IDEAS

for better education & training for engineers

Quality Engineering Education Towards Engineering the Future

Committee on Education In Engineering

World Federation of Engineering Organisations

October 2022

Myanmar Engineering Council

WFEO-CEIE

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WORLD FEDERATION OF ENGINEERING ORGANIZATIONS

FÉDÉRATION MONDIALE DES ORGANISATIONS D'INGÉNIEURS

COMMITTEE ON EDUCATION IN ENGINEERING

Journal IDEAS No. 20 October, 2022

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 2022) virtually on July 16th and 17th 2022. The Conference deliberations were on the theme "Quality Engineering Education towards Engineering the Future". ICEEA 2022 was 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.

As an immediate follow up of ICEEA 2022, ***WFEO-CEIE & Myanmar Engineering Council*** are publishing the IDEAS Journal (issue number 20) in mid-October 2022. There are around 8 papers on Engineering Education from both local and international experts presented at ICEEA 2022 in this issue. More papers would be gathered from experts presented at ICEEA 2022 for upcoming issues of IDEAS Journal.

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Message from President of World Federation of Engineering Organizations (WFEO)

Prof. José Vieira

IDEAS Journal Editorial

Prof. José Vieira (19.10.2022)

I was very pleased to take part in the July 2022 International Conference on Engineering Education Accreditation Conference. This event brought together scientists, engineers and educators from a great variety of disciplines and regions, with a focus on the key challenge of helping more countries to reach the appropriate education and graduation standards.

The World Federation of Engineering Organizations (WFEO) has identified this objective as critical in so many aspects, for achieving the United Nations 2030 Agenda of Sustainable Development Goals (SDGs).

As we have pointed out in our contributions to the UNESCO 2021 Engineering Report, in order to be up to the tasks of climate change mitigation and adaptation, safe drinking water and sanitation, clean energy supply, disaster risks reduction, and many others, we need to train more engineers with the right skills.

This can only happen if a thoughtful harmonization of engineering education systems is accomplished, through shared and up to date standards, mentorship processes and integrated governance systems. In order to do this, WFEO fosters cooperation between global institutions such as UNESCO, the International Engineering Alliance (IEA), and other regional and national professional engineering institutions.

I want to thank the Myanmar Engineering Council for organizing this conference which has strongly addressed those issues, and give a special appreciation to Dr. Zaw Min Aung, Chair of the WFEO Committee on Education in Engineering, for his dedication to such a crucial matter.

José M.P. Vieira
WFEO President

Message from President of Myanmar Engineering Council, Vice President of ASEAN Academy of Engineering and Technology

Prof. Dr. Aung Kyaw Myat

It is with the utmost pleasure that we heartily welcome the publication of IDEAS journal by CEIE. The Myanmar Engineering Council, ensures its role as a regulatory and statutory authority body for Myanmar Engineers by means of the engineering standards being relevant, and ASEAN and internationally recognized, is also currently hosting the Committee for Education in Engineering (CEIE) of WFEO.

We do this in order to support the activities of CEIE and to meet its valuable objectives.

The distribution of IDEAS journal publication is a priceless opportunity to promote the efforts in Myanmar Engineering Education development and mobility facilitation.

We maintain continuing engineering professional registration and licensing, as well as engineering education accreditation, in accordance with the Myanmar Engineering Council Law, and we work with international organizations to promote the mobility of Myanmar professional practitioners in accordance with international rules and regulations. We will reap many benefits for the implementation of Myanmar sustainable development with the inclusion of the development of human resources in a 21st century if we achieve the expected goals of the Myanmar Engineering Council in cooperation with national and international partners. Another benefit is to raise Myanmar Engineering Education System obtaining full signatory status for all Engineering Accords of the International Engineering Alliance (IEA). I am very grateful and indeed an honor to the local and international speakers for their leadership, mentoring, and contributions to the accomplishment of IDEAS journal. I am also delighted that I would like to extend a very warm welcome to the readers and hope you will join as authors, reviewers, and editors in the future.

Best Wishes,

Prof. Dr. Aung Kyaw Myat
President of Myanmar Engineering Council

Message from Chair of WFEO Committee on Education in Engineering

Prof. Dr. Zaw Min Aung

The IDEAS Journal of WFEO-Committee on Education in Engineering (CEIE) has long been the emblematic journal of the WFEO education committee and its restart is an important event. It is, indeed, a great honor to me to make it happen with papers presented at the International Engineering Education Accreditation Conference (ICEEA 2022) and it is a great occasion to announce and promote this launching.

Looking at the 2 days conference, this enhances keynotes and plenary talks with around 30 technical papers both from academic and industrial scientific arenas.

17 international speakers from world reputed organizations and more than 10 local speakers from Myanmar Engineering Council (MEngC) and Center of Excellent Local Universities were sharing the innovative ideas regarding the future engineering, goals for the sustainable development around the world. I would like to express my gratitude to the presence of around 600 conference attendees.

At the present, we have created this publication with the intention among the professionals and experts from world reputed organizations to achieve the quality engineering education and accreditation. Our intention is also the immediacy of e-based publication makes it possible for all of us to be fully connected to each other and developments in our field and to directly involve in ongoing knowledge construction. This publication may be a great opportunity to gather many researchers to be a part of the discussions and presentations with leading experts in the world about the new advances and innovations in the engineering field.

This journal can be viewed directly at WFEO website upon the electronic publication of journal issues. Once more, on behalf of the organizing members, I would also provide to be a part of this new initiative, and in that you are joining us as readers and hope you will also join us as contributors. On behalf of the Conference and Journal Organizing Members, I would encourage all the authors/ speakers to publish their innovative contribution in our IDEAS Journal upcoming issues.

I like to express my thanks and gratitude to the members of organizing committee, thanking them for all the great work they have given to the ICEEA 2022 to happen. Special thanks go to President, Editorial Board Members of Journal, Executive Members of MEngC, especially Secretariat of MEngC, Engineering Education Accreditation Committee Members and International Relation Consultant of CEIE for their incomparable moral and financial support. Also, a great thanks is for the honorable international experts, participating universities and organizations.

Prof. Dr. Zaw Min Aung

Chair of WFEO-Committee on Education in Engineering (CEIE)

Transforming Engineering Education for Sustainable Development: From Vision to Actions with Impact

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I. INTRODUCTION

In September 2015, the United Nations General Assembly adopted its Resolution 70/1 announcing the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs), which take an integrated approach to future development, combining progress in economic prosperity, social inclusion and environmental sustainability.

Engineers and engineering are critical for achieving the SDGs. Engineers have a key role in supporting the growth and development of essential infrastructures such as: roads, railways, bridges, dams, waste management, water supply and sanitation, energy and digital networks. They are responsible for developing and implementing technologies and systems that contribute towards achieving the SDGs as they relate to water, energy, environment, sustainable cities, natural disaster resilience and other areas, which will benefit people and the planet for greater prosperity and better quality of life.

The World Federation of Engineering Organizations (WFEO) is committed to advancing the UN Sustainable Development Goals through Engineering. WFEO is the leading international body for professional engineering institutions, founded in 1968, under the auspices of UNESCO. WFEO members consist of more than 100 national professional engineering institutions and 12 international and continental/regional professional engineering institutions, representing more than 30 million engineers. WFO is the Co-Chair of the Major Science and Technology Stakeholder Group at the United Nations and represents engineering at major the UN Organisations, including the UNFCCC and the COP meetings, UNEP, UNDP and other UN organisations.

WFEO is committed to playing a key role in leading and coordinating projects to achieve the SDGs through engineering. WFEO can bring together its members, educational institutions, government and industry to address the need for engineering capacity and the quality of engineers around the world and develop strategic frameworks and best practices for the implementation of engineering solutions for sustainable development. The national and regional members of WFEO, that are leading professional engineering institutions, are developing country and region-specific responses.

Engineering Education, Capacity Building and Ethics were the three core purposes when WFEO was founded in 1968. These topics continue to be important for the Federation. The WFEO Committee for Education in Engineering has one of the longest histories, starting in 1986, it has been hosted by the engineering institutions of India, Argentina, Hungary, Poland, Lebanon and now Myanmar, though the Myanmar Engineering Council. The work being done by the Committee is an important aspect of the strategic focus of WFEO.

II. WFEO VISION FOR ADVANCING SUSTAINABLE DEVELOPMENT

The celebration of WFEO's 50th anniversary in 2018 was a catalyst to develop a framework for an action plan for the engineering capacity that is required to achieve the SDGs. The event resulted in a joint Declaration between WFEO and UNESCO on a commitment to advance the UN Sustainable Development Goals through engineering (1).

WFEO also presented the Engineering 2030 Plan (2). The Plan is a framework for action and brings together WFEO members, educational institutions, government and industry to address the need for engineering capacity and the quality of engineers around the world.

In their joint Declaration, WFEO and UNESCO committed to the following objectives for action through engineering to achieve the SDGs:

a. "*Increase the numbers and quality of engineering graduates that meet the needs of sustainable development with rapidly changing technologies, in collaboration with educators, government and industry;*

b. *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;*

c. *Support capacity-building through strong institutions for engineering education and the development of accreditation bodies for the recognition of professional credentials;*

d. *Establish policy frameworks and best practices, notably through WFEO Standing Technical Committees, as digital technologies, data sciences and artificial intelligence have ethical and social implications.*"

The work of the WFEO Committee of Education in Engineering advances the first three of these objectives.

WFEO is progressing the work from vision to actions with impact in partnership with our peer international organisations in engineering. Together we are working on joint objectives in education, training and sustainable development. WFEO has formal partnerships with:

- International Engineering Alliance (IEA), representing 29 signatories and 41 jurisdictions through the engineering education Accords and professional competency Agreements;
- International Federation of Engineering Education Societies (IFEES), representing the engineering educators around the world;
- Federation of International Consulting Engineers (FIDIC), representing the consulting engineering companies and engineers around the world;
- International Network for Women Engineers and Scientists (INWES), representing the women in engineering and science around the world;
- International Centre for Engineering Education (ICEE, UNESCO Category II Centre) at Tsinghua University, China, representing UNESCO Category II centres in engineering education.

Agreements signed in 2018, have been renewed beyond 2022, for a further four years. Three working groups have been established to progress these goals. Progress that has been achieved is described below.

III. PROGRESS ACHIEVED WITH WORKING GROUP 1

Working Group 1 addressed the need for a recognised global benchmark - for engineering education and professional development. WFEO recognises the International Engineering Alliance (IEA) Graduate Attributes and Professional Competencies (GAPC) benchmark as the pre-eminent global standard for engineering education. WFEO worked in partnership with the International Engineering Alliance and other peer international engineering organisations for the review of the GAPC for a consistent and contemporary Framework. This addresses **Elements 3 and 4 of the Engineering 2030 Plan.**

The priorities for the review of the GAPC global engineering education benchmark for engineering was to reflect changes in societal needs and contemporary values including:

- Impact of engineering work on the UN Sustainable Development Goals
- Diversity and Inclusion in engineering teams
- Emerging technologies and disciplines in engineering
- Rapidly changing technology environment and learning systems
- Ethics
- Commitment to Lifelong learning
- Development of skills for critical thinking, innovation, assessment of outcomes

The Working Group for the review of the GAPC was chaired by Prof. Bulent Ozguler, representing MUDEK (Association for Evaluation and Accreditation of Engineering Programs), a full signatory organization at the IEA. I was proud to lead the review on behalf of WFEO and leverage WFEO partnerships for the global consultation of the proposed reviewed GAPC Framework.

The review was supported and endorsed by the UNESCO Assistant Director General, Natural Sciences Sector. ***Recognition by UNESCO Natural Sciences Section and the UNESCO Assistant Director General, ensures that the IEA GAPC is the pre-eminent international benchmark for engineering education.***

This work is a milestone in transforming the WFEO vision to action with impact. The work was completed in record time between Nov 2019 and March 2021, following global consultation across 60 countries and extensive feedback from WFEO members and IEA signatories. The Working Group consulted with engineering educators, industry, women and young people. This is the first item that such extensive consultation had occurred. The consultation also raised the profile of the IEA and GAPC Framework itself among a diverse range of stakeholders around the world.

The work commenced in November 2019 and the updated GAPC Framework was approved by the IEA Annual Meeting in June 2021. It is published on the IEA and WFEO websites and has been translated into the six UNESCO official languages, in addition to English, French, Spanish, Russian, Chinese and Arabic (3).

Figure 1: The approved IEA Graduate Attributes and Professional Competencies Framework (3)

IV. PROGRESS ACHIEVED WITH WORKING GROUP 2

Working Group 2 was established in November 2019 to support the development of national engineering education systems to comply with the IEA standards. **This addresses Element 5 the Engineering 2030 Plan.** The working group is chaired by the Chair of the WFEO Committee for Education in Engineering and members of the Working Group are representatives of IEA signatories and WFEO members. The Myanmar Engineering Council that is the host for the WFEO Committee for Education in Engineering provides very capable secretariat support for these projects.

The IEA is an umbrella organisation for seven (7) international multilateral agreements. It is a global not-for-profit organisation, which comprises signatories from 41 jurisdictions within 29 countries.

These international agreements govern the multi-lateral mutual recognition of engineering educational qualifications and professional competencies. Through these international multilateral agreements, the IEA establish and enforce internationally benchmarked standards for engineering education and expected competencies for engineering practice. This promotes international mobility for engineers after graduation and in professional practice.

The Working Group is seeking to increase the number of economies that are signatories to the IEA Accords and Agreements. The main gaps are in Africa, Middle East, Asia and Latin America as shown in the map in **Figure 2**. The green areas are where there are IEA Signatories and the orange areas are the signatories to the European system of mutual recognition. The grey areas are the countries that need to be supported to achieve the international standards and shows the great deal of work to be done in these regions.

