsibility**: Engineering education should include discussions on ethics and social responsibility. This includes considerations of the environmental and social impacts of engineering projects and decisions.
- **Leadership and Project Management**: Soft skills related to leadership and project management are crucial for engineers who often lead projects that have sustainability implications. These skills help ensure projects are completed efficiently and sustainably.
- **Cultural Sensitivity and Diversity Training**: To work on a global scale, engineers should be culturally sensitive and aware of diversity issues. This promotes a more inclusive approach to sustainable development.
- **Environmental and Social Awareness**: Engineers should be educated about the global challenges addressed by the SDGs, such as climate change, poverty, and inequality. Understanding the context and urgency of these challenges can motivate engineers to develop solutions that align with the 2030 Agenda.

- **Interdisciplinary Education**: Encourage collaboration between engineering and other disciplines such as social sciences, economics, and policy studies. This can help students understand the broader context of sustainable development and the interconnectedness of global challenges.
- **Service Learning and Internships**: Practical experiences in real-world projects related to sustainable development can provide students with opportunities to apply their soft skills and gain a deeper understanding of the challenges and solutions.
- **Assessment and Evaluation**: Incorporate soft skills into the curriculum and assess them alongside technical competencies. This reinforces the importance of these skills and ensures students develop them throughout their education.
- **Continual Improvement**: Engineering programs should adapt and evolve to incorporate soft skills in response to changing societal needs and priorities related to sustainability.

In the following pages, there is an analysis on how incorporating soft skills into higher studies of engineering would be crucial for preparing students to contribute effectively to the 2030 Agenda for Sustainable Development. These skills complement technical knowledge and empower engineers to address complex global challenges in a holistic and responsible manner. By nurturing soft skills in engineering education, it would be possible to create a generation of engineers who are not only technically proficient but also socially and environmentally conscious, making a significant contribution to achieving the SDGs by 2030.

II. COMMUNICATION SKILLS

Improving communication skills in the higher studies of engineering is essential for engineers to effectively contribute to the 2030 Agenda for Sustainable Development. Communication skills are vital for conveying technical information, collaborating with diverse stakeholders, and advocating for sustainable solutions. There are some strategies to enhance communication skills in engineering education to align with the 2030 Agenda:

- Incorporate Communication Courses: Integrate communication courses into the engineering curriculum. These courses should cover various aspects of communication, such as technical writing, oral presentations, and visual communication.
- **Project-Based Learning**: Incorporate projects that require students to communicate their ideas and findings effectively. Emphasize the importance of clear and concise documentation and presentations.
- **Interdisciplinary Projects**: Encourage engineering students to collaborate with students from other disciplines, such as environmental science, public policy, and business. This collaboration exposes them to diverse communication styles and perspectives.
- **Communication Workshops and Training**: Offer workshops and training sessions focused on improving communication skills. These sessions can cover areas like public speaking, effective writing, and interpersonal communication.
- **Peer and Self-Assessment**: Implement peer and self-assessment for communication assignments. This helps students evaluate their own work and provides constructive feedback to their peers, promoting continuous improvement.
- **Mentorship Programs**: Establish mentorship programs where experienced engineers or communication experts can provide guidance and feedback to engineering students on their communication skills.
- **Real-World Case Studies**: Use real-world case studies related to sustainable development projects to teach students how to communicate complex technical information to non-technical stakeholders. Analyze successful and unsuccessful communication strategies.
- **Multimedia Tools**: Encourage students to use multimedia tools, such as videos, infographics, and interactive presentations, to convey technical information in engaging and accessible ways.
- **Cross-Cultural Communication**: Address cross-cultural communication challenges, as engineers often work on global projects. Teach students how to adapt their communication style when working with diverse teams and stakeholders.
- **Debate and Discussion**: Organize debates and discussions on engineering ethics, sustainability, and societal impacts. These activities help students develop argumentation and persuasion skills.
- **Professional Writing**: Emphasize professional writing skills for reports, proposals, and technical documents. Ensure that students can communicate complex engineering concepts clearly and concisely.
- **Public Speaking Opportunities**: Provide opportunities for students to present their research and projects in public forums, conferences, or competitions. Public speaking experiences help build confidence and effectiveness in communication.
- **Social and Environmental Context**: Teach students to communicate the social and environmental context of engineering projects. Help them articulate the broader implications of their work for sustainability and societal well-being.
- **Role-Playing Exercises**: Use role-playing exercises to simulate real-world communication scenarios, such as meetings with stakeholders, regulatory agencies, or the public. This allows students to practice communication in a controlled setting.
- **Feedback and Reflection**: Encourage students to reflect on their communication experiences and seek feedback from instructors and peers. Reflection promotes self-awareness and continuous improvement.
- **Assessment and Grading Rubrics**: Develop clear assessment criteria and grading rubrics for communication assignments. This ensures that students understand expectations and receive consistent feedback.
- **Sustainability Communication**: Emphasize the importance of communicating sustainability principles and solutions effectively. Explore case studies of successful sustainability communication campaigns.

III. TEAMWORK AND COLLABORATION

Improving teamwork and collaboration in higher studies of engineering is vital for achieving the 2030 Agenda for Sustainable Development, as many of the SDGs require interdisciplinary and collaborative efforts. There are strategies to enhance teamwork and collaboration among engineering students:

- **Interdisciplinary Projects:** Design courses and projects that require students to work with peers from different engineering disciplines, as well as students from other fields such as social sciences, business, or environmental studies. Encourage them to understand and appreciate diverse perspectives.
- **Problem-Based Learning:** Integrate problem-solving activities into the curriculum, where students must work together to find solutions to real-world challenges. These activities should mirror the complexity of the problems presented in the SDGs.
- **Team-building Exercises:** Conduct team-building activities and exercises to help students build trust, communication, and cooperation skills. These activities can be part of orientation programs or workshops.
- **Diverse Teams:** Encourage the formation of diverse teams in terms of gender, nationality, and background. Diverse teams tend to be more creative and innovative, leading to better problem-solving.
- **Clear Roles and Responsibilities:** Define roles and responsibilities within teams to ensure everyone understands their contribution. This reduces conflicts and confusion.
- **Effective Communication Training:** Teach students effective communication skills, including active listening and constructive feedback. These skills are essential for resolving conflicts and fostering collaboration.
- **Project Management Skills:** Incorporate project management principles into the curriculum. Understanding project management techniques helps students coordinate tasks, meet deadlines, and work efficiently as a team.
- **Peer Assessment:** Use peer assessment as a tool to evaluate individual contributions within a team. This can encourage accountability and ensure fair grading.
- **Mentorship Programs:** Establish mentorship programs where senior engineering students or faculty members guide and support younger students in collaborative projects.
- **Real-world Partnerships:** Collaborate with industry partners, NGOs, or governmental organizations on projects that address SDGs. Students can benefit from real-world experience and exposure to different stakeholders.
- **Global Collaboration:** Encourage international collaboration through partnerships with universities in different countries. This can provide students with a global perspective on sustainable development challenges.
- **Ethical Considerations:** Discuss the ethical aspects of teamwork and collaboration, such as plagiarism, intellectual property, and responsible conduct in research and projects.
- **Inclusive Environments:** Create inclusive learning environments that value and respect diverse opinions and backgrounds. This fosters a culture of collaboration and mutual respect.
- **Technology Tools:** Use collaboration and project management tools like Slack, Trello, or Microsoft Teams to facilitate communication and coordination among team members, especially when working remotely.
- **Assessment and Reflection:** Include teamwork and collaboration as part of the assessment criteria for projects. Encourage students to reflect on their collaborative experiences and identify areas for improvement.
- **Feedback Mechanisms:** Establish mechanisms for students to provide feedback on their collaborative experiences, courses, and projects. Use this feedback to continuously improve the collaboration aspects of the curriculum.
- **Faculty Development:** Provide training and support for faculty members to facilitate effective teamwork and collaboration among students.