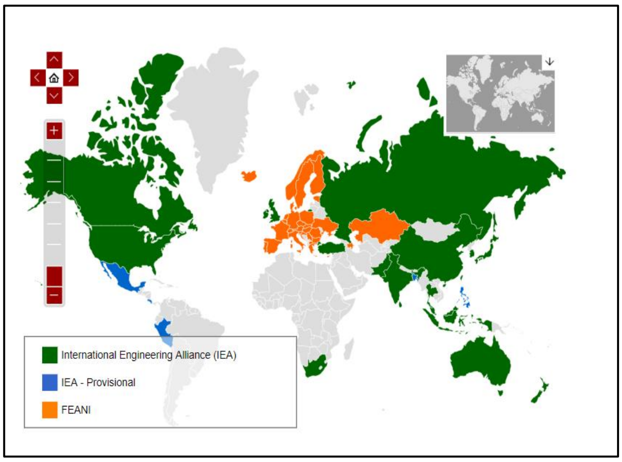

Figure 2: Map showing the gap in mutual recognition systems around the world
Source: https://www.engc.org.uk/international-activity/international-relationships-map

WFEO has established working groups to mentor and support accreditation bodies to achieve signatory status at the International Engineering Alliance. I am proud to be leading this work on behalf of WFEO. There are three working groups currently supporting the accreditation bodies of Kenya, Mauritius and Ghana:

a. Institution of Engineers Mauritius (IEM) mentored by India (NBA – National Board of Accreditation) and South Africa (ECSA Engineering Council of South Africa)

b. Engineers Board of Kenya (EBK) mentored by Pakistan (PEC- Pakistan Engineering Council) and Malaysia, (BEM - Board of Engineers Malaysia)

c. Ghana Tertiary Education Commission (GTEC), mentored by China (CAST – China Association of Science and Technology) and Turkey (Association for Evaluation and Accreditation of Engineering Programs, MÜDEK)

Monthly mentoring meetings have been held virtually as shown in **Figure 3** and significant progress has been made. The mentors have developed structured systematic work plans for provisional signatory status applications.

Figure 3: Online mentoring for Institution of Engineers Mauritius (IEM) Engineering Accreditation Board by National Board of Accreditation (NBA, India) & Engineering Council of South Africa (ECSA), with Myanmar Engineering Council being the Chair and Secretariat.

Figure 4: Site Visit to University of Mauritius to observe accreditation by the Institution of Engineers Mauritius (IEM) Engineering Accreditation Board, June 2021.

The Working Group has also developed a preliminary questionnaire to gather initial information from economies to be mentored to assist with the discussions of requirements for achieving IEA signatory status.

A hub and spoke model strategy is being used to expand support in three regions of Africa: South, East and West form these initial economies that are being supported.

V. PROGRESS ACHIEVED WITH WORKING GROUP 3

Working Group 3 was established in March 2022 to support capacity building for accreditation of engineering education and accreditation bodies and professional engineering institutions**. This addresses Elements 6 and 7 of the Engineering 2030 Plan.**

The Working Group members include representatives of the signatories of the International Engineering Alliance (IEA), International Federation of Engineering Education Societies (IFEES), Global Engineering Deans Council (GEDC) and WFEO members.

The partners have agreed to share webinars previously presented by experts in engineering education from around the world. These webinars are made available on the training website to provide structured training for accreditation bodies, professional engineering institutions, engineering educators and also to provide engineers, technologists and technicians – non-discipline specific training to support their career development.

The website has been established at www.wfeoacademy.com. The WFEO Academy uses **UNESCO Open Science Principles** (4) to provide vital training. Individuals can access the courses at no cost as long as they are a member of a WFEO member, associate or affiliate organization.

The website uses innovation and advanced technology to make content available inclusively to all. Individuals are encouraged to register and take up the courses and are issued with certificates of completion with additional bronze, silver and gold awards are proposed to encourage the uptake of multiple courses. The website is presented in nearly 100 languages and scripts, it can be accessed by all, men and women wherever they are, and ensures that no one is left behind.

Future work will establish recognition of training through national and international registers to facilitate the mobility for engineers, technologists and technicians.

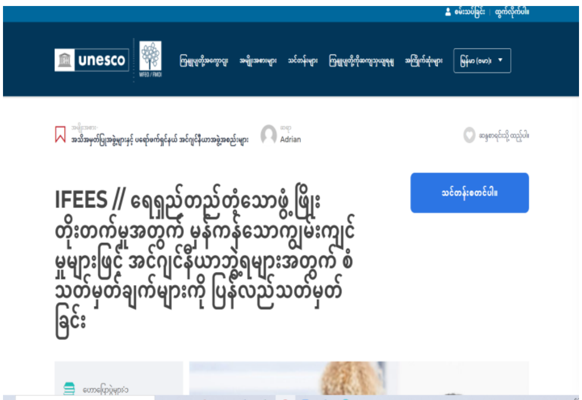

Figure 5: Translation of WFEO Academy website into Myanmar language

UNESCO Natural Sciences Sector Capacity Building Division, is a key supporter of this project. This project uses innovation and technology to transfer much needed skills to developing countries in Asia, Africa and Latin America.

VI. CONCLUSION

WFEO is working hard through its Committee on Education in Engineering for more engineers in countries where engineers are needed most – Africa, Asia and Latin America. WFEO is working with its partners to realize this vision and translate it into action with the endorsement of the UNESCO Natural Sciences Sector Capacity Building Division.

This work is being done on a volunteer basis and with a very limited budget. However, the benefits of this project are global and will continue to have far reaching impacts and will advance the vision of WFEO for more engineers with the right skills for sustainable development and for our sustainable future.

Figure 6: Welcome message from Dr Shamila Nair-Bedouelle on the WFEO Academy website

IV. REFERENCES

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Engineering education and accreditation focus on a better future for all

Emeritus Professor Elizabeth Taylor AO

Chair Washington Accord

Deputy Chair Governing Group International Engineering Alliance

Extended Abstract

Engineering appears to be on the cusp of a new technologies revolution as the physical, digital and biological blur. A melting pot of technologies and cyber-physical systems offer great potential and challenge. At the same time the environmental-socio-geopolitical landscape is shifting rapidly and this has, and will increasingly have, significant impact, with poverty, inequality, climate, and environmental degradation borne heavily and inequitably across our communities. Engineering a better future for all will require very different skills, knowledge and attitudes to those which have underpinned engineering to date.

Over the past few hundred years we engineers have constructed ourselves in terms of western classical liberalism's grand and noble narratives for the greater common good. This was exemplified by George Morrison in his Presidential Address to the American Society of Engineers in 1895 when he stated: *"We are the priests of material development or the work which enables men to enjoy the fruits of the great resources of power in nature, and of the power of mind over matter. We are the priests of a new epoch, without superstitions."* Engineers have been quick to take ownership of powerful advances in the human condition (for some), such as public health improvements driven by large scale water and sewerage infrastructure. However we have been less vocal and committed to challenge ourselves about negative legacies, such as the environmental and health impacts of pollution or the scarity and inequities arising from the profligate use of resources. We have a limited philosophical / reflective tradition and have not considered the possiblity that humans might be expendable within the broader universe and that we engineers might be the tools of human extinction.

With these thoughts in mind, the present and future require a recalibration of our engineering relationship with our communities and with the planet we call home. Shifting our perspective on how we might articulate success for engineering endeavours impacts on how we need to operate into the future and how we must educate and assure for the future.

Engineering education can no longer be viewed as an unproblematic/assumption driven 'add on' activity for researchers. It is a professional activity in its own right and, increasingly, is being treated as such. Empowering engineers to engage with their communities to build shared ownership of technology decisions requires changes in our engineering education discourse:

- From teaching to learning.
- From certainty to chaos.
- Accepting the reality of contested 'truth'.
- Recognising porous professionalism.
- Leveraging fact plus initiative plus innovation.
- From knowledge silos to interdisciplinary engagement.
- Recognising theory and practice interdependence.
- Moving from 'sage on the stage' to student-centred learning.
- Realising connected universities – "gown and town" together.

There are numerous macro learning and teaching strategies, including problem / project based learning, work integrated learning, collaborative learning, blended learning, and simulation and games available to engineering educators. These are complex, contested concepts discussed extensively in academic literature and implemented in a variety of ways.

The International Engineering Alliance (IEA) is structured to create networks and share ideas, drawing on its members diversity to facilitate engineering mobility and quality. The constituent Accords and Agreements validate jurisdictional accreditation and registration/chartered systems, embedding the diversity arising from cultural and jurisdictional imperatives. This aligns with sociological, anthropological and ecosystem studies which suggest that diversity in our systems drives innovation and capacity to meet complexity, disruption and change. Whenever a system is captured by one culture, by one world view, or one intellectual tradition and iterates to one metric (standard) of success, its capacity for intellectual flexibility and agility is significantly reduced.

While pivoting engineering to self reflection and sharing techology decisions with its communities will be a major shift, a case study on how listening to diversity can provide a powerful tool to manage disruptor challenges can be found in the IEA response to the COVID19 pandemic impact on engineering education and accreditation. Through self generated collaboration symposium, conferences, discussion groups, seminars and meetings IEA members drew on their collective wisdom and experience to share best practices and policies. Together they charted achievable pathways, that could be customised for local needs, to mitigate the negative impact of the pandemic.

Cultural Intelligence in Engineering Education

Ir. Academician Emeritus Professor Tan Sri Dr. Chuah Hean Teik

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Extended Abstract

Engineering Education is of utmost importance for sustainable development of a nation. The new Digital Revolution (commonly known as the 4th Industrial Revolution) causes anxiety in the industry, academia and society as we are uncertain of the future of our jobs and what new disruptive technologies are coming. This puts a lot of pressure on the academia for training of engineers who are to be internationally bench-marked and could be recognised for practice across countries. Due to the desire for regional and international mobility, there is thus a need for international bench-marking of engineering educatiion and accreditation systems, so that engineers trained are of substantial equivalence in quality and standard. Engineering education is about training of engineers for public good as engineers must uphold integrity and public safety and health. What is good for one country may not necessarily be applicable to another country as different countries are in different stages of development and thus different sets of human resources are required. Thus is is important for institutions of higher learning in one country to develop and design curriculum which will enable the graduates to fit welll into the industry in the country, thus contributing to the economic growth of the country; while still prepare them sufficiently to fit into neighbouring countries in the region and the world at large.

In the opinion of the author, what is important now is for the educators to train future graduates who can embrace life-long learning and professional skills with strong basic fundamentals of natural sciences and engineering, and who are ready-to-evolve rather than graduates who are just ready-to-market as many of the graduates will be entering a whole new and unknown sea of employment. Thus policy makers, accreditation bodies, institutions of higher learning and other stakeholders must adapt to new environment, new technologies, new teaching and learning methods, new curriculum, etc. In short we must cope with all changes, as Charles Darwin once said “it is not the strongest of the species that survives, nor the most intelligent, but the most responsive to change”. Engineering education should aim to:

- strengthen engineering and scientific fundamentals and principles
- develop analytical and logical mind
- cultivate knowledge exploration
- encourage self-development and life-long learning
- create platform for social networking
- train students to survive constraints and challenges
- develop deep expertise in one’s specialization
- develop broad knowledge across many domains – engineering, management, communications, leadership etc
- cultivate collaboration and cooperation mindset with team members from diverse background
- develop social skills including communication skills, negotiation skills, cultrual intelligence and other life skills
- develop decision making and judgement skill

A Professional Engineer needs to have the relevant competency to carry out his duties and responsibilities in coming out with innovative solutions for complex engineering problems. The engineering education curriculum must be designed to take cognizance of the competency profile required by the professional engineer. In the formal engineering education, the students must attain all the necessary graduate attributes or outcomes at the point of graduation so that they can continue to develop the engineering competency based on the graduate attributes attained. The International Engineering Alliance has establised an excellent graduate attribute profile and competency profile for the engineering team [1].

The author would like to highligh one very important aspect of engineering competency: Cultural Intelligence. Culture is a pattern of learned beliefs, values, and behavior that are shared within a group; it includes language, styles of communication, practices, customs, and views on roles and relationships [2]. Cultural intelligence is the ability to interpret the stranger's behavior the way the stranger's compatriots would [3]. When engineers work, many a times we need to interact with people from different cultures, different backgrounds, different races and different reglions. Thus it is imperative for the engineers to

- learn various human civilizations
- be aware of world history
- know your geography
- understanding the local beliefs, practices, traditions, and even local languages/dialects
- appreciate local taboos
- respect religious differences

- embrace diversity and be colour-blind

Developing cultural intelligence is a dynamic and life-long process. One must recognise one's own biases and prejudices, and learn to listen and understand past and comptemporary issues. One must learn how to communicate and present oneself in a lucid manner. One must show empathy in all situations. In the engineering curriculum, we can develop cultural intelligence via:

- Subjects on world history and human civilizations
- Appreciation course on world religions
- Projects on contemporary social issues vis-à-vis engineering profession
- Subject on foreign languages/dialects
- International student and staff exchange programmes
- Cross cultural Activities, including sports and music

Globalization, characterized by the increase in international trade, mobility of labour and capital, as well as borderless communication, presents new opportunities and challenges for the engineering sector. It opens up boundless opportunities in the mobility of engineering experts within the region and the global community. Engineers should aim at achieving engineering excellence not only in their home countries, but also contribute to the development of the region and the world. Local professional engineers should look beyond national boundaries and create winning partnerships with foreign professionals and high technology industry leaders abroad. Cooperation and smart partnership, capitalizing on strength of each other, is the key to conquer regional and world markets.

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A Study on Becoming Full Signatory of Washington Accord for a Statutory and Regulatory Body such as Myanmar Engineering Council (MEngC) through Quality Engineering Education towards Engineering the Future

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Myanmar Engineering Council

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Abstract - The Myanmar Engineering Council (MEngC) which is a Statutory and Regulatory Body to develop the Engineering Education in Myanmar and maintain the internationally recognized standards of professional competence and ethics, was founded in December 2013. Its vision is "to improve Engineering Education in Myanmar, a first step to Nation Building Level, second to FEIAP Level, then up to the ultimate goal of becoming a Full Signatory of Washington Accord (WA) for professional engineers". In this Paper, there are 4 Chapters: Chapter I - Criteria for Admission to and Maintenance of Signatory Status in an Accord, Chapter II - Guidelines, Chapter III - Rules and Procedures of becoming a Full Signatory of WA of IEA and Chapter IV – Overview and Conclusion which have to be studied thoroughly for the sake of good practices of Engineering Education in Myanmar. MEngC became a Provisional Signatory of WA on 12th June 2019. The Aim of this paper is to obtain knowledge through a study about WA, then to give awareness to the persons concerned how to implement the tasks and fulfill the requirements for becoming a Full Signatory of WA in due course. (Total No. of Words: 186)

Keywords - Criteria, Engineering Education, Full Signatory, Guidelines, Myanmar Engineering Council (MEngC), Rules and Procedures, Statutory and Regulatory Body, Washington Accord (WA)

I. INTRODUCTION

The Myanmar Engineering Council (MEngC) which is a Professional Statutory and Regulatory Body to develop the Engineering Education in Myanmar and maintain the internationally recognized standards of professional competence and ethics, was founded in December 2013. Its vision and mission are "to improve Engineering Education in Myanmar, a first step to Nation Building Level, second to the Federation of Engineering Institutions in Asia and the Pacific (FEIAP) Level, then up to the ultimate goal towards becoming a Full Signatory of Washington Accord (WA) for Professional Engineers" and "to hold paramount the safety, health and welfare of the public" respectively.

MEngC became a Provisional Signatory of WA on 12th June 2019 at the International Engineering Alliance (IEA) meetings in Hong Kong and the Accreditation System for engineering programmes in Myanmar implemented by MEngC has been considered as in compliance with the standards and best practices established in FEIAP Engineering Education Guidelines, on 30th June in Xian, China.

There are Criteria for Admission to and Maintenance of Signatory Status in an Accord, Guidelines, Rules and Procedures of becoming a Full Signatory of WA of IEA, which have to be studied thoroughly by the concerning personnel for the sake of good practices of Engineering Education. Quality Engineering Education could be achieved by the implementation of Accreditation System for engineering programmes in compliance with the above mentioned facts of IEA by MEngC and the Technological Universities (education providers) in Myanmar.

A. *Engineering Education*

Engineering education is the activity of teaching knowledge and principles for the professional practice of engineering.

It includes an initial education (bachelor's and/or master's degree), and any advanced education and specializations that follow.

Engineering education is typically accompanied by additional postgraduate examinations and supervised training as the requirements for a professional engineering license.

Practice of Engineering means any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising, or managing any of the foregoing, that requires the application of engineering principles and that concerns the safeguarding of life, health, property, economic interests, the public welfare or the environment.

B. *The Washington Accord*

The Washington Accord is an agreement between accreditation agencies in different jurisdictions that seeks to provide mutual recognition of education programmes that provide the academic preparation for professional engineers.

The Accord exists through the agreement of its signatories and is therefore autonomous and self-governing. The signatories to the Accord are national organizations that accredit engineering higher educational programs that provide graduates with the educational foundation for entry to professional engineering practice, registration or licensing.

Mutual recognition is based on the substantial equivalence of the signatories' programme outcomes, known as graduate attributes, and accreditation processes, verified for each signatory by peer review at the time of admission as a signatory and periodically thereafter.

Signatories agree, if it is within their power, to grant graduates of each others' accredited programs the same recognition, rights and privileges as they grant to graduates of their own accredited programs for the purpose of registration or licensing. Where the registering or licensing body is separate from the accrediting body the signatory undertakes to recommend to the relevant national registration body that accredited programs be recognized. By these provisions, the Accord facilitates mobility of graduates between signatory jurisdictions.

II. AIM

The Aim of this paper is to obtain knowledge through a study about Washington Accord, then to give awareness to the persons concerned how to implement the tasks and fulfill the requirements mentioned in Criteria, Guidelines, Rules and Procedures of IEA for becoming a Full Signatory of the Accord in due course.

III. BECOMING A SIGNATORY CRITERIA FOR ADMISSION TO AND MAINTENANCE OF SIGNATORY STATUS IN AN ACCORD

A. The criteria apply in the following cases:

(1) A provisional signatory under consideration for admission as signatory to an Accord; or

(2) A signatory undergoing periodic monitoring.

B. Accreditation agencies under review must:

(1) Continue to satisfy the requirements defined in Criteria for Admission to Provisional Signatory Status in an Accord; and

(2) Satisfy criteria C, D and E below:

C. The agency's accreditation system and processes conform to the Accord accepted practice as exemplified by:

(1) High standards of professionalism, ethics and objectivity;

(2) All involved in programme evaluation are competent in the agency's accreditation system, and are of high standing as educators or practitioners in the profession;

(3) The defined evaluation standards and processes are applied consistently and fairly;

(4) The accreditation report records and justifies accreditation recommendations in sufficient detail to support decision-making and clearly differentiates recommendations from requirements.

(5) The decision making body demonstrates capacity to make difficult decisions in a way likely to be beneficial to the engineering community in the longer term.

D. The graduate outcomes standard applied for accreditation is substantially equivalent to the Accord as exemplified by the Graduate Attribute exemplars as reflected in:

(1) The agency's documented programme outcome standard;

(2) The standard required of accredited programs in practice.

E. The agency and its accreditation system are sustainable and adequately managed as indicated by:

(1) Data from institutions offering educational programs that have sought accreditation in the jurisdiction;

(2) Data regarding programs that have sought accreditation in the jurisdiction;

(3) The extent to which programs have gone through a full accreditation cycle and been re-evaluated;

(4) The depth of considerations observed during the accreditation visit and decision making meeting enabling appropriate accreditation outcomes to be achieved for a range of evidence of programme quality;

(5) Mechanisms for the periodic review of accreditation policies, criteria and procedures;

(6) The depth of training of programme assessors;

(7) The accreditation programme is led by personnel with appropriate expertise in engineering education, engineering practice and educational quality assurance.

(8) Separation of policy making from accreditation decision making

(9) Mechanism exists to make consistent accreditation decisions sustainably;

(10) The agency's history of involvement (if any) with other Education Accords under the International Engineering Alliance with evidence of general, consistent conformance with published accreditation policies and procedures.

IV. BECOMING A SIGNATORY GUIDELINES

During the period of provisional status, it shall be open to all signatories to visit the applicant at their own cost, but this is not a requirement, nor part of the Assessment process towards becoming a signatory.

Organizations holding provisional status shall seek guidance from their mentor/s (if any) and the Committee as to how soon during their granted period of provisional status they might apply for Assessment towards becoming a signatory.

Upon processing of the application as stated in the Application Process, the Committee must assign signatories to provide three Assessors to review on-site the applicant's accreditation system and make recommendations to all signatories.

The Assessors may be guided in their approach to undertaking the assessment by the guidelines for conducting a Periodic Review of an existing signatory.

The Assessors will evaluate the standards and systems of the applicant against the Requirements. Indicators of attainment and/or typical characteristics of accreditation/recognition systems operated by other signatories and meeting the Requirements are set out below:

The accreditation system and processes are substantially equivalent to those of other signatories of the Accord:

A. Accreditation criteria and accreditation processes are clearly documented and publically available.

B. The criteria for accreditation/recognition include requirements for:

(1) A suitable environment to deliver the programme

(2) Adequate leadership of the programme

(3) Suitably qualified engineering practitioners teaching in the programme

(4) An engineering curriculum providing a broad basis for engineering practice

(5) Appropriate entry and progression standards

(6) Adequate human, physical and financial resources to support the programme

There are mechanisms for addressing conflicts of interest for all involved in the accreditation/recognition process including visiting teams, accreditation/ recognition decision-makers and policy makers.

There is an appropriate decision making body that demonstrates a capacity to make difficult decisions in a way likely to be beneficial to the engineering community in the longer term.

C. The accreditation process involves:

(1) A self-review by the education provider seeking accreditation

(2) An on-site review by a visit team comprised of peers

(3) Periodic re-evaluation to maintain accreditation/ recognition status

(4) An accreditation report is produced that documents and justifies accreditation recommendations against published criteria and clearly differentiates between requirements and recommendations.

(5) Decision making processes are clearly defined, demonstrably objective and include provision for appeal.

D. The graduate outcomes standard applied for accreditation is substantially equivalent to that of the Accord (as illustrated by the Accord graduate attributes exemplar).

(1) There is a documented accreditation outcome standard that is publically available.

(2) Substantial equivalence to exemplar graduate profile of relevant Accord.

The organization seeking signatory status, and its accreditation/recognition systems are sufficiently well established and managed that it has made in the recent past, and is likely to continue, making consistent accreditation or recognition decisions.

E. It is generally expected that signatory organizations will satisfy the following general characteristics:

(1) Legal incorporated in their home jurisdiction

(2) Representative of the engineering community with statutory powers or recognized professional authority for the accreditation of engineering education programmes designed to satisfy the academic requirements for admission to practicing status (e.g. licensing, registration or certification) within a defined jurisdiction (e.g. country, economy, geographic region)

(3) Accredits/recognizes programmes at institutions that have legal authority to confer higher education degrees/qualifications

(4) Accreditation/recognition is consistent with the organization's mission

(5) Independent of educational providers delivering accredited programmes, within the jurisdiction

(6) Non-governmental

(7) Has the autonomy to set policies and make accreditation/recognition decisions independent of stakeholder influence

V. BECOMING A SIGNATORY RULES AND PROCEDURES

A. An application for admission to signatory status to an Accord must:

(1) Include a self-study report containing information demonstrating that they meet the Criteria for Admission to and Maintenance of Signatory Status in an Accord, and a gap analysis of the applicant's accreditation criteria against the Graduate Attribute exemplars;

(2) Include Accreditation statistics and other requested information listed in the template provided by the Secretariat;

If mentoring is required, at least one letter of support by a mentor:

(3) Made from first-hand knowledge of the applicant's accreditation system and operating context; and

(4) Declaring that the mentor(s) consider that the applicant's accreditation system meets the criteria for signatory status;

(5) Be prepared in the English language;

(6) Be received complete in all respects to the Secretariat no later than 120 days before the IEAM at which the applicant wishes the application to be considered.

B. The application received will be processed as follows:

(1) The Secretariat must distribute the application to all Accord signatories no later than 90 days from the start of IEAM;

(2) The signatories must review the application and provide questions/comments no later than 45 days prior to IEAM;

(3) Questions/comments received shall be forwarded to the applicant no later than 30 days prior to IEAM;

(4) Arrangement of three Assessors to visit the organization's jurisdiction shall commence upon voting in the IEAM by all eligible voting accord signatories with two-thirds majority.

(5) Assessors must not be from signatories which have served as nominators and/or mentors of the applicant.

The organization applying to become a signatory must provide the Assessors with reasonable notice of proposed visit dates, which must all be no later than 150 days prior to the IEAM at which the organization wishes its application for upgrading to become a signatory to be considered.

The Assessors and the organization seeking upgrading must, without unreasonable delay, jointly develop a proposed assessment programme, which will normally include visits to at least 2 education providers, including a total of at least 4 programmes undergoing evaluation. If possible the programme will be co-ordinated as part of a single visit to the jurisdiction by all three Assessors, but organizations operating low volume accreditation or recognition systems may need to arrange for more than one visit by Assessors. At least two Assessors must observe each individual accreditation/ recognition visit that forms part of the assessment programme. The assessment programme must also include observation (by a method approved by the Committee) of at least one meeting of the accreditation/ recognition board or other body responsible for the final accreditation/recognition decisions at which reports from the observed accreditation/recognition visits are considered.

The assessment programme must be approved by the Committee. The Committee must satisfy itself that the assessment programme is sufficient in coverage, taking into account the range of engineering disciplines, the sizes and types of education provider in the jurisdiction, the number of programmes actually or likely to be accredited or recognized within the jurisdiction, and the overall cumulative experience of the organization in undertaking accreditation or recognition activity in the context of the International Engineering Alliance.

The management of assessments shall conform with any policy approved by the International Engineering Alliance in regard to risks to the safety and security of Assessors.

The Assessors will evaluate the standards and systems of the applicant against the Requirements. The Assessors will be guided in their evaluation by the Indicators of Attainment/Characteristics of Accreditation/Recognition Systems.

The Assessors will furnish a written report to the signatories no later than 90 days prior to the IEAM at which the application for upgrading will be considered, unless a shorter period (of at least 30 days) is agreed by the Committee to be sufficient in the circumstances.

All discussions concerning the assessment must be held in confidence by the Assessors. The Assessors shall prepare a report with recommendations. This report shall be sent to the Committee in draft form to ensure that it specifically addresses the need of the Accord. This may be done at the same time as the draft report is sent to the applicant for checking on matters of fact.

C. The signatories must consider the Assessors' report at the meeting at which it is presented and must decide one of the four following actions:

(1) that the organization holding provisional status be made a signatory and the date at which recognition by the other signatories of the substantial equivalence of the engineering academic programmes concerned shall become effective is stated (this would normally be the date on which the new signatory is admitted), or

(2) that the organization holding provisional status be declined becoming a signatory, but that provisional status be extended for a further period (in which case reasons must be stated), or

(3) that the organization holding provisional status be declined becoming a signatory and that provisional status not be extended (in which case the reasons must be stated), or

(4) that the decision on the assessment recommendations be deferred for a specified period of time (in which case the reasons must be stated).

During consideration of an Assessors' report each signatory which chooses not to support the recommendation from the Assessors must provide to all other signatories its reasons.