These skills will not only benefit their academic endeavors but also prepare them for successful careers as engineers contributing to SDGs.

IV. PROBLEM-SOLVING AND CRITICAL THINKING

Engineers will play a pivotal role in addressing the complex challenges outlined in the SDGs. There are some strategies to enhance problem-solving and critical thinking in higher studies of engineering for sustainable development:

- **Interdisciplinary Learning**: Promote interdisciplinary courses and projects that expose students to diverse perspectives and approaches to problem-solving. Collaborative work with students from other fields fosters critical thinking by challenging traditional engineering solutions.
- **Real-World Projects**: Engage students in real-world projects that require them to address complex, multidisciplinary sustainability issues. These projects should encourage students to integrate technical knowledge with social, economic, and environmental considerations.
- **Case Studies and Simulations**: Use case studies and simulations to present students with real-world problems and scenarios. Analyzing these cases encourages critical thinking and helps students apply engineering principles to practical situations.
- **Socratic Questioning**: Incorporate Socratic questioning techniques into classroom discussions and problem-solving sessions. Encourage students to ask probing questions to gain a deeper understanding of problems and potential solutions.
- **Critical Reading and Research**: Assign readings and research projects that require students to critically analyze academic papers, reports, and data related to sustainability challenges. Encourage them to evaluate the quality and relevance of sources.

- **Debate and Discussion**: Organize debates and discussions on controversial engineering and sustainability topics. Encourage students to articulate and defend their positions using evidence and logical reasoning.
- **Ethical Dilemmas**: Present students with ethical dilemmas related to engineering and sustainability. Challenge them to consider the ethical implications of their decisions and solutions.
- **Mentoring and Peer Learning**: Encourage peer learning and mentoring relationships among students. Working together on problem-solving tasks and discussing solutions can enhance critical thinking skills.
- **Feedback and Reflection**: Provide constructive feedback on assignments and projects, emphasizing the importance of critical thinking and problem-solving skills. Encourage students to reflect on their thought processes and decision-making.
- **Problem-Based Learning (PBL)**: Implement problem-based learning approaches where students work in small groups to tackle open-ended, real-world engineering challenges. PBL encourages active engagement and critical thinking.
- **Diversity of Perspectives**: Foster an inclusive learning environment that values diverse perspectives. Encourage students to consider different viewpoints when addressing sustainability issues.
- **Continuous Assessment**: Include ongoing assessments that evaluate problem-solving and critical thinking skills, not just technical knowledge. Use a variety of assessment methods, such as essays, presentations, and practical problem-solving tasks.
- **Encourage Innovation**: Encourage students to think innovatively by exploring unconventional solutions to sustainability problems. Highlight the role of innovation in achieving the SDGs.
- **Feedback Loops**: Teach students to establish feedback loops in their problem-solving processes to assess the effectiveness of their solutions over time and make necessary adjustments.
- **Capstone Projects**: Design capstone projects that require students to address significant sustainability challenges. These projects should encompass research, analysis, design, and implementation.

These skills will empower future engineers to tackle complex and multifaceted sustainability challenges and work towards the achievement of the SDGs.

V. ETHICAL AND SOCIAL RESPONSIBILITY

Improving ethical and social responsibility in higher studies of engineering is essential for achieving the 2030 Agenda for Sustainable Development. Engineers play a pivotal role in addressing global challenges, and instilling a strong sense of ethics and social responsibility in engineering education can help prepare future engineers to contribute effectively to sustainable development. There are some strategies to enhance these aspects of engineering education:

- **Incorporate Ethics and Social Responsibility into the Curriculum**: Develop dedicated courses or modules that focus on ethics, social responsibility, and sustainability in engineering. Integrate ethical considerations into existing engineering courses, emphasizing the moral implications of engineering decisions.
- **Case Studies and Real-World Examples**: Use case studies and real-world examples to illustrate ethical dilemmas and social responsibility issues in engineering practice. Analyze historical engineering failures and successes to highlight the importance of ethical decision-making.
- **Guest Lecturers and Industry Experts**: Invite guest lecturers and industry experts to share their experiences and insights on ethical and socially responsible engineering practices. Encourage discussions and debates on ethical challenges in engineering with input from professionals.
- **Ethical Codes and Standards**: Familiarize students with relevant ethical codes and standards, such as the Engineering Code of Ethics established by professional engineering organizations. Encourage students to reflect on these codes and apply them in their coursework and future careers.
- **Service-Learning and Community Engagement**: Promote service-learning projects that allow students to apply engineering skills to address real community needs, emphasizing the social impact of their work. Encourage volunteerism and involvement in community service organizations to foster a sense of social responsibility.
- **Interdisciplinary Collaboration**: Encourage interdisciplinary collaboration with fields such as sociology, economics, and environmental science to broaden students' perspectives on societal and ethical issues. Collaborate on projects that address SDGs and involve multiple disciplines.
- **Debate and Discussion Forums**: Create forums for open discussions and debates on ethical and social responsibility topics relevant to engineering. Encourage students to voice their opinions and engage in critical thinking about complex ethical dilemmas.
- **Research Opportunities**: Support research projects that explore ethical and socially responsible solutions to engineering challenges, particularly those related to the SDGs. Encourage students to publish research findings that contribute to the knowledge base in this area.
- **Ethical Decision-Making Frameworks**: Teach students about ethical decision-making frameworks and models, such as utilitarianism, deontology, and virtue ethics, and how they can be applied in engineering contexts. Engage students in ethical decision-making exercises and discussions.
- **Assessment and Evaluation**: Assess students' understanding of ethics and social responsibility through assignments, projects, and examinations. Provide constructive feedback to help students improve their ethical reasoning and decision-making skills.
- **Faculty Development**: Invest in faculty development programs to ensure that instructors are well-equipped to teach ethics and social responsibility in engineering effectively.

- **Continuous Improvement**: Regularly review and update the curriculum to incorporate emerging ethical challenges and new developments in social responsibility. Seek feedback from students, alumni, and industry partners to enhance the program's effectiveness.