When the decision in regard to an application for upgrading is deferred, the signatories may agree to reconsider the application by a Special Meeting held by a suitable meeting method prior to the next scheduled General or Mid-term Meeting if there is a reasonable expectation that information that will allow the application to be decided will be available, but no such meeting will occur sooner than 60 days after the organization holding provisional status or the Assessors provide the necessary information to the secretariat.

VI. OVERVIEW AND CONCLUSION

A. *Overview*

It is appreciated that the Criteria, Guidelines, Rules and Procedures for becoming Full Signatory are interrelated and interconnected and that accreditation/recognition systems, processes, monitoring and evaluation to be implemented by signatories have been strengthened with the time, situation and up to date technologies.

B. *Conclusion*

The Engineering Education is absolutely essential for all engineers, technologists and technicians who perform their duties in the respective roles. In this paper, the importance of the Washington Accord (WA) of the International Engineering Alliance (IEA) has been emphasized for the professional engineers. Becoming Full Signatory of WA is possible only by Quality Engineering Education through the Accreditation Systems and Processes which have been controlled by the systematic Criteria, Guidelines, Rules and Procedures of IEA.

The MEngC and its associate body, EEAC (Engineering Education Accreditation Committee) have submitted the Annual Report 2022 to WA Committee of IEA in which Strategic Roadmap for Washington Accord has been mentioned with the aim of submission of application to IEA in February 2023 and the task will be carried out in order to fulfill the requirements mentioned in Criteria, Guidelines, Rules and Procedures of IEA for becoming a Full Signatory as per Roadmap.

The Accreditation Visit by 3 Assessors will be conducted at Yangon Technological University (YTU) for 2 Programmes and at Mandalay Technological University (MTU) for 2 Programmes in September 2023 tentatively. Therefore, it is concluded that the utmost active and enthusiastic performance of the MEngC, EEAC and the Engineering Education providers in Myanmar plays a vital role for the success.

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Review on Assessment of Final Year Project Performance in Civil Engineering

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Abstract– *This paper describes a review of the assessment of the student's performance in the Final Year Project (FYP), civil engineering. Marks of the project for the final year students over the past two consecutive academic years (2017-2018) and (2018-2019) were recorded and analyzed. A detailed and comprehensive assessment of the marks achieved was made according to Engineering Education Accreditation Committee Manual (2018). Assessment was carried out based on the marks of students; including marks for seminar presentations, and for report writing. There are five categories to account for regarding individual student's marks for oral presentation as well as three categories regarding report writing. The results show that the number of students and class average marks for these two academic years were 33 nos., 80 marks, and 40 nos., 83 marks, respectively. This shows notable improvement could be achieved year by year in accord with the recommendations of the EEAC accreditation panel on their last visit in 2018. The panel pointed out to find areas to be improved upon in the curriculum, generic skills, facilities, and procedures involving laboratory sessions and FYP. The assessment of graduate attributes for FYP performance in civil engineering students for two consecutive years was analyzed and reviewed. Based on the modified assessment of rubrics, 12% of students got high marks in presentation skills, and 95% of students obtained high marks in report writing in the (2018-2019) Academic Year. The overall analysis of GAs in (2017-2018) and (2018-2019) academic years showed relatively good achievements with above 75% and 80% respectively. It is noticeable that there are 100% of A+ students, who obtained greater than or equal to 75 marks in the 2018-2019 academic year. Inputs, suggestions, and recommendations given by the program's stakeholders and accreditation panel are also important so the civil engineering department at Mandalay Technological University is cooperating with all stakeholders to conduct the CQI (Continuous Quality Improvement) processes.*

Keywords– *Assessment, Class Average, CQI, EEAC, Final Year Project.*

I. INTRODUCTION

The Department of Civil Engineering, Mandalay Technological University (MTU), has implemented the Outcome-Based Education (OBE) approach since 2012-2013 Academic Year. The department offers the degree program leading to the Bachelor of Engineering (Civil). The program provides a strong base in Civil engineering with a balance between theory and experiments during the six years of study. One of the requirements to obtain a Bachelor of Engineering (Civil) degree is to submit his/her FYP in time in the second semester. Each project provides valuable experience and competency for individual Civil Engineering student.

The final year project (FYP) is the culminating learning experience of engineering programs. It requires students to demonstrate that they can integrate knowledge, skills, and professional graduate attributes developed during the program and perform at a standard expected of graduates. National and international literature outline a variety of information regarding the capstone FYPs structures, elements of its assessment criteria, and methodologies of learning and teaching. More specifically, the study seeks to map the processes, assessment, and supervision practices of capstone FYPs and to provide a set of guidelines and tools to ensure quality outcomes of capstone FYPs [1].

The assessment process should be coherent and consistent in light of good education practices. The literature also reports that there are no definite or guaranteed assessment criteria for assessing FYPs highlighting the need for the development of guidelines for the FYPs and assessment criteria [2, 3–6]. Practices differ greatly between universities and limited work has been initiated that seeks to identify good practice. Although some research exists on group work and peer assessment, further investigation into the methodologies behind individual project work is required [4, 5].

EEAC 2018 guidelines require engineering programs to show that students are capable of personally conducting and managing an engineering project to achieve a substantial outcome to professional standards [2].

So, this study is done to review the assessment on the student's results of the Final Year Project (FYP). Therefore, the project marks obtained over the past two consecutive academic years (2017-2018) and (2018-2019) were collected and analyzed.

II. OBJECTIVES OF THE STUDY

The objectives of the study are as follows;

- To assess the FYP performance of Civil Engineering Students at Mandalay Technological University.
- To review the assessment of Graduate Attributes achievement for FYP performance in

two consecutive academic years (2017-2018) and (2018-2019).

III. METHODOLOGY AND APPROACH

A systematic approach is suggested using statistical analysis in order to examine the final year students' project performance in civil engineering. Project marks of the final year student in civil engineering obtained in the past two years (2017/2018-2018/2019) were reviewed and analyzed. The collected data and assessment criteria are presented in Table 1 to Table 3.

Grade	Mark	(2017-2018) Academic Year		(2018-2019) Academic Year	
		No. of student	% (Nos)	No. of student	% (Nos)
A+	75	31	94%	40	100%
A	70	2	6%	0	0%
A-	65	0	0%	0	0%
B+	60	0	0%	0	0%
B	55	0	0%	0	0%
B-	50	0	0%	0	0%
C+	45	0	0%	0	0%
C	40	0	0%	0	0%
D	< 40	0	0%	0	0%
Total		33		40	

Table 1. Number of students with grade in the year analysed

Since performance, presentations and the final report contribute directly to the overall mark of the FYP, all of them were considered for FYP assessment. The seminar's presentation skills were considered in five parts: 1- the quality of the presentation, 2- the content of technology, 3- the ability of the student to answer questions directed to him/her at the end of the presentation, 4- the ability of the student to present fluently in English, and 5-the content of research performance. The project report was assessed based on three parts: 1- research performance, 2- content in the report, and 3- English skills in writing report.

Seminar Presentation Mark (SPM) (%)																		
Supervisor						Members						External Examiner						
P	T	Q & A	E	R P	Total	P	T	Q & A	E	R P	Total	P	T	Q & A	E	R P	Total	Avg.
10	10	10	10	10	50	10	10	10	10	10	50	10	10	10	10	10	50	50

(a)

project report mark (PRM) (%)													TOTAL
Supervisor				Members				External Examiner					50% SPM+50% PRM
RM	C	W	Total	RM	C	W	Total	RM	C	W	Total	Avg	
20	20	10	50	20	20	10	50	20	20	10	50	50	

(b)

Table 2. Breakdown of (a) seminar marking, (b) final project report assessment, and overall mark for (2017-2018) Academic Year

No.	Item	Marks (%)	
		2017-2018 Academic Year (50%)	**2018-2019 Academic Year (30%)**
1	Presentation (P)	10	6
2	Technology (T)	10	6
3	Questions and answers (QA)	10	6
4	English (E)	10	6
5	Research Performance (RP)	10	6

Table 3-a. Rubrics for Seminar Presentation

No.	Item	Marks (%)	
		2017-2018 Academic Year (50%)	**2018-2019 Academic Year (70%)**
1	Research Methodology (RM)	20	20
2	Content (C)	20	30
3	Writing in English (W)	10	20

Table 3-b. Rubrics for Report Writing

The department used rubrics of 50% for seminar presentation and 50% for report writing in 2017-2018 academic year. Some of the continuous quality improvement (CQI) actions are based on the concerns and recommendations of the EEAC accreditation panel on their last visit in 2018. Based on the assessments, the department has identified the improvements to be made to the curriculum, generic skills, facilities, and procedures involving laboratory sessions and FYP.

So the performance of (2018-2019) academic year's seminars presentation, and the final report, contribute 30%, and 70% respectively of the overall total. The supervisors supervised and guided the student for the respective academic year. Also, an experienced teacher from another Technological University, who is familiar with the topic of the project, was as the external examiner, and the chairperson and the two members were from the Civil Engineering Department.

IV. RESULTS AND DISCUSSION

Course outcomes and Domain and Taxonomy level for FYP and mapping of COs to GAs for FYP (CE-62004) are shown in Tables 4 and 5. The learning and graduate attribute mapping for the FYP course of two consecutive academic years are recorded as shown in Tables 6 and 7.

CO (s)	Description	Domain &Taxonomy Level
CO 1	Ability to understand the design of general Civil infrastructure system	C1,A1,A2, P1,P2
CO 2	Ability to analyze and design infrastructure	C5, A2, A3, A4, P2, P3
CO 3	Ability to present project findings effectively and produce a project report	C6, A3, A4, P2, P3

Table 4. Course Outcomes & Domain and Taxonomy Level for FYP(CE-62004)

Course Outcomes	Engineering Knowledge	Problem Analysis	Design/ Development of Solutions	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Management and Finance	Project Life-long Learning
	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA 10	GA 11	GA 12
CO 1	√				√	√	√	√		√		
CO 2				√	√	√	√	√	√			
CO 3				√	√	√				√	√	

Table 5. Mapping of COs to GAs for FYP (CE-62004)

	Seminar Presentation					Report Writing		
Sub.	P	T	QA	E	RP	RM	C	W
Full Mark	10	10	10	10	10	20	20	10
Strongly Achieved (%) (80%-100%)	0	0	0	0	0	30	31	26
Achieved (%) (50%-79.9%)	33	33	33	33	33	3	2	7
Achieved (%) (0%-49.9%)	0	0	0	0	0	0	0	0

Table 6. Learning and graduate attribute mapping for FYP of (2017-2018) Academic Year

	Seminar Presentation					Report Writing		
Sub.	P	T	QA	E	RP	RM	C	W
Full Mark	6	6	6	6	6	20	30	20
Strongly Achieved (%) (80%-100%)	5	1	0	0	1	38	39	39
Achieved (%) (50%-79.9%)	35	39	40	40	39	2	1	1
Achieved (%) (0%-49.9%)	0	0	0	0	0	0	0	0

Table 7. Learning and graduate attribute mapping for FYP of (2018-2019) Academic Year

At the end of the FYP course, the GAs achievement in two consecutive academic years is shown in Figure 1.

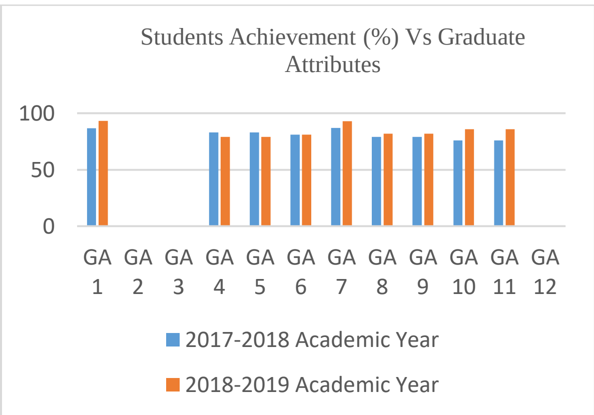

Figure 1. GA Achievement for FYP in the year analyzed

For the FYP course of (2017-2018) Academic Year, the distribution of marks is given as Seminar Presentation (50%) which is related to GA 4,5,6, 8,9, 10, and 11, and Report Writing (50%) which concerns GA 1, 4, 5, 6, 7, 8, 9, 10 and 11. The GA achievement for the 2017-2018 academic year indicates the percentage of students achieving GA 1 as 86.7%, GA 4 and GA 5 as 83%, GA 6 as 81%, GA 7 as 87%, GA 8 and GA 9 as 79%, GA 10 and GA 11 as 76%, out of a total of 33 students. On the overall analysis of GAs in (2018-2019) Academic Year, the achievement of GAs is relatively good with 80% and above, out of a total of 40 students. Based on the modified rubrics, students got high marks in presentation skills and report writing in (2018-2019) Academic Year. After doing an assessment of students' achievement with GAs, FYPs' total mark was classified into 5 groups using 3 class intervals. The frequency of the number of students in two consecutive academic years is shown in Table 8.

Class Interval	Number of Students	
	2017-2018 Academic Year	**2018-2019 Academic Year**
70-72.9	0	0
73-75.9	3	0
76-78.9	3	2
79-82.9	24	14
83-85.9	3	24

Table 8. The Frequency of the number of students in the year analyzed

The result of two consecutive years of analysis is shown in Figure 2. It is shown that the number of students getting over 75 marks gradually increased in the (2018-2019) academic year.