By implementing these strategies, higher studies of engineering can better prepare students to embrace ethical and socially responsible engineering practices, aligning their efforts with the 2030 Agenda for Sustainable Development and contributing to a more sustainable and just world.

VI. LEADERSHIP AND PROJECT MANAGEMENT

Improving leadership and project management skills in higher studies of engineering is essential for contributing to the 2030 Agenda for Sustainable Development. Engineers with strong leadership and project management abilities can better plan, execute, and oversee projects that align with SDGs. There are some strategies to enhance these skills in engineering education:

- **Integrate Leadership and Project Management Courses:** Include dedicated courses in leadership and project management in the engineering curriculum. These courses should cover both theoretical principles and practical applications in the context of sustainable development projects.
- **Case Studies and Real-World Projects:** Incorporate case studies and real-world projects into the curriculum. These provide students with opportunities to apply leadership and project management concepts to actual sustainability challenges.
- **Interdisciplinary Projects:** Collaborate with other departments or schools (e.g., business, environmental sciences, social sciences) to create interdisciplinary projects. This exposes engineering students to diverse perspectives and challenges, which is crucial in achieving SDGs.
- **Guest Lecturers and Industry Experts:** Invite guest lecturers and industry experts who have experience in leadership and project management related to sustainability. They can share practical insights and real-world examples.
- **Simulation and Role-Playing Exercises:** Use simulation and role-playing exercises to mimic leadership and project management scenarios. These exercises allow students to practice decision-making, conflict resolution, and team coordination in a controlled environment.
- **Mentorship Programs:** Establish mentorship programs where students can be paired with experienced professionals in engineering leadership roles. Mentors can provide guidance, share experiences, and offer career advice.
- **Ethical Leadership Discussions:** Include discussions on ethical leadership and responsible project management. Emphasize the importance of considering the social and environmental impacts of engineering projects.
- **Team Building Activities:** Conduct team-building activities and exercises to improve collaboration, communication, and conflict resolution within project teams. These skills are vital for successful project management.
- **Technology and Tools:** Teach students to use project management software and tools commonly used in the industry. Familiarity with tools like Gantt charts, PERT diagrams, and project management software enhances their practical skills.
- **Assessment and Feedback:** Develop clear assessment criteria for leadership and project management skills. Provide constructive feedback to students on their performance in group projects and leadership roles.
- **Industry Internships and Co-op Programs:** Encourage students to participate in industry internships or co-op programs. These experiences allow them to apply leadership and project management skills in real engineering settings.
- **Sustainability Courses:** Integrate sustainability-focused courses into the engineering curriculum, highlighting the relationship between sustainable practices and effective project management.
- **Continual Improvement:** Regularly review and update the curriculum to ensure it remains relevant to evolving sustainability challenges and best practices in leadership and project management.
- **Soft Skills Training:** In addition to technical skills, emphasize the development of soft skills like communication, negotiation, and conflict resolution, which are critical for effective leadership and project management.
- **Global Perspective:** Promote a global perspective by encouraging students to work on international projects or collaborate with students from other countries. This fosters an understanding of global sustainability challenges.

These skills will enable graduates to lead projects that address complex global challenges while considering environmental, social, and economic sustainability.

VII. CULTURAL SENSITIVITY AND DIVERSITY TRAINING

Improving cultural sensitivity and diversity training in higher studies of engineering is essential for achieving the 2030 Agenda, as it promotes inclusivity and a broader perspective in engineering practices. There are some strategies to enhance cultural sensitivity and diversity training in engineering education:

- **Integrate Diversity into the Curriculum**: Include modules or courses dedicated to *Diversity, Equity, and Inclusion* (**DEI**) within the engineering curriculum. These courses should cover topics like unconscious bias, cultural awareness, and the importance of diversity in problem-solving.
- **Interdisciplinary Collaboration**: Encourage interdisciplinary collaboration between engineering and social sciences, cultural studies, and other relevant fields. Joint projects and courses can provide engineering students with a broader understanding of cultural and social issues.
- **Diverse Faculty and Staff**: Promote diversity among faculty and staff. Diverse role models can inspire and support students from underrepresented backgrounds.

- **Cultural Awareness Workshops**: Offer cultural awareness workshops or seminars for students, faculty, and staff. These sessions can provide insights into various cultures, customs, and perspectives.
- **Global Experiences**: Encourage students to participate in study abroad programs, international internships, or cross-cultural projects. These experiences expose students to different cultures and perspectives, fostering a global mindset.
- **Cultural Competency Training**: Develop and offer training programs that focus on cultural competency, emphasizing skills such as active listening, empathy, and effective communication across cultures.
- **Diverse Guest Speakers and Panels**: Invite guest speakers and experts from diverse backgrounds to share their experiences and insights with students. Organize diversity panels and discussions to facilitate dialogue on DEI topics.
- **Inclusive Language and Materials**: Ensure that course materials, assignments, and assessments use inclusive language and incorporate diverse examples and case studies.
- **Mentoring and Support**: Implement mentoring programs that pair students with mentors who can provide guidance on diversity-related issues and career development.
- **Cultural Competency Assessment**: Include cultural competency assessments as part of the curriculum. This can help measure students' progress in developing cultural sensitivity and awareness.
- **Student Organizations**: Support and promote diversity-focused student organizations within the engineering department. These groups can organize events, workshops, and awareness campaigns related to cultural sensitivity and diversity.
- **Feedback Mechanisms**: Establish feedback mechanisms for students to share their experiences and suggestions for improving diversity training. Act on this feedback to continually enhance the curriculum and training programs.
- **Partnerships with Industry**: Collaborate with engineering firms and organizations that prioritize diversity and inclusion. This can provide students with real-world examples of inclusive engineering practices.
- **Inclusive Recruitment Practices**: Implement inclusive recruitment practices to attract a diverse student body. Scholarships, outreach programs, and partnerships with underrepresented communities can help achieve this goal.
- **Faculty Development**: Provide training and resources for faculty to create inclusive classrooms and teaching environments.
- **Assessment and Accountability**: Regularly assess the effectiveness of diversity training programs and hold departments accountable for progress in achieving diversity and inclusion goals.

VIII. ENVIRONMENTAL AND SOCIAL AWARENESS

Improving environmental and social awareness in higher studies of engineering is crucial for preparing future engineers to contribute effectively to the 2030 Agenda. There are several strategies to enhance awareness in engineering education:

- **Incorporate Sustainability Courses**: Integrate mandatory sustainability and social responsibility courses into the engineering curriculum. These courses can cover topics such as environmental science, social equity, sustainable design principles, and the UN SDGs.
- **Multidisciplinary Approach**: Encourage collaboration between engineering and other disciplines such as environmental science, sociology, economics, and policy studies. Interdisciplinary projects and coursework can help students understand the broader context of sustainability challenges.
- **Real-World Case Studies**: Use real-world case studies to illustrate the environmental and social impacts of engineering projects. Analyzing past successes and failures can help students appreciate the consequences of engineering decisions.
- **Guest Speakers and Industry Experts**: Invite guest speakers and industry experts to share their experiences and insights related to sustainability and social responsibility in engineering. This provides students with real-world perspectives and connections to the industry.
- **Sustainability Research Projects**: Encourage students to conduct research on sustainability-related topics. Engage them in projects that address specific SDGs or local environmental and social challenges, fostering a sense of responsibility and empowerment.
- **Field Trips and Site Visits**: Organize field trips to sustainable infrastructure projects, renewable energy facilities, environmental conservation sites, or socially responsible organizations. These visits offer hands-on experiences and showcase best practices.
- **Community Engagement**: Encourage students to engage with local communities on projects that address their specific needs and concerns. This can foster a deeper understanding of social issues and the role of engineers in addressing them.
- **Ethical Dilemma Discussions**: Facilitate discussions and debates around ethical dilemmas in engineering. Present students with scenarios that require them to consider the environmental and social consequences of their decisions.
- **Ethics Training**: Offer workshops or courses on ethics and social responsibility within the engineering profession. Emphasize codes of conduct and ethical decision-making frameworks.
- **Sustainability Assessment Tools**: Teach students how to use sustainability assessment tools and frameworks, such as *Life Cycle Assessment* (**LCA**) and *Social Impact Assessment* (**SIA**), to evaluate the environmental and social impacts of engineering projects.
- **Green Campus Initiatives**: Implement sustainable practices on the campus itself, such as energy-efficient buildings, waste reduction programs, and renewable energy installations. These initiatives serve as living examples of sustainability principles.
- **Student Organizations**: Encourage the formation of student organizations focused on sustainability and social responsibility in engineering. These groups can organize events, projects, and awareness campaigns.

- **Sustainability Competitions**: Participate in or organize sustainability-focused engineering competitions. These competitions challenge students to apply their engineering skills to solve real-world environmental and social problems.
- **Mentorship Programs**: Pair students with mentors who have expertise in sustainability and social responsibility. Mentors can provide guidance, share experiences, and inspire students to pursue sustainable engineering careers.
- **Assessment and Certification**: Implement assessment criteria and certification programs that recognize and reward engineering programs for their commitment to sustainability and social responsibility.
- **Continuous Learning**: Promote a culture of lifelong learning by encouraging engineers to stay informed about emerging sustainability trends and technologies throughout their careers.

By implementing these strategies, higher education institutions can equip engineering students with the knowledge, skills, and ethical awareness needed to make meaningful contributions to the 2030 Agenda.

IX. INTERDISCIPLINARY EDUCATION

There are strategies to enhance interdisciplinary education in engineering to align with the 2030 Agenda:

- **Develop Cross-Disciplinary Courses**: Create courses that bring together engineering students with those from other disciplines, such as environmental science, economics, public policy, and social sciences. These courses should focus on sustainability-related topics and challenges.
- **Integrate Sustainability Across Engineering Disciplines**: Ensure that sustainability principles and concepts are integrated into the core curriculum of various engineering disciplines, from civil to electrical engineering.
- **Interdisciplinary Research Centers**: Establish research centers or labs that encourage collaboration between engineering departments and other academic units. These centers can focus on sustainable technology, policy, and social solutions.
- **Capstone Projects**: Incorporate interdisciplinary capstone projects into the curriculum. These projects can bring together students from different disciplines to tackle real-world sustainability challenges.
- **Cross-Training**: Encourage engineering faculty to participate in training and workshops related to interdisciplinary teaching and research. This will enable them to better facilitate interdisciplinary learning.
- **Hiring Interdisciplinary Faculty**: Recruit faculty members who have expertise in both engineering and related fields. This can facilitate interdisciplinary teaching and research within engineering programs.
- **Create Shared Spaces**: Design physical or virtual collaborative spaces where students and faculty from different disciplines can meet, exchange ideas, and work on projects together.
- **Interdisciplinary Conferences and Seminars**: Organize events that bring together experts from various fields to discuss and explore sustainable development challenges. Encourage students to attend and participate.
- **Student Organizations**: Support and fund student-led interdisciplinary clubs or organizations focused on sustainability, where students can collaborate on projects and initiatives.
- **Competitions**: Participate in interdisciplinary competitions or challenges related to sustainability. These events can motivate students to work together on innovative solutions.
- **Assessment and Evaluation**: Develop clear learning outcomes for interdisciplinary education, and regularly assess and evaluate students' abilities to work across disciplines to solve complex problems.
- **Feedback Mechanisms**: Gather feedback from students and faculty to identify areas for improvement in interdisciplinary education efforts.
- **Partnerships and Engagement**: Forge partnerships with industry, non-governmental organizations, and government agencies engaged in sustainability initiatives. These partnerships can provide students with real-world exposure and opportunities for interdisciplinary work. Encourage students to engage with local communities to address sustainability challenges. Such projects can provide valuable interdisciplinary experiences.
- **Flexibility and Adaptation**: Be flexible in updating the curriculum and interdisciplinary programs to address evolving sustainability challenges and emerging technologies.
- **Interdisciplinary Leadership Training**: Develop leadership programs that specifically focus on training engineers to lead interdisciplinary teams and projects related to sustainable development.
- **Promote Awareness and Advocacy**: Conduct awareness campaigns and seminars to educate students about the importance of interdisciplinary approaches in achieving the SDGs.

X. SERVICE LEARNING AND INTERNSHIPS

There are some ways to enhance service learning and internships in engineering education to align with the 2030 Agenda:

- **Align Internship Opportunities with SDGs**: Collaborate with organizations and companies that are actively working on projects related to the SDG. Ensure that internships provide direct exposure to sustainability initiatives.
- **Establish Clear Learning Objectives**: Define specific learning objectives and outcomes for each internship or service-learning experience. These objectives should focus on both technical skills and soft skills related to sustainability.
- **Interdisciplinary Collaboration**: Encourage interdisciplinary collaboration during internships by placing engineering students alongside students from other disciplines like environmental science, public policy, or social sciences. This promotes a holistic approach to problem-solving.
- **Mentorship and Guidance**: Assign experienced mentors to guide students during their internships. Mentors can provide valuable insights, help students navigate challenges, and connect them with relevant resources