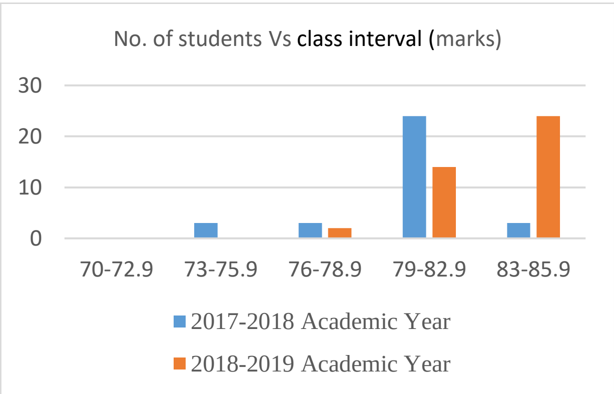

Figure 2. No. of students Vs class interval (marks)

V. CONCLUSIONS

The assessment of graduate attributes for FYP performance in civil engineering students for two consecutive years is analyzed and reviewed. Based on the modified rubrics, 12% and 95% of students got high marks in presentation skills and report writing respectively in (2018-2019) Academic Year. It is concluded that 100% of A+ students of the 2018-2019 academic year are noticed. This improvement is due to the listening of the voices of the panels and other stakeholders. So, the department is willing to further cooperate with the panel and stakeholders to conduct CQI process continuously.

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Implementation and Assessment Methods of Outcome-Based Education in Engineering Education

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Abstract- *Myanmar Engineering Council is currently a provisional member of the Washington Accord. The Engineering Education Accreditation Committee (EEAC) is shifting its paradigm to an outcome-based approach for the accreditation of engineering undergraduate degrees. Implementing outcome-based education to evaluate Course Outcomes and Graduate Attributes is a standard practice at the Department of Mechanical Engineering, Mandalay Technological University. This paper describes the importance of implementing OBE and assessment methods for Engineering Education. Foreign and local companies, government, and private industries need qualified young graduates to meet the needs of the industries. Technological Universities in Myanmar are working to improve the quality of engineering education under the guideline of the Engineering Education Accreditation Committee (EEAC). Under EEAC analysis of the achievements of Graduate Attributes (GAs), Course Outcomes (COs), and Programme Educational Objectives (PEOs) are necessary for all Engineering Departments. OBE implementation requires a lot of planning coordination and involves many assessment methods. Outcome-Based Education requires formulating Programme Educational Objectives (PEOs) and Graduate Attributes (GAs) and Course Outcomes (COs). PEOs are formulated based on inputs from various stakeholders. Graduate Attributes (GAs) that students shall attain after completing the program are based on what is expected of an engineering graduate as required by the Washington Accord. Graduate Attributes (GAs) are supported by the Course Outcomes (COs), the competency level expected of the student after completing an engineering course. The main purpose of this paper is to give the course leaders a clear understanding of how to implement an Outcome-Based Education system and assessment methods.*

Keywords - *Course Outcome, Engineering education, Graduate Attributes, OBE, Programme Educational Objectives.*

I. INTRODUCTION

An engineer may be a key person for the event of worldwide quality of life. Engineering education must be relevant and effective so as to satisfy the requirements of the mandate to responsibly cater to society. Previously used syllabus, curriculum, and teaching methods may no longer be in keeping with the changing times. Therefore, due to technological advances, the syllabus and curriculum of engineering courses need to be updated to meet the needs requirements.

The academic community has come to recognize OBE as the best way to address the challenges. The OBE approach is a successful way to focus and organize an education system around what is essential for students to achieve success. First, it is important for course leaders to have a clear idea of what students need to be able to do in order to succeed. Then they can create a curriculum, instruction, and assessment plan to help ensure that this learning happens. As such, OBE is a dynamic method that involves the restructuring of syllabus, assessment, and new practices for engineers to rise replicate the accomplishment of higher-order learning and mastery [1].

The main benefits of implementing OBE are that it can help students develop skills and abilities that are more relevant to real-world challenges. The university encourages high expectations and promotes greater learning for all students. This prepares them for life and works within the globe. OBE will help students to be able to write a good project proposal, complete projects, analyse case studies, give case presentations, and express their abilities to think, question, research and make decisions based on the findings. The programme educational objectives (PEOs) are to identify what aspects of the program should be focused on in order to achieve the desired outcomes. Due to the ambiguity of the curriculum, students are unable to reach their goals. Engineering education underwent a vital transformation because of the necessities obligatory by the Washington Accord [2].

Data gathering is the process of assessment. In more detail, assessment refers to the strategies employed by course leaders to collect information about their lessons and students' progress. For the student, an assessment may be a major motivator for studying because they must learn and comprehend the information in order to pass an assignment. For academics, assessment is a chance to assess the level at which students are functioning; it can serve the twin purposes of providing information on students' standing as well as the efficiency of the instruction and study materials offered. For the institution, assessment enables the establishment of the criteria for judgments regarding whether students are permitted to continue and complete their studies as well as if they can receive a certain qualification [3].

II. IMPLEMENTATION OF OUTCOME-BASED EDUCATION

OBE is an educational paradigm that focuses on achieving the goals of a curriculum leading to an engineering undergraduate degree. In Myanmar, the EEAC accreditation manual of 2018 serves as a reference for OBE implementation. To meet EEAC criteria, the signatory concerned must create paperwork such as Standard Operating Procedure, Course files; Problem-based assignments, exams, lab manuals, industrial training reports, etc. With the aid of input from industry and professional organizations, the following parameters must be precisely defined for the OBE system to be implemented successfully [4].

A. Institutional Requirements
B. Programme Requirements
C. Course Outcomes
D. Assessment Methods

A. *Institutional Requirements*

- Core values, commercial values, and ethical values are all stated in the institution's strong vision and mission statements.
- The departmental education committee and all stakeholders must be trusted in the vision and mission statement.

B. *Programme Requirements*

- The curriculum for the particular course was created with consultation from professional and industry organizations.
- Create Programme Educational Objectives (PEOs) and Graduate Attributes (GAs).
- Align the PEOs and GAs with the university's mission and vision statements.

C. *Course Outcome*

- For every course, develop the Course Outcomes (COs).
- Establish assessment standards to determine if students have met the course objectives.

D. *Assessment Methods*

Both direct and indirect forms of assessment are referred to as assessment methods or assessment tools. Direct assessment methods examine the student's work during the program's exam as well as the material they have studied. Exams/Tests, Quizzes, Papers, Oral Presentations, Group Work, Integrated Design Projects, Assignments, Semester Exams, and Portfolios are some instances of direct measurement methodologies.

Indirect evaluations look at how students or graduates feel about their knowledge, skills, attitudes, and learning experiences, as well as how they feel about the services they received or the opinions of job candidates. Surveys of students, exit interviews, surveys of alumni, and surveys from the Industry Advisory Panel, surveys of external examiners, and surveys of recent graduates are some instances of indirect measuring techniques [5].

(1) *Formative Assessments*

Students' progress is monitored using formative assessments, which include interactive class discussions, self-evaluations, warm-up tests, mid-semester evaluations, exit tests, etc. These are short-term because they are most useful when students are absorbing new information and relating it to what they already are aware of. The most noticeable aspect of these evaluations is the immediate feedback, which enables students to improve their comprehension of the subject matter and enables teachers to determine student understanding and make necessary adjustments. Generally, the student grade does not receive any credit for these kinds of tests.

(2) *Summative Assessments*

Summative evaluations measure student learning at the conclusion of a unit of teaching by comparing it to a standard or benchmark. These assessments are often midterm or final exams. These exams are official and directly affect students' grades. The student's input can be very limited. In most cases, students cannot retake the test. The outcomes of these tests can assist students understand where they stand in the class by comparing grades and, if applicable, by looking at descriptive statistics like average, median, and standard deviation.

The use of information, skills, and attitudes is directly demonstrated through authentic assessment, which is a type of direct assessment. It is frequently called alternative evaluation or performance assessment. Oral interviews, written samples, exhibitions, experiments, observation, arguing, and portfolios are some instances of authentic assessment [6].

Implementing OBE involves these three facts. (i) the achievement of COs for each course (ii) the achievement of GAs for each course and (iii) the achievement of PEOs for each course. OBE is a process that restructures the curriculum, assessments, and reporting procedures in education to emphasize high-order learning and mastery instead of the build up after all credits. The implementation of OBE involves the following steps:

1. Course Content - Reviewing course material to align with defined Graduate Attributes, current studies, customer requirements, industry requirements, professional body accreditation standards, etc.
2. Teaching-Learning Methods - Introducing novel, adaptable teaching strategies and delivery systems to foster PEOs and GAs in learners and graduates.
3. Assessment and Evaluation Techniques - A variety of assessment and evaluation tools are introduced in order to gauge PEOs and GAs performance.
4. Data and Evidence Gathering - Gathering documentation of the procedures taken and the PEOs and GA's accomplishments.
5. CQI – Closing the loop.

Any program can now start to run since the PEOs, GAs, and COs are in place. The applicable COs are used by course leaders to frame their modules, and the COs are also used to map the evaluations. The CO achievement of a student in the module is determined after the assessments are finished. Additionally, the GA accomplishment can be determined (since the COs and GAs are mapped to each other). In essence, engineering programs set Key Performance Indicators (KPI) for such scores, such as having 60% of students in a module achieve all COs. The course leader would then need to develop a continual quality improvement (CQI) strategy for the following semester if that KPI is not met [7].

The CQI plan's objective is to make sure the KPI is met for the forthcoming semester. A comparable CQI strategy can be created at the program level, for example, if it is discovered that a cohort of students' GA achievement does not meet the KPI, changes to the program can be made to ensure that the KPI is fulfilled in the program's second year of operation. It should be emphasized that any changes to the module or the program must have the approval of the pertinent stakeholders at all stages of the process. When combined with the GA-CQI plan, CQI improvements at the program level (to improve GAs) lead to improvements at the PEO level. CQI improvements at the module level (to improve COs) precede improvements at the program level (to improve GAs). A process diagram for outcome-based education is shown in Fig. 1. Continual quality improvement process is necessary for the three stages, such as course outcome, graduate attributes and programme educational objectives assessments.

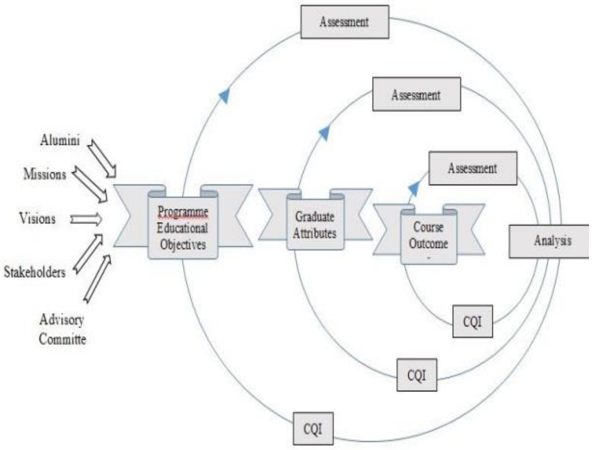

Fig. 1 Continuous Quality Improvement Loop

III. COURSE OUTCOMES

Based on the EEAC manual's 2018 GAs, each course's course objectives were constructed. Course outcomes are declarations that detail important knowledge that students have acquired and can conclusively demonstrate on completion of a course. This means that course outcomes specify the knowledge and skills a student will possess at the conclusion of a course. Cognitive, psychomotor, and affective learning domains should all contribute to the measurement and observation of course outcomes. To put it another way, course learning outcomes should reflect the fundamental information, abilities, and attitudes that must be had, as well as the minimum standards that must be met in order to pass a course. As shown in Fig. 2, the course outcome is created using Bloom's Taxonomy, which involves the three learning domains of cognitive, emotional, and psychomotor. Table 1 illustrates the strategies of implementation of outcome based education.

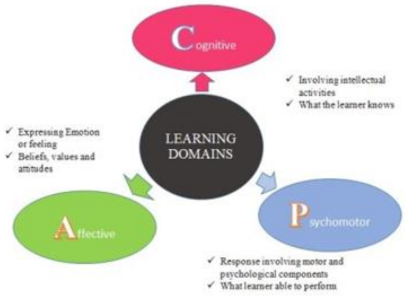

Fig. 2 Course Outcome Domain in OBE Implementation

Domain	Learning Domain	Teaching Approach
Cognitive (Thinking Domain)	Relates to the learner's intellectual, mental, and thought processes and involves the gathering of knowledge	Lecture One-to-one instruction Computer-based instruction
Affective Domain (Feeling Domain)	Increased internalization or commitment to feelings expressed as emotions, interests, attitudes, values, or beliefs is referred to as being affective	Case study Role Playing Simulation Group Discussion
Psychomotor (Skills Domain)	Consist of learning skills and having the capacity to carry out perceptual tasks.	Demonstration Practice

Table 1 Strategies of Implementation of OBE

These are the methods that have been used throughout implementation to exceed expectations for the previous three domains. The Graduate Attributes can be used to assess course outcomes. When creating course outcomes for any given course, the course leader first list the Graduate Attributes that each set of course outcomes will address.

Course Outcomes	Description	Graduate Attributes
CO1	---------	GA2, GA3
CO2	---------	GA3, GA4,GA7, GA8
CO3	---------	GA3, GA4,GA7, GA8

Table 2 Template of CO's vs GA's

Table 2 explains which COs from the EEAC manual 2018 cover specific GAs in detail. The final exam, midterm exam, laboratory, assignments, and other forms of assessment are ways to gauge the GAs. The achievement of each CO can be determined by computing the GA's percentage. For instance, the CO1 attainment will be (60+50)/2 = 55 percentage if GA2 and GA3 are both 60 and 50 percentage. The departments will be in charge of continuously evaluating the course learning outcomes using a mix of direct and indirect evaluation methods. The lecturer for each course is in charge of keeping an accurate course syllabus that thoroughly outlines the course's content and learning objectives (GAs). Course objectives, taxonomy levels, instructional strategies, and evaluation procedures should all be included in the syllabus.

The CO assessment runs continuously from the first lecture week to the last lecture week. The analysis of the course's learning outcomes is separated into two phases: after test 1 (week 7) and after the final exam (week 14). All course leaders are required to complete a course evaluation at the conclusion of the learning process and assessment in order to measure student achievement in terms of GA and Taxonomy Level.