- **Feedback and Reflection**: Incorporate regular feedback sessions and reflective exercises throughout the internship or service learning experience. Encourage students to critically evaluate their work and its impact on SDGs.
- **Project-Based Learning**: Emphasize project-based learning during internships. Students should work on meaningful projects that address real sustainability challenges, enabling them to see the tangible results of their efforts.
- **Community Engagement**: Encourage students to engage with local communities and stakeholders to better understand their needs and perspectives. This can foster a sense of social responsibility and cultural sensitivity.
- **Sustainability Metrics and Measurement**: Integrate sustainability metrics into internship projects so that students can measure and report on the environmental, social, and economic impacts of their work.
- **Global Perspective**: Promote international internships or collaborations with organizations and projects in different parts of the world. This can help students gain a global perspective on sustainability challenges and solutions.
- **Ethical Considerations**: Discuss ethical considerations and dilemmas that may arise during sustainability-focused internships. Encourage students to think critically about the ethical implications of their work.
- **Networking Opportunities**: Facilitate networking opportunities for students during their internships. This can include connecting them with professionals in the field, alumni, and organizations actively engaged in sustainability efforts.
- **Assessment and Evaluation**: Develop assessment criteria to evaluate the effectiveness of internships in meeting sustainability goals. Use feedback from students, mentors, and employers to continually improve the program.
- **Integration with Curriculum**: Integrate service learning and internship experiences into the engineering curriculum. Ensure that these experiences are seen as an integral part of the education process rather than optional add-ons.
- **Support and Resources**: Provide students with access to resources and tools that can enhance their ability to contribute to sustainability efforts during internships. This may include access to relevant research, software, or databases.
- **Promote Long-Term Engagement**: Encourage students to continue their involvement in sustainability initiatives beyond their internships, fostering a lifelong commitment to sustainable development.

These experiences can empower future engineers to make meaningful contributions toward a more sustainable and equitable world.

XI. ASSESSMENT AND EVALUATION

Effective assessment and evaluation can help measure students' understanding of sustainability concepts, their ability to apply them in engineering projects, and their development of soft skills necessary for sustainable development. There are some strategies to enhance assessment and evaluation in engineering education for sustainable development:

- **Align Assessments with SDGs:** Ensure that assessment criteria and learning outcomes are aligned with the specific SDGs relevant to engineering disciplines. Make it clear to students how their coursework and projects contribute to these goals.
- **Incorporate Sustainability into Course Objectives:** Integrate sustainability as a core component of course objectives, emphasizing its importance alongside technical content. This will set the tone for assessments that reflect sustainability principles.
- **Authentic Assessment:** Move beyond traditional exams and quizzes and implement authentic assessments that mirror real-world engineering challenges. This could include project-based assessments, case studies, and simulations that require students to address sustainability issues.
- **Rubrics for Sustainability Competencies:** Develop rubrics that explicitly outline the criteria for assessing sustainability competencies, such as ethical decision-making, systems thinking, and social responsibility. These rubrics can guide both instructors and students.
- **Interdisciplinary Assessments:** Collaborate with other departments or faculties to create interdisciplinary assessments that reflect the complexity of sustainable development challenges. This encourages students to consider various perspectives and solutions.
- **Peer and Self-Assessment:** Incorporate peer assessment and self-assessment as valuable tools for students to reflect on their sustainability knowledge and skills. This can encourage self-directed learning and peer-to-peer feedback.
- **Longitudinal Assessment:** Assess sustainability competencies and knowledge development over the course of a student's academic career rather than in isolated courses. This provides a more comprehensive view of their growth in sustainability.
- **Community Engagement and Service Learning:** Implement assessments that require students to engage with local communities or work on real sustainability projects. These experiences can be assessed through reflective journals, reports, or presentations.
- **Capstone Projects:** Require engineering students to complete capstone projects that address real-world sustainability challenges. These projects should be assessed not only on technical aspects but also on their alignment with sustainable development principles.
- **Portfolio Assessment:** Encourage students to maintain a portfolio of their work, including essays, projects, and reflections on sustainability topics. Portfolios can serve as a comprehensive assessment tool for sustainability competencies.
- **Continuous Feedback:** Provide timely and constructive feedback to students on their sustainability performance. This feedback should focus on strengths and areas for improvement.
- **Faculty Development:** Offer training and professional development opportunities for faculty members to enhance their understanding of sustainability and assessment methods. This will enable them to design effective assessments.

- **External Stakeholder Input:** Seek input from external stakeholders, such as industry professionals and sustainability experts, to ensure that assessments are relevant and align with real-world sustainability challenges.
- **Data Analysis and Evaluation:** Collect and analyze assessment data to identify trends and areas where improvements are needed in the curriculum. Use assessment results to inform curriculum enhancements.
- **Transparency and Communication:** Clearly communicate assessment expectations and criteria to students. Engage in transparent dialogue about the role of assessments in preparing students for sustainable development challenges.

XII. CONTINUAL IMPROVEMENT

Continual improvement in higher studies of engineering is essential to ensure that engineering education remains aligned with the goals. To enhance this aspect, institutions and educators could consider the following strategies:

- **Establish a Culture of Continuous Improvement**: Create a culture within engineering programs that values ongoing improvement and innovation in teaching and curriculum development. Encourage faculty, staff, and students to actively participate in and contribute to the improvement process.
- **Engage Stakeholders**: Involve various stakeholders, including industry professionals, alumni, students, and community members, in the evaluation and improvement of engineering programs. Seek feedback and input from these stakeholders to identify areas for enhancement.
- **Data-Driven Decision Making**: Collect and analyze data on student performance, learning outcomes, and program effectiveness. Use assessment results and feedback to identify areas in need of improvement and make data-driven decisions.
- **Curriculum Review and Revision**: Regularly review and update the engineering curriculum to ensure it aligns with the latest industry trends, technological advancements, and sustainability principles. Incorporate interdisciplinary and sustainability-focused courses and projects into the curriculum.
- **Faculty Development**: Invest in faculty development programs to keep educators updated on the latest teaching methods, technologies, and research in their fields. Encourage faculty to integrate sustainability concepts and practices into their courses.
- **Quality Assurance Mechanisms**: Implement quality assurance mechanisms, such as program accreditation and peer review, to ensure that engineering programs meet established standards and continuously improve. Monitor and assess program outcomes to maintain and enhance quality.
- **Benchmarking**: Compare engineering programs with similar institutions and programs nationally and internationally to identify areas where improvements can be made. Benchmarking can provide insights into best practices and areas for enhancement.
- **Interdisciplinary Collaboration**: Promote collaboration between engineering programs and other departments or colleges, such as environmental science, business, and policy, to foster a multidisciplinary approach to sustainability challenges.
- **Incorporate SDGs**: Integrate the SDGs into the curriculum and research activities to highlight the importance of sustainability in engineering education. Encourage students to work on projects and research that directly contribute to SDGs.
- **Experiential Learning**: Emphasize experiential learning opportunities, such as internships, co-op programs, and service-learning projects, that allow students to apply their engineering skills in real-world sustainable development contexts.
- **Feedback Loops**: Establish feedback loops between students, faculty, and administrators to ensure that concerns and suggestions for improvement are heard and acted upon. Regularly solicit feedback from students about their educational experiences.
- **Partnerships with Industry and *Non-Governmental Organizations* (NGOs)**: Collaborate with industry partners and NGOs that have expertise in sustainable development to provide students with practical experiences and insights.
- **Sustainability Committees**: Form sustainability committees or task forces within engineering departments or institutions to focus on sustainability initiatives and improvement efforts.
- **Long-Term Planning**: Develop long-term strategic plans that outline specific goals and timelines for continual improvement in alignment with the 2030 Agenda.
- **Publicize Achievements**: Celebrate and publicize the successes and achievements of engineering programs in contributing to sustainability and the SDGs. This can help motivate stakeholders and attract students who are passionate about sustainability.