Results may point to changes that are required in the GAs, COs, curriculum, or other areas. Fig. 3 shows course outcome assessment method.

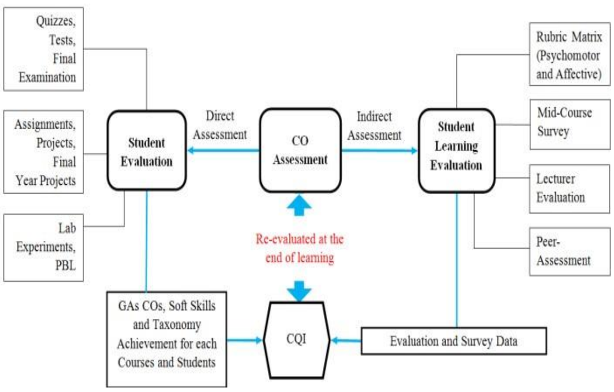

Fig. 3 Course Outcome Assessment Method

IV. ASSESSMENT OF GRADUATE ATTRIBUTES

Students should have attained the GAs by the time they graduate. Graduate Attributes (GAs) are defined in the EEAC manual as assertions that specify what students should know, be able to do, or achieve by the time they graduate. Students should obtain the GAs, according to the EEAC manual 2018, to develop their abilities, knowledge, and behaviour. Based on the numerous self-accreditation reports of engineering programs that have undertaken the accreditation procedure, a general technique of GA assessment has been determined. The following are typical current evaluation best practices:

1. The course outcomes are directly linked to the corresponding GA for every subject in the curriculum.
2. The CO will be evaluated via tests, exams, lab reports, homework assignments, project reports, etc.
3. The final grades will be the average of each student's individual marks, normalized to 100 percent and added together.
4. The grades are used to assess each GA's performance. Then, the GA is determined by averaging each mark for the GA.
5. A performance indication is typically thought to be around 60%.
6. Surveys, including exit, end-of-course, and industrial training surveys, make up indirect methods.

Separately from the average grade will be displayed the survey's results. Iterative processes are used to establish and track GA development at the Curriculum and Course primary level. The template in Table 3 provides the assessment technique with the course outcomes and graduate attributes, and can be used to conduct the direct assessment.

Mode of Assessment	Percent (%)	Graduate Attributes				
		GA 1	GA 2	GA 5	GA 9	GA 10
Final Exam	60	20	40			
Mid-term Exam	10	4	6			
Laboratory	20			10	5	5
Individual Assignment	10		10			
Total	100%	24%	56	10%	5 %	5 %
Course Outcomes		CO1 CO2 CO3	CO1 CO2 CO3	CO1 CO2 CO3 CO4	CO4	

Table 3 Objective Matrix of PEO and GA

Fig. 4 provides a clear explanation of the graduate attribute assessment process. There are two important processes for graduate attributes assessment. The first process is course outcome evaluation and the second is the curriculum evaluation. Direct assessment tools are used for the first process and the indirect assessment tools are used for the second process. Several direct and indirect assessment tools are used for both processes.

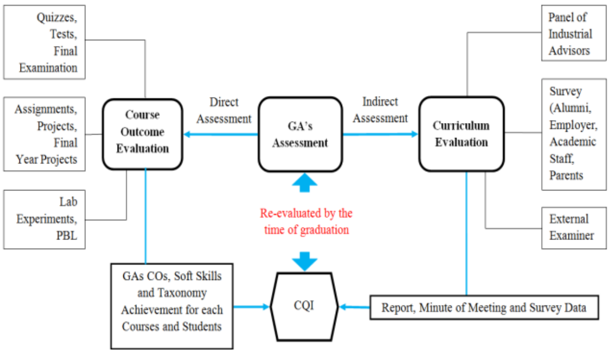

Fig. 4 Graduate Attributes Assessment Method

V. ASSESSMENT OF PROGRAMME EDUCATIONAL OBJECTIVES

The PEOs are a list of assertions that serve as the foundation for the kind of engineering graduate that was generated. Each graduating student must meet the PEOs, which are concrete, measurable objectives, three to five years after graduation. A strong set of PEOs are often designed for engineering programs to make sure that graduates can become Professional or Chartered Engineers five years after graduation. The aims and objectives of the University and the curriculum are also briefly outlined in PEOs.

The GAs is developed based on the PEOs themselves after the PEOs statements have been formulated [7]. The GAs is a list of objectives that students must fulfil in order to graduate. These objectives are once more explicit and measurable. Based on the PEOs and the pertinent criteria established by the EEAC, the GAs is created. The pertinent modules and their COs are chosen when the GA statements have been established. The COs is a set of precise and quantifiable goals that students must attain after completing the pertinent engineering curriculum courses. Table 4 demonstrates how GAs and PEOs are mapped out. The mapping of PEOs and GAs is shown in Table 4. According to the EEAC manual from 2018, PEOs must be based on all GAs qualities. The EEAC and program mission statement are used to guide the creation of the PEOs.

PEO \ GA	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
PEO 1	×	×		×								
PEO 2			×		×	×	×				×	
PEO 3								×	×	×		×

Table 4Objective Matrix of PEO and GA

Each graduating student can evaluate the PEOs 3 to 5 years after graduation. Utilizing the Alumni survey and the Industry survey, PEO can be evaluated. In two different methods, the faculty involves its alumni in its evaluation process:

[1] The Alumni Advisory Board, which is made up of ten business and alumni members. The board meets one or two times a year to discuss matters pertaining to alumni activities, comments from the industry, and the effectiveness of the faculty in achieving the program's educational objectives and outcomes.

[2] A survey of former students' alumni was conducted. The Alumni Advisory Board serves as a conduit between the department and its industry partners because several of its members are employed by the business community and hold executive positions at eminent organizations that recruit a significant portion of our graduating seniors. Similar to this, the alumni survey aids in gathering opinions from alumni across many businesses.

The method for establishing, analysing, and assessing programme educational objectives is shown in Figure 5. The program's mission statement and the EEAC manual are used to guide the creation of the PEOs.

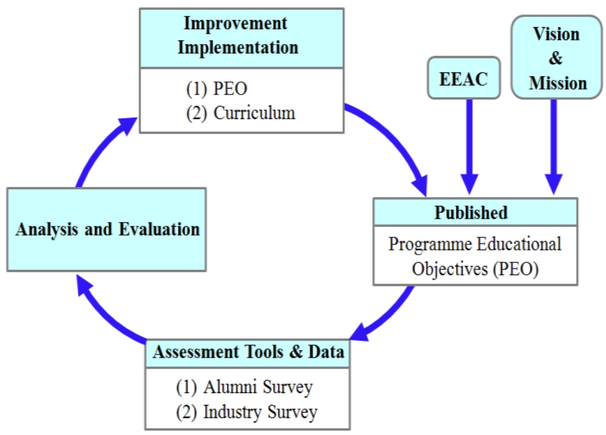

Fig. 5 PEO Assessment Method

VI. RESULTS AND DISCUSSION

The presented assessment approach is anticipated to offer a clear framework for evaluating each of the GA, leading to a more deliberate and objective application of CQI inside the program. More importantly, it is hoped that this will result in a notable improvement in the calibre of graduates from Engineering Departments. Numerous short- and long-term advantages result from implementing the planned OBE.

Benefits of Assessments are (1) The proposed assessment technique represents an understanding of learning that is multifaceted, integrated, and expressed in performance across time, (2) Student learning begins with educational values, (3) Assess the alignment and effectiveness of the curriculum, (4) Recognize the effects of program changes, (5) When requesting resources, give justification for the requirement.

Based on the aforementioned advantages, each program should regard the assessment technique as a means of evaluating the student's achievement of the Graduate Attributes, which will result in an improvement in the student's knowledge, abilities, and attitude. Therefore, each GA should be considered as a significant drive with clear performance standards that, when measured, will enable one to objectively assess whether the students have made progress.

There are four primary issues that course leaders face when adopting OBE in technological university: (1) course leader workload (2) poor curriculum delivery (3) unstable implementation system (4) lack of administrator support.

For a course leader to successfully implement OBE in teaching and learning in a university there must be significant changes. The workload for the course leader is increased by adding extra tasks. To prepare course leader with new knowledge for applying OBE, courses and training are required. Student absenteeism and the issue of low student knowledge make it difficult and challenging for course leaders to execute teaching and learning based on OBE. The course leaders' attitudes are the challenges to OBE implementation in teaching and learning at Technological University. A course leader who has been in the educational system for a running time would traditionally have the attitude of not wanting to change.

Problems and challenges within the performance of OBE arise during the implementation of assessment and evaluation from the approach of final evaluation review and the creation of non-uniform questions. This is due to the fact that the assessment and evaluation process offers institutions, educators, and administrators' crucial information on the efficiency of program design, delivery, evaluation, and training. Due to the semester schedule, course leaders have limited time to implement teaching and learning. A few of the administrators' acts are mentioned to be weak and ineffective. Instructors' workloads, inadequate curriculum delivery, unstable system implementation, and a lack of administrator assistance are problems for course leaders in implementing the teaching and learning process based on OBE. Feedback on the process of progress for each difficulty encountered strengthened the OBE system.

VII. CONCLUSIONS

There have been more institutions around the world offering technical education over the past ten years. Unfortunately, there is a lot of space for improvement within the quality of education and training in many places. In view of labour mobility and international agreements, quality assurance in education is now essential, especially in the case of engineering education. The Washington Accord agreement's mandate has caused a significant revolution in engineering education.

All engineering programs in Myanmar are now required to assess and evaluate their Programme Educational Objectives (PEOs), Graduate Attributes (GAs), and Course Outcomes (COs). The OBE technique of evaluation, which is used by many engineering programs, had confusing results. The suggested approach makes it simple to adopt OBE and evaluate its effectiveness using predetermined performance standards. The suggested assessment approach is anticipated to provide an impartial evaluation of whether the students have satisfied the requirements and consequently promote CQI deployment within the program.

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Analysis of Course Outcomes in Electrical Power Engineering Curriculum using Illustrative Verbs derived from Bloom's Taxonomy

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Abstract–Course outcomes are goals for student learning. They demonstrate what the instructor wants students to know, do, or value by the end of the course. Course outcomes are essential to any curriculum in education, where they need to be clear, observable and measurable. However, some instructors structure course outcomes in a way that does not promote student learning. The purpose of this article is to present the analysis of course outcomes of an Electrical Power Engineering curriculum offered at Department of Electrical Power Engineering at Mandalay Technological University (MTU), in order to determine if instructors are structuring them in a way that enables student learning. A qualitative case study is used where the course outcomes from 37 subjects of undergraduate course of Electrical Power Engineering are reviewed using illustrative verbs derived from Bloom's Taxonomy. Results indicate that 6% of all the course outcomes are unclear, 4% are unobservable and 23% are unmeasurable. According to the results of analysis, it is necessary to provide regular workshops to assist instructors in reviewing their course outcomes using the illustrative verbs derived from Bloom's Taxonomy, thereby ensuring that their course outcomes promote student learning.

Keywords - Bloom's Taxonomy, course outcomes, curriculum, illustrative verbs, promote student learning

I. INTRODUCTION

Nowadays, all the institutions are working in the direction to provide their students the education which is based on some desired outcome i.e., the Outcome Based Education (OBE) and for that purpose the analysis of Course Outcome (CO) is an essential tool [7].The program outcome of a particular course/discipline is decided by the stakeholders in the department and approved by the department advisory committee that includes members of institution and industry as major stakeholders. The faculty members formulate the outcomes of their respective courses and discuss the same with all the stakeholders in the programme. These course outcomes of a particular subject are an essential tool for the assessment of the Programme outcomes. The students must be made aware of the course outcomes and mapping of the course outcomes with the Programme outcomes. The students are the major stakeholders in the outcome-based education. The performance of students is analysed after calculating their marks on the basis of weightage of course outcomes. Then later on the percentage of Programme outcomes is calculated based on those calculations. The Programme outcomes are further mapped with the Programme educational objectives. The successful implementation of outcome-based education can be quantified by the performance of the students in the different exams or tests as set up by the institution/university. This process is repeated for six years till the students complete their graduation [7]. Implementation of outcome-based education ensures that a graduate not only possess a sound knowledge in the specific program but also has a global mobility and acceptance [7].

Course outcomes are at the centre of learning in numerous institutions of Higher Education. In spite of the fact that course outcomes are at the centre of Higher Education learning, there is limited scholarship about how they are used by educators and students (Hadjianastasis 2016). Few research studies consider analysing course outcomes in terms of Bloom's Taxonomy, in order to understand whether instructors develop them in a way that is clear, observable and measurable. This study seeks how to develop course outcomes in a correct way.

II. AIM

The purpose of this study is to present the analyses of course outcomes of an Electrical Power Engineering curriculum offered in Department of Electrical Power Engineering at Mandalay Technological University in Myanmar in order to determine whether instructors are structuring them in a way that enables student learning. The study begins by conceptualising course outcomes in terms of how they are defined, how they differ from aims and objectives and what their fundamental purpose in education is. In this paper, the theoretical framework, the context of this study and the research methodology are introduced. The main aim of this paper is to check the course outcomes of curriculum whether the instructors develop them in a correct way.

III. BLOOM'S TAXONOMY

In higher education, Bloom's Taxonomy is necessary to classify learning stages from remembering facts to creating new ideas based on the acquired knowledge. The idea of Bloom's Taxonomy is that learning is processing consecutively. We must understand all concepts in real life before applying it. We must remember the key facts related to it before we understand a concept. Although initially described as a framework, Bloom's Taxonomy is now often depicted as a pyramid. The basis of the pyramid is Knowledge, the first level of learning and above it step by step lies Comprehension, Application, Analysis, Synthesis and Evaluation. Each level above builds upon the one below, it can only move up the pyramid one step at a time [6].