XIII. CONCLUSIONS

In the pursuit of the 2030 Agenda for Sustainable Development, engineering education stands as a vital catalyst for shaping a sustainable future. To effectively contribute to this ambitious global agenda, engineering programs must evolve and adapt. Two fundamental pillars emerge: the integration of soft skills and a commitment to continual improvement.

The infusion of soft skills into engineering education recognizes that the challenges of sustainability extend beyond technical proficiency. Effective communication, teamwork, ethical awareness, and cultural sensitivity are paramount in addressing complex global issues. Soft skills empower engineers to convey the importance of sustainable practices, collaborate across disciplines and cultures, and navigate ethical and social dimensions. Engineering graduates armed with these skills become versatile change agents, well-prepared to engage with diverse stakeholders and drive progress toward the SDGs.

However, soft skills alone are insufficient without a robust mechanism for continual improvement in engineering education. To maintain relevance and responsiveness to evolving sustainability needs, institutions must cultivate a culture of perpetual enhancement. This entails regular curriculum updates, data-driven decision-making, faculty development, and engagement with stakeholders. Sustainability, as embodied by the SDGs, should permeate engineering programs, from course content to research endeavors. Quality assurance mechanisms, benchmarking, and interdisciplinary collaboration ensure that educational offerings align with global best practices and emerging trends.

In conclusion, the nexus of soft skills and continual improvement forms the cornerstone of engineering education's contribution to the 2030 Agenda. By nurturing soft skills and fostering a culture of perpetual refinement, higher studies of engineering can produce graduates who are not only technically proficient but also socially conscious, culturally adept, and environmentally responsible. These graduates are poised to drive innovation, tackle sustainability challenges, and make a lasting impact on the path to a more equitable, resilient, and sustainable world. Engineering education, thus, emerges as a pivotal force in building a better future for all.

Globalization of Engineering Capacity Building and its Realization Path

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1. Globalization of Engineering Capacity Building

Sciences help us understand the world, and engineering helps us transform it. Engineering ability is an important force for human beings to develop economy, eliminate regional differences and achieve the United Nations 2030 Sustainable Development Goals.

How to improve the engineering capacity of various regions has been highly valued by the United Nations. UNESCO' s Medium-Term Strategy 2022-2029 clearly states that UNESCO will work to ensure that countries in the developing world are not mere users of these technologies, but are also equipped to actively participate in their design and development so as to benefit from the economic, Social and cultural opportunities they offer. It also points out that the international coordination for the achievement of SD4 and the development of the global education agenda based on research, foresight and innovation.

In order to achieve the above goals, UNESCO put forward its own plan of "strengthening impact and partnerships", including strengthening cooperation with non-governmental organizations. World Federation of Engineering Organizations (WFEO) and its member, the Federation of Engineering Institutions of Asia and the Pacific (FEIAP), have become UNESCO's global and regional partners in the engineering field.

In March 2018, UNESCO and WFEO jointly signed their Paris Declaration, Advancing the United Nations Sustainable Development Goals through engineering, on our commitments to progress the United Nations Sustainable Development Goals through engineering. UNESCO hopes to turn its goals into concrete implementation measures, which is to promote the realization of the goals through engineering. This Declaration establishes the role that WFEO will play with UNESCO in leading engineering projects which meet this objective.

The Paris Declaration declares: Inform global standards for engineering education, support the development of a range of engineering education systems to comply with agreed standards and facilitate the mobility of engineers and support capacity-building though strong institutions for engineering education and the development of accreditation bodies for the recognition of professional credentials.

This means that the globalization of engineering capacity building needs a global standard.

In November 2019, The Declaration of Global Engineering Education Standards and Capacity Building for Sustainable Development was signed between WFEO, UNESCO and International Engineering Alliance(IEA) on the need to work together for internationally recognised engineering education standards and capacity building in engineering education.

This decaration further clarifies that Recognise the Current IEA Graduate Attributes and Professional Competencies Framework as international engineering benchmark standards. Extend the global reach of the IEA Agreements and Accords though capacity building efforts. Facilitate the international mobility of engineers.

WFEO and IEA have become an important force to enhance global engineering capability and achieve the sustainable development goals of the United Nations through engineering.

Marlene Kanga, the former president of WFEO, must be mentioned here. On behalf of WFEO, she signed the above two declarations with UNESCO and IEA, making outstanding contributions to the globalization of engineering capacity building and the international mobility of engineers.

2. Roadmap of Globalization of Engineering Capacity Building and the Role of FEIAP

As a member of WFEO, FEIAP is the most influential engineering organization in the Asia-Pacific region. FEIAP itself has the engineering ability standard and engineering education standard which are essentially equivalent to IEA. In recent years, FEIAP has made continuous efforts in promoting the standardization of engineering education in the Asia-Pacific region and the world, and improving the engineering capabilities of various regions, and has become the most dynamic organization among global engineering organizations.

During the 31st FEIAP GA and 7th Special Distinguished Lectures held in Naypyidaw, Myanmar in September, 2023, Dr Marlene Kanga, the former president of WFEO, and Prof. Elizabeth Taylor, the Chair of the Governing Group of IEA, both spoke highly of FEIAPs work in recent years in their Lectures.

FEIAP, as a non-governmental engineering organization alliance, pays attention to the development of the whole South and actively promotes South-South cooperation on the premise of focusing on the development of the Asia-Pacific region. In April 2022, FEIAP and Federation of Africa Engineering Organizations (FAEO) signed the AFRICA, ASIA and THE PACIFIC ACCORD (AAP ACCORD). It says This AAP Accord should be able to pave the way to a more integrated approach to engineering education amongst member economies, and hence encourage and facilitate mobility. The AAP Accord allows compatibility of standards and procedures, and aims to achieve substantial equivalence. This Accord will provide a platform for mutual recognition of the substantial equivalence of the engineering academic qualifications and for promotion of mobility of engineering work force for AAP Graduate Engineers, AAP Graduate Engineering Technologists and AAP Graduate Engineering Technicians.

This agreement has been strongly supported by UNESCO and WFEO. Representatives from UNESCO headquarters, offices in Asia-Pacific and Africa, and WFEO attended the signing ceremony.

At present, on the basis of realizing the integration of engineering education standards in Africa, Asia and the Pacific, FEIAP and FAEO are actively seeking cooperation with Latin American engineering organizations, so as to sign an agreement of Africa, America, Asia and the Pacific (AAAP ACCORD) to realize the integration of engineering education and engineering capability standards in the whole South. Through superior cooperation, the engineering education level and engineering capability of the whole South can be improved, the economic development of the whole South can be promoted, and the sustainable goals of the United Nations can be achieved. To this end, we can outline the road map of globalization of engineering capacity building.