A. *Original Bloom's Taxonomy*

American educational psychologist Benjamin Bloom and his coauthors Max Englehart, Edward Furst, Walter Hill, and David Krathwohl were first describe the original taxonomy in 1956 in the book Taxonomy of Educational Objectives. In their book, learning goals are classified into one of the categories mentioned above (from Knowledge to Evaluation). The goal of this taxonomy was to provide instructors with a common vocabulary to discuss curricular and evaluation problems with greater precision. From the date of its publication, the original taxonomy has been translated into more than twenty languages and is now used for instructional design worldwide. However, the book is currently more often applied in its revised version [6].

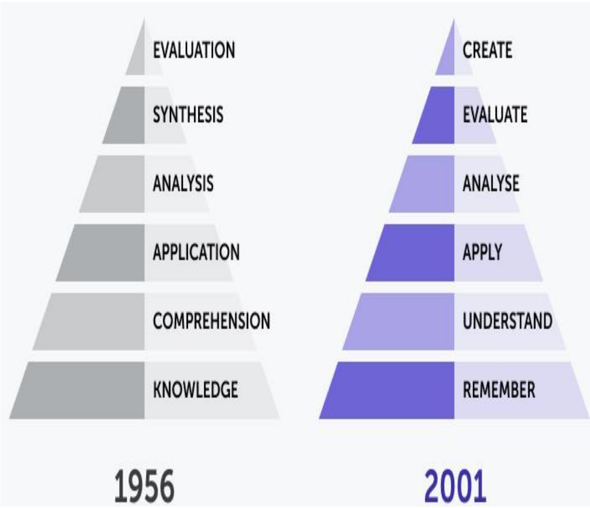

Figure 1. Original and Revised Bloom's Taxonomy

B. *Revised Bloom's Taxonomy*

In 2001, a group of researchers led by Bloom's colleague David Krathwohl and one of Bloom's students, Lorin Anderson, revised the taxonomy to provide learners with clearer instructional goals.

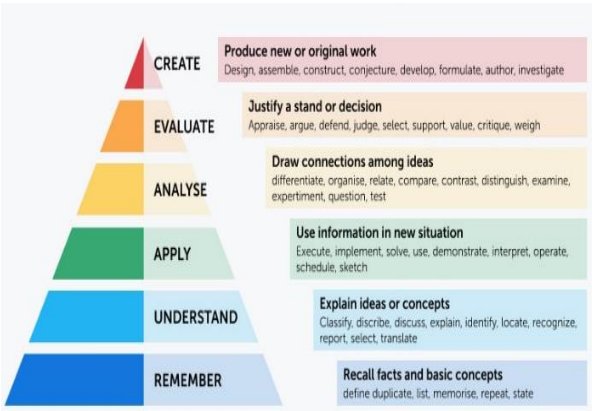

Figure 2. Revised Bloom's Taxonomy and Action verbs

In the new variant Bloom's Taxonomy model, nouns were replaced by action verbs and the two highest levels swapped. The new learning stages are Remember, Understand, Apply, Analyse, Evaluate and Create.

IV. BLOOM'S TAXONOMY LEVEL

Based on the revised Bloom's Taxonomy which is a revised framework a Taxonomy for Learning, Teaching and Assessing by Krahtwohl and Anderson, we cant's take a closer look at each learning stage. They recommend to read the name of each learning category as though preceded by the phrase "The student is able to" or "The student learns to"

A. Remember

This stage is about memorizing basic things such as facts, dates, events, persons, places, concepts and patterns. At this level, instructors might ask students simple questions like:

- What are the most spoken languages of Asia?
- What is the chemical formula of salt?
- Who is the current president of the United States?

B. Understand

At this stage, students might be asked to explain a concept in their own words, describe a mathematical graph or clarify a metaphor.

C. Apply

At this point, students must able to use learned facts and abstractions in new contexts and particular situations.

For example, they might be asked to discuss phenomena described in the scientific paper using terms and concepts of other papers.

D. Analyze

Now, students should be able to break down concepts and examine their relationships. For instance, students might be asked to recognize the genre of a painting or describe the leading causes of the Great Depression.

E. Evaluate

At this point, students should be able to use their knowledge and skills to appraise a situation, justify their stand or criticize others' opinions. They expected to point out logical fallacies in arguments or compare a work to the highest standards in the field.

F. Create

This stage is the most complex learning process and the top level of the revised Bloom's Taxonomy. At this level, students combine known facts, patterns and ideas to create original work or formulate to solve their problems. The students are expected to compose a song, rewrite a story in another setting or formulate a hypothesis and propose a way of testing it.

G. ***Bloom's Taxonomy Verbs***

Bloom's Taxonomy can help instructors to design learning objectives within a single lesson or even a whole course.

Using the taxonomy as a guide, instructors can identify clear goals of each courses corresponding to each taxonomy level and create plans to achieve them.

By setting learning objectives in correct way for students, instructors make them more active and responsible for their education.

Figure 3. Bloom's Taxonomy with illustrative verbs [8]

It can also be useful for evaluating students correctly. For example, an essay is probably not the best form of testing when students only need to remember terminology and basic facts related to the topic, but at the evaluation stage, it will be appropriate when the student are able to formulate their opinion on an issue. Bloom's taxonomy allows instructors to gauge the students' progress. It helps instructors to determine which level every student is on and assign them an individual task.

In discussing Bloom's taxonomy, action verbs associated with the categories and cognitive processes are also mentioned. Instructors use these verbs to describe activities which are required to achieve educational objectives corresponding to each level.

V. THEORETICAL FRAMEWORK

The guide for this study is based on the different levels of Bloom's Taxonomy. Bloom's Taxonomy provides a hierarchy of increasingly complex cognitive functions which ranges from lower levels to higher levels. In original Bloom's taxonomy, six cognitive levels were stipulated with knowledge being the lowest and evaluation being the highest level. The two lower levels (knowledge and comprehension) promote lower order thinking while the next four levels (application, analysis, synthesis and evaluation) promote higher order thinking [2]. Some verbs such as ***define*** and ***discuss*** are often associated with knowledge and comprehension. A verb associated with application is often ***calculate***, with analysis it is ***distinguish***, with synthesis it is **combine** and with evaluate it is ***concluded***. Students will learn effectively and they become critical thinkers when they can expose to the full range of the Bloom's taxonomy. The original objectives are contrasted to the revised ones is shown in Table 1.

The main difference between original and revised Bloom's Taxonomy is the renaming of a number of levels; evaluation becomes creating, synthesis becomes evaluating, comprehension becomes understanding and knowledge becomes remembering [3].

A revised vision of Bloom's Taxonomy was done by one of Bloom's original co-authors in order to make instructional tasks and assessment activities easier to design.

The revised taxonomy also presents each cognitive activity as a verb, indicating the action that a student is expected to demonstrate. This makes it easier for educators to write course outcomes which are clear, observable and measurable.

Original objective	Revised objective	Definition	Synonyms	Illustrative verbs	Levels
Evaluation	Creating	Creation or development of something	Creation Combining	Create, assemble, construct, design, develop, formulate	Highest level dependent on students reasoning ability
Synthesis	Evaluating	Judging the value of the system based on given criteria	Judgement Assessment	Justify, criticise, conclude, evaluate, verify, confirm, determine, analyse	Higher level
Analysis	Analysing	Breakdown of a system into its elements/parts	Study Scrutiny Breakdown	Analyse, appraise, distinguish, compare, contrast, differentiate, classify, categorise, experiment	Higher level
Application	Applying	The use of abstractions in particular and concrete situations	Use Purpose Apply	Apply, develop, demonstrate, modify, solve, use, show, calculate, compute	Higher level
Comprehension	Understanding	Translation, interpretation and extrapolation of elements/parts	Understand Grasp	Explain, convert, estimate, rearrange, summarise, derive, review, relate	Lower level
Knowledge	Remembering	Recall or recognition of specific elements/ parts	Information Facts Data	Name, label, list, state, define, describe, order, outline, relate, repeat, discuss, identify, select, insert, complete, label	Lowest level dependent on students' memory ability

Table 1. Revised Bloom's Taxonomy with appropriate synonyms and illustrative verbs

The most appropriate framework for this study is chosen to explain Bloom's Taxonomy and it has been noted to be the best starting point for writing course outcomes. It is globally used and provides a ready-made structure of appropriate illustrative verbs which instructors can use in order to measure student learning. In this study, Bloom's Taxonomy was chosen as many universities that they have adopted it as a means of evaluating their final examination papers in order to ensure that students are assessed with regard to the right graduate attributes. To articulate clear study guides, the illustrative verbs from Bloom's Taxonomy should be contained. The university conforms to Blooms' Taxonomy so that study guides with course outcomes which do not have verbs consistent with the theory are labelled poor as they will be ambiguous, unmeasurable and unobservable.

The important technique of analysing is that course outcomes should be clear, observable and measurable involving the use of illustrative verbs defined for the different levels of Bloom's Taxonomy [4]. This was done for the curriculum of the Electrical Power Engineering which forms the context of this study.

VI. CONTEXT OF THIS STUDY

Electrical Power Engineering course is carefully designed to enable students to be competent in analysing, solving, managing and taking responsibility for complex engineering problems and activities. The programme has a set of compulsory courses in Electrical Power engineering principles, MEF, mathematics, Electrical engineering design, control and management. These core courses give a breadth and depth to the qualification, whilst the specialized courses within the Electrical Power Engineering programme provide discipline-specific knowledge and skills. This programme covers all the required technical and non-technical areas as recommended by Engineering Education Accreditation Council (EEAC), with a total of 211 credit hours including 159 credit hours for Engineering courses and 52 credit hours for general and related courses. Among these courses, Electrical Power Engineering Department offer total 37 subjects which are listed in Table 2.

No.	Code	Subject Name	COs
1	EP-21011	Electrical Engineering Circuit Analysis I	5
2	EP-21014	Basic Electronics	5
3	EP-21033	Computer Programming Language I	6
4	EP 21013	Principles of Electrical Engineering	6
5	EP21012	Lighting and Illumination	3
6	EP-22011	Electrical Engineering Circuit Analysis II	5
7	EP-22014	Digital Electronics	5
8	EP-22015	Fundamental Measurement	5
9	EP-22033	Computer Programming Language II	6
10	EP-31015	Advanced Measurement and Illumination	4
11	EP-31014	Power Electronics I	2
12	EP-31029	Electromagnetic Field I	6
13	EP-31026	Power Generation	4
14	EP-32011	Electrical Transient	6
15	EP-32014	Power Electronics II	5
16	EP-32029	Electromagnetic Field II	7
17	EP-32026	Power Transmission and Distribution	4
18	EP-41027	Linear Control System I	4
19	EP-41041	High Voltage Engineering	5
20	EP-41012	Electrical Properties of Materials I	4
21	EP-41042	Power System Network	6
22	EP-41024	Electrical Machines I	7
23	EP-42027	Linear Control System II	5
24	EP-42037	Power System Protection	4
25	EP-42012	Electrical Properties of Materials II	4
26	EP-42042	Power System Analysis	6
27	EP-42024	Electrical Machines II	5
28	EP-51027	Modern Control System	5
29	EP-51014	Electrical Law and Safety	5
30	EP-51042	Power System Control	5
31	EP-51012	Machine Drives and Control I	4
32	EP-51015	Renewable Energy	8
33	EP-52027	Control System Design	5
34	EP-52012	Machine Drives and Control II	4
35	EP-52022	Electrical Engineering Management	5
36	EP-52042	Energy Storage System	8
37	EP-52015	Energy and Environment	6
Total Course Outcomes			189

Table 2. Subjects offered by Electrical Power Engineering Department [1

From these list, 34 subjects are offered for Electrical Power Engineering students and 3 subjects are offered for related Engineering students. The number of course outcomes for each subject is shown in the list and total 189 course outcomes are analysed for this study.

VII. METHODOLOGY

This study uses a qualitative approach to analyse the course objectives of curriculum. A qualitative approach was chosen which is compatible with a documentary review that was used in our study. Documentary review refers to a systematic process of analysing written texts that contain information about the phenomenon under study [5]. This study focused on the Electrical Power Engineering curriculum offered by the Department of Electrical Power Engineering at Mandalay Technological University (MTU) in Myanmar. In this study, the phenomenon is to analyse course outcomes to determine the extent to which instructors conform to the institution's recommended theory of Bloom's Taxonomy. Documents reviewed in this study were 37 subjects used in the Electrical Power Engineering curriculum.

The criteria for rating/scoring the learning outcomes are based on the use or non-use of illustrative verbs that inform the six cognitive levels of Bloom's Taxonomy as shown in Figure 4. Any course outcome that does not include an illustrative verb is deemed unclear, not observable and unmeasurable (poorly structured). Illustrative verbs, also known as “action verbs” can note a measurable behaviour. A well-structured course outcome included one illustrative verb that may be correlated to Bloom’s Taxonomy, clearly conveying to students what is expected of them. A poorly structured outcome was identified when the course outcome had no illustrative verb, making it challenging to determine what students should be able to do at the end of the unit or module.

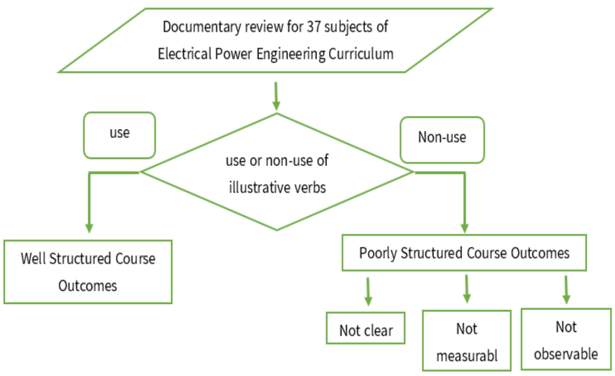

Figure 4. Rating/Scoring method for course outcomes

VIII. FINDINGS

Findings of this study suggest that the Electrical Power Engineering curriculum comprises a mixture of both well-structured and poorly structured course outcomes. The curriculum has a total of 189 course outcomes, of which 127 (67%) were deemed to be well-structured, containing illustrative verbs from Bloom’s Taxonomy informing students what they should be able to do. The remaining 62 course outcomes (33%) were deemed to be poorly structured, giving a vague idea of what students should do in the module. The results of the findings are shown in Figure 5.