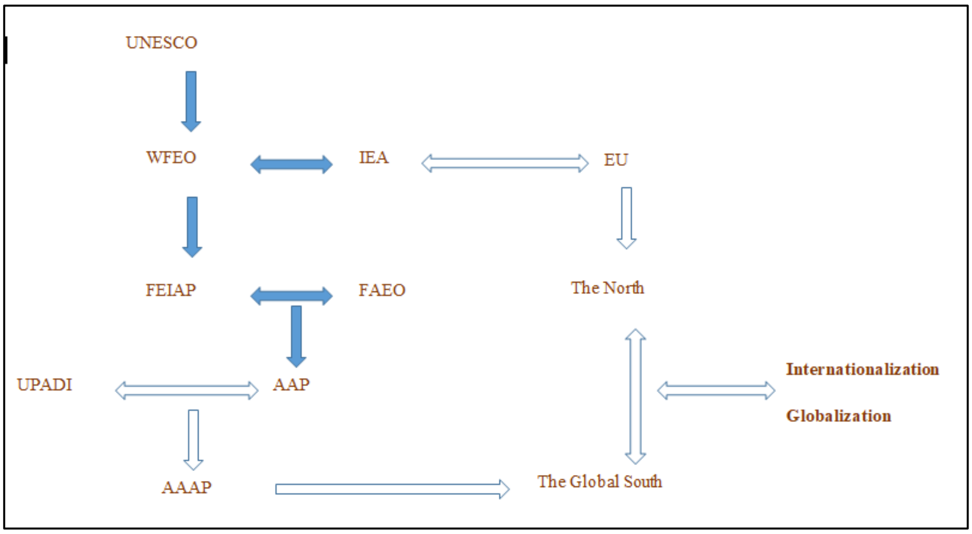

Figure 1. Here UPADI means Union Panamerican de Asociaciones de Ingenieros.

3. Nest Steps

In order to realize the cooperation of all southern engineering organizations in engineering capability and engineering education standards, during the period of 31th FEIAP GA, FEIAP GA passed a motion suggested by The representative of CAST to hold an international engineering organizations conference together with Chinese Society of Engineers. The first congress of international engineering organizations is scheduled to be held in Taizhou, China in 2024, and will be held every two years with Taizhou, China as the fixed venue, so as to become a public platform for engineering organizations to negotiate and cooperate around engineering capacity building and engineering education with the support of UNESCO, WFEO and IEA. This is an important achievement of 2023FEIAP GA. Achieving this goal will be of great significance to promoting all-South cooperation in the engineering field and promoting the realization of the sustainable goals of the United Nations.

SUSTAINABILITY DEVELOPMENT GOALS & ENGINEERING EDUCATION

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I. INTRODUCTION

Sustainability has been recognised as the most important requirement in the entire world, as for quite some time, world witnessed the damages it could suffer in the absence of the awareness. Pandemic COVID-19 strengthened this realisation still further. World leaders, political, economic or social all have been debating the issue for several years and had already defined 17 sustainability goals and fixed 2030 as the target date to achieve the same. It is well appreciated that this is not an easy task and as of date, target does not seem reachable in the defined timeframe, thus enhancing the concerns.

I have always believed that the fundamental duty of any Engineer is to make living better which might mean more comfortable, more healthy, more productive, more efficient or more useful to the society at large. We cannot afford any more time to be lost in ensuring that all Engineers are sustainability conscious as they will have to contribute a major share in the journey towards these goals. Best for this will be to start with Engineering Education as to make Engineers contribute in this direction from day one of their professional careers.

In addition to the sustainability, as priority certain other demands of present-day Global Economy are: Creativity & Innovation, Application Orientation, Critical Analysis, Optimum Synthesis & Collaborative Learning. We need workforce capable of retaining and learning new skill/competencies in addition to the awareness of, Sensitivity towards and Implementation of Sustainable Development Goals. Conventional Approach of treating education as transmission of expert knowledge is just not suitable for achieving these goals.

II. SUSTAINABILITY DEVELOPMENT GOALS

"Transforming our world: the 2030 Agenda for Sustainable Development" has realised that Technology and social organization can be both managed and improved to make way for a new era of economic growth. It is now well appreciated that the Sustainable Development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs.

To facilitate this, the following 17 Sustainable Development Goals (SDGs) have been identified in the 2030 Agenda for Sustainable Development.

- Eliminate Poverty
- Erase Hunger
- Establish Good Health and Well-Being
- Provide Quality Education
- Enforce Gender Equality
- Create Decent Work and Economic Growth
- Reduce Inequality
- Develop Life Below Water
- Advance Life on Land
- Guarantee Peace, Justice, and Strong Institutions
- Build Partnerships for the Goals
- Improve Clean Water and Sanitation
- Grow Affordable and Clean Energy
- Increase Industry, Innovation, and Infrastructure
- Mobilize Sustainable Cities and Communities
- Influence Responsible Consumption and Production
- Organize Climate Action

At times, I find even Engineers having the view that Engineering Education is to contribute only to some of these SDGs. I disagree and disagree strongly. Engineers will be needed to have an upscaled mindset for contributing to each of the SDGs. To explain my point, let us take the first Goal of 'Eliminate Poverty'. It may look like purely a social or economic problem, but will we ever be able to achieve this without breakthrough revolutions in Food Technology or Agricultural Engineering? Similarly, tackling the second SDG 'Erase Hunger' will require cost effective living, Quality affordable Food, etc. Also, most of these Goals are closely interrelated. Some, of course such as Affordable and Clean Energy, Clean Water & Sanitation, Climate Action are more directly connected to Engineering.

III. NEED FOR CREATIVITY

More important point, which I wish to make is that traditional thinking of incremental improvements will not take us towards the Solutions. These are complex problems. Some of these will have difficult Solution, while quite a few may have rather simple solutions. But Creative 'Out-of-the-Box-Thinking' is a must. The tools and technologies which have brought us up to this point will not take us beyond this point.

Fortunately, Creativity is hardwired into everyone's brain. The challenge is to unleash this all-too-often untapped potential. The challenge is to combine peoples' talent with their passion and to ensure that we do not provide an environment which suppresses Creativity. The connection between big picture and details inspires breakthroughs in all kinds of fields. Creativity flourishes neither in complete chaos nor in complete order. Creativity, it is shown seems, flourishes when people see not just the individual trees but the forest as well. To be able to appreciate the 'Crow view' of an issue as well as 'Snail View' of that issue is necessary to solve such problems.

My emphasis on Creativity stems from the fact that I cannot visualise solutions to Sustainability Issues in a reasonable time frame at an affordable cost by using routine thought process, howsoever intense. We have to resort to insights enabling a breakthrough, which will occur when routines are broken. Constantly looking at the same problem with the same eye never brings a 'Eureka' moment. History of Eureka moments leads us to a find the generation of revolutionary thought while in the Bath, travelling in the Bus or just in the Bed relaxing. Creativity is normally possible only when you permit distractions and when the mind is not focusing on the problem at hand. The great mathematician Paul Erdos puts it.

"A mathematician is a machine for turning Coffee into theorems." Many creative inventions occur at a small coffee shop or in a small park while relaxing or just gossiping.

IV. SOME SUSTAINABILITY INNOVATIONS

I am not talking in the abstract and am just mentioning a few innovative Engineering solutions for complex Sustainability Issues, which have already become a reality:

1. Air pollution can now be transformed into jewellery
2. An autonomous solar balloon bringing electricity to disaster zones
3. The Green Building Initiative
4. A sustainable plastic for the future
5. Solar Glass could cover your home in the future
6. Fabric created with recycled coffee grounds
7. An All-Natural Alternative to Plastic Bottles
8. Converting fog into drinking water
9. The ethical smart phone
10. Get Cash for Your Old Electronics

These examples will illustrate adequately how change of mindset is the primary ingredient for sustainable solutions. Could anyone imagine even a couple of years ago that an organisation like 'Apple' will give up their USP of 'Use and Throw' for the sake of sustainability. They have now set up most sophisticated repair centres even up to the level of 'parts. More importantly, they have been able to successfully convince their clients all over the world that 'Sustainability' is the joint responsibility of all of us even at the cost of a bit of inconvenience of not getting the new phone as an instantaneous replacement.

V. FOCUS ON QUALITY IN ENGINEERING EDUCATION

These changes can come in only by Quality focussed Outcome Based Innovative Engineering Education. The contribution of International Engineering Alliance IEA in this regard is a great step. After a lot of thought process and efforts, IEA and the signatories of the Washington Accord, WA had prepared a list of 12 Graduate Attributes, GAs as expected outcomes for any Engineering Graduate. The most fundamental criterion for granting accreditation to any Engineering Degree Institution is to confirm that its graduates are proficient in having achieved these GAs. One of the greatest contributions of the IEA and WA in the world is to bring in the reality that:

- Program Based Accreditation,
- Outcome Based Education, and
- Graduate Attributes, Or Program Outcomes

are practically synonymous.

IEA's Graduate Attributes Program Committee GAPC first approved GAs in June 2013 by IEA and has been an excellent benchmark over the years. The progress report to the IEA Governing Group in May 2020 contained a detailed exposition of the role, purpose, composition of the Working Group set up for the review and a summary of project activities. The cause and time for review were ripe due to the following stimuli:

- Need to accommodate future needs of engineering professionals and the profession
- Emerging technologies
- Emerging and future engineering disciplines and practice areas
- Need to incorporate UN Sustainable Development Goals
- Rising relevance of diversity and inclusion
- Urgency to emphasize intellectual agility, creativity and innovation.

It was also observed that the coalition of EWB's including Engineers Without Borders International, Australia, UK, Canada, and its research offshoot Engineering Change Lab, Brazil, India, the Netherlands, the Philippines, and the USA were calling for following three core competencies to be universally incorporated. It was observed that these observations practically echo the deliberations of WA/IEA to go in for major changes in Engineering Education System:

1. Emphasis on critical thinking as a fundamental cornerstone of engineering competence – critically analysing and critiquing the role of engineering, its relationship with humanity, and its impact on our past and potential futures.
2. Deeper comprehension of the ethical issues inherent in engineering due to the relationship between engineering, people and the planet, and greater focus on developing the skills necessary to navigate these complex issues.
3. Broader appreciation for the knowledge needed to make effective engineering judgments, including explicitly acknowledging the value of the social sciences in helping engineers understand the implications of their work.

VI. TRANSFORMATIVE LEARNING APPROACH

It is thus highly required to adopt a transformative learning approach which will incorporate creative thinking. When the students worked on real life problems in their projects at Laboratories and at internship, they will come up with sustainable solutions which will be economically viable, environmentally friendly and socially feasible. It was necessary for them to acquire:

- Sensitivity towards SDGs
- Awareness & understanding of SDGs
- Preparedness towards contributing to SDGs

This has resulted in a revised set of GAs which will be now incorporated by all members of WA in a phrased manner. The updated objectives of present-day Engineering Education have to be:

- Design solutions for complex engineering problems keeping economic, environmental and societal components in focus.
- Access to affordable, reliable, sustainable and modern energy
- Sustainable management of water and sanitation
- Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- Sustainable consumption and production patterns
- Make cities and human settlements inclusive, safe, resilient and sustainable suggestions

As a first step, it is suggested that:

1. Let every project by the Engineering Student in any course have subsections on:
   - Cost estimation & comparison with existing alternatives
   - Energy requirements & comparison with existing alternatives
   - Feasibility of use of environment friendly materials and/or green energy
2. Prepare at least one term report/self-study course dissertation demonstrating the use of Engineering Knowledge towards chosen SDG.
3. Conduct Frequent Seminars on increasing awareness with defined objectives.

For these changes to be really implementable, we must shift to Outcome Based Framework from the conventional Time-Based Framework, which was really designed for its suitability to the Industrial Age. This Framework was designed with the following features:

- Calendar Defined
- Constrained Opportunity
- Custodial Credentialing
- Content Segmentation
- Curriculum Coverage
- Cumulative Achievement
- Selection Categories
- Contest Learning
- Comparative Evaluation
- Cellular Structure

These Characteristics are not really suitable for Outcome based Education or Creative Education. We have to swich to the Information Age Paradigm with the following features:

- Outcome Defined
- Expanded Opportunity
- Performance Credentialing
- Concept Integration
- Instructional Coaching
- Culminating Achievement
- Inclusionary Success
- Cooperative Learning
- Criterion Validation
- Collaborative Structure

VII. SIMPLE MINDSET CHANGE NEEDED

At the end, I shall formulate the entire issue in the form of some questions which we should try to consider:

Universal Standards ***OR*** Personalization?

Whole Systems ***OR*** Autonomous Institutions?

Best Practices ***OR*** Innovations?

Teaching ***OR*** Technology?

Disciplinary ***OR*** Interdisciplinary?

Public ***OR*** Private?

Strategy ***OR*** Implementation?

Knowledge ***OR*** Skills?

My analysis leads to the need for:

Universal Standards ***AND*** Personalization

Whole Systems ***AND*** Autonomous Institutions

Best Practices ***AND*** Innovations

Teaching ***AND*** Technology

Disciplinary ***AND*** Interdisciplinary

Public ***AND*** Private

Strategy ***AND*** Implementation

Knowledge ***AND*** Skills

We need not waste our time in answering any of these alternatives. All these are relevant in some context and some point of time. My take is just converting *OR* to *AND* and go ahead.

ACKNOWLEDGEMENT

This is not a research paper in the conventional sense. It is the text of the invited talk which gives adequate IDEAS for the intended publication in 'IDEAS'. The material has been from several formal/informal sources in Books, Journals, e-content (blogs, etc). I acknowledge all these sources as it is not possible to list all these individually.

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Myanmar Engineering Council

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ISBN 978-99986-0-111-6
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