Well-structured course outcomes are consistent with the illustrative verbs used in Bloom’s Taxonomy, being clear, observable and measurable, clearly conveying what the instructors expect from the students.

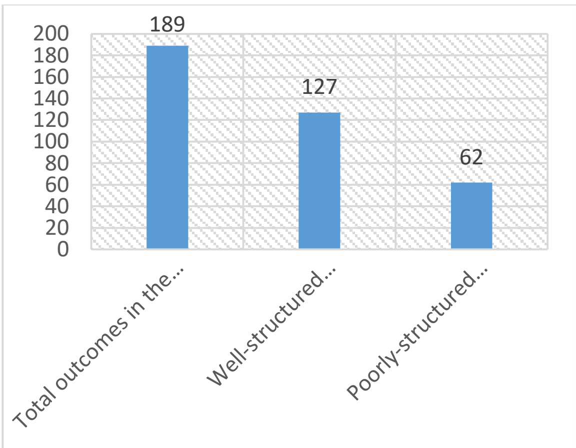

Figure 5. Total course outcomes in Electrical Power Engineering curriculum

Outcomes which are classified as Poorly-structured consist of words or phrases which are unclear, unobservable and unmeasurable.

In Figure 6, the most recurring verbs include ***understand*** (56), ***memorize*** (19), ***analyse*** (15), ***apply*** (15), ***explain*** (9), ***use*** (9), ***develop*** (8), ***define*** (7), ***calculate*** (6) and ***knowledge*** (6). Many of these verbs promote lower order thinking (understand, memorize and explain). Some of the recurring verbs, such as ‘knowledge’ and ‘use’ are tantamount to the word understand, which is very difficult to observe or measure accurately.

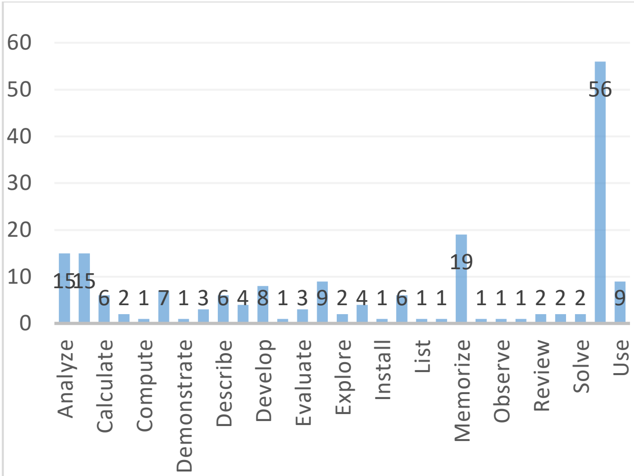

Figure 6. Most recurring verbs in the curriculum

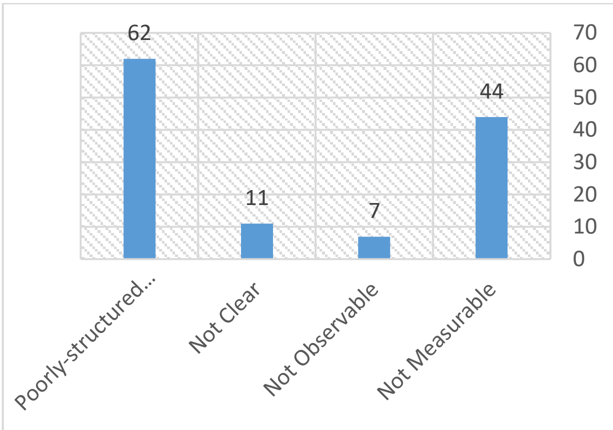

Figure 7. Histogram of poorly-structured course outcomes

The proportion of poorly-structured learning outcomes (subdivided into the three key requirements: being not clear, not observable and not measurable) is shown in Figure 7. Eleven course outcomes (18%) were determined to be not clear. These outcomes do not vividly indicate to students what they are supposed to be able to achieve at the end of the course. Seven course outcomes (11% of the poorly-structured learning outcomes) were determined to be not observable.

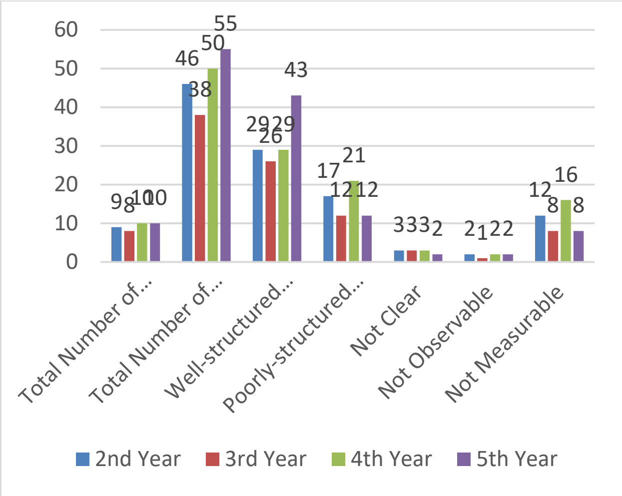

Figure 8. Course outcomes for each academic year in curriculum

An outcome which is not observable is structured without an illustrative or action verb which makes it easy for students to understand what they can able to achieve. Of the 62 poorly structured learning outcomes, 44 (71%) are not measurable. In this study, instructors may not be able to ascertain or accurately measure student learning whether student learning has actually occurred.

The total number of subjects, course outcomes, well-structured course outcomes, poorly-structured course outcomes, unclear course outcomes, unobservable course outcomes and unmeasurable outcomes are shown in Figure 8. The most well-structured course outcomes were found in fifth year courses and the most poorly-structured course outcomes were found in fourth year courses.

IX. CONCLUSIONS

The purpose of this study was to present an analysis of learning outcomes of an Electrical Power Engineering curriculum offered by Department of Electrical Power Engineering at Mandalay Technological University in order to determine whether instructors are structuring them in a way that enables student learning. The course outcomes of the Electrical Power Engineering curriculum were reviewed with regard to three key requirements: being clear, observable and measurable. These three requirements must be met as it will benefit both students (clearly know what is expected of them) and instructors (clearly know what and how to assess). Results indicate that 33% of the 189 course outcomes are poorly-structured, where 6% are unclear, 4% are unobservable and 23% are unmeasurable. The most well-structured course outcomes were found in fifth year courses and the most poorly-structured course outcomes were found in fourth year courses.

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Achievement and Challenges Encountered during the Implementation of Quality Management System and Accreditation in Mandalay Technological University

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Abstract– This paper is based on achievement and challenges encountered during the implementation of quality management system and accreditation system in Mandalay Technological University. In 2017, seven engineering departments of the university have been provisionally accredited by Engineering Education Accreditation Committee (EEAC), Myanmar. After that, one engineering department is fully accredited for one year, three engineering departments are accredited for two years and three engineering departments are accredited for three years. This achievement motivated themselves to continue the accreditation processes, and motivated other engineering departments, which do still need to carry out accreditation processes, to meet the criteria. The human resources, such as skillful full-time faculty members, are still necessary and the departments need to upgrade laboratory facilities with modern tools. University-industry cooperation is also needed to be further promoted. Long term alumnus performance and evaluation after graduation are also needed to perform to possess better development of future education.

Keywords – ***Accreditation system, engineering departments, quality management system, laboratory facilities with modern tools, long term alumnus performance.***

I. INTRODUCTION

Myanmar Engineering Council has published accreditation policies and procedures annually since 2017. To ensure the rights and welfare of universities and programs seeking accreditation, Mandalay Technological University tried to follow the Myanmar Engineering Council Regulations. Accreditation of engineering programmes is undertaken by the EEAC at the request of the IHLs. The EEAC's accreditation process will focus on outcomes and the internal systems to ensure that the graduates are adequately prepared to enter the engineering profession. The process also involves determining the effectiveness of the quality assurance systems and procedures that ensure graduates are adequately prepared to enter engineering practice.

II. OBJECTIVES

The objectives of this paper are to review and analyze the achievement and challenges of quality management system and accreditation in Mandalay Technological University and to produce necessary facts for improvements in Quality Management System (QMS) and accreditation in Mandalay Technological University for future.

III. ACHIEVEMENT AND CHALLENGES OF QUALITY MANAGEMENT SYSTEM IN MANDALAY TECHNOLOGICAL UNIVERSITY

ISO 9001-2015 was introduced since 2015 in Mandalay Technological University.

A. Vision and Mission of Mandalay Technological University

Mandalay Technological University has the vision to produce outstanding engineers and architects through international quality-based education practices and stand out as an advanced technological university that carries out researches and innovations. Therefore, our university's missions are to implement the quality assurance systems of University to upgrade from a national university to be an international level institution of engineering and technology driven by quality assessment and accreditation process of its programs and to place emphasis on establishing a research-based and outcome-based education system.

B. *Challenges of Quality Management System in Mandalay Technological University*

At the early stage of quality management system in Mandalay Technological University, there were many difficulties in introducing quality management process and following the guidelines.

(1) Participation of all staff

The university needed new academic and support staff. Generally new staff were unfamiliar with Quality Management System (QMS) process and they did not participate systematically in preparing the documents.

(2) Lack of facilities

Most of the engineering departments required more facilities such as teachers' rooms with enough space and specific research areas to do group discussions at least once a week, laboratory rooms with lecture space and discussion tables as well as digital library access.

(3) Training Needs and Training Plans

Training needs, training plan and assessment were major challenges found during Quality Management System (QMS) process in Mandalay Technological University. Engineering departments planned well to invite experts from industries for training. At the start of each semester, each department prepared what kinds of training were needed for students and staff. Then training plans were produced according to academic calendar, available time and human resources. Regarding the training needs and training plans, one weak point was lack of systematic training assessment. Although training assessment was performed in each department, there was a need to evaluate and analyse the training outcomes more systematically. The university should give more chances for staff training not only in local industries but also in foreign industries like short-term training in abroad. After participating in trainings, it is essential to make knowledge sharing and to apply in department effectively. Each department took assessment and evaluation on training outcomes. However, training needs and plans could be modified based on the assessment and evaluation results for future.

C. *Achievements of Quality Management System in Mandalay Technological University*

After overcoming the above challenges, ISO 9001-2015 was awarded to MTU on 14th September 2018. Due to the Covid-19 Pandemic, quality management process was delayed to proceed. However, recertification process was carried out on 26th April 2022.

IV. ACHIEVEMENT AND CHALLENGES OF ACCREDITATION SYSTEM IN MANDALAY TECHNOLOGICAL UNIVERSITY

Accreditation may be defined as – institution-level and programme-level. Institution-level accreditation performs overall processes and quality of an institution, whereas programme-level accreditation reviews specific programmes within institutions and attainment of results and student success in depth. Outcomes of accreditation status have significant impact on many aspects of HEIs. First of all, it helps for improving the quality of H.E. through improving its policies, processes and core functional areas, such as research, academics, teaching-learning etc. An accreditation process involves internal and external examiners to assure the public about the compliance of prescribed criteria/standards. The purpose of accreditation is to improve academic quality and public accountability of HEIs.

A. *Accreditation Criteria and Qualifying Requirements*

The program needs to follow the accreditation criteria to be an accredited program. According to the criteria, the following areas were well-prepared in the engineering departments of Mandalay Technological University.

(1) Program Educational Objectives (PEOs)

In order to know whether PEOs are in line with the country development plan or not, Alumni and Industry Advisory Panel (IAP) meetings are held annually. Alumni suggest the industrial needs according to their expert area.

(2) Graduate Attributes (GAs)

For checking GAs attainment in every subject, department meeting is conducted at the end of every semester in order to know whether GAs are covered or not. If GAs are not covered, the course leader need not only to improve teaching method and assessment method but also COs should be reviewed and revised to cover GAs. The program needs to review the contribution of Graduate Attributes (GAs) and Course Outcomes in each semester. If necessary, the contribution is adjusted for each subject to improve students' performance.

(3) Academic Curriculum and Syllabus

In order to develop the course of CE 52036 comprehensively, Physical River Models, Mathematical Models of sediment transport and Coastal Engineering (two-dimensional wave equations) were added. The syllabus and curriculum review meetings were held before the start of a new academic year to discuss and revise the syllabus and curriculum. Syllabus and curriculum was modified based on alumni meetings and comments.

(4) Benchmarking

With the help of Professors from high-ranking university, the benchmarking for syllabus and curriculum of the program is conducted. For CE 31013, CE 32013 and CE 41013 subjects, syllabus and curriculum were revised in civil engineering department according to the comments from other university, for example. All engineering departments also performed benchmarking process and reformulated syllabus and curriculum according to their comments. Some subjects were modified with updated articles in syllabus and curriculum to be in line with the development of industries in the country.

(5) Academic and Support Staff

Academic and support staff play a vital role in improving the engineering education in the program. Therefore the program currently permits the academic staff to participate in private projects as consultants to get field experiences and know industrial needs. The support staff and lab technicians in every laboratory are required to perform laboratory works to understand both theory and practical problems. The university would like to produce graduates with initial competencies of professional practices.

(6) Facilities

The university needs to improve facilities such as laboratory facilities, library, classrooms and other infrastructure buildings for students. To add laboratory equipment such as experimental flume with data logger, laser apparatus, apparatus for hydrology in civil engineering departments are urgently needed. In Mandalay Technological University, university library and department library are already established with resources. However, library status is still needed to be upgraded with digital application, faster internet speed, e-library access to international book and journal resources. Classroom requirements are already provided in the campus. Classroom facilities including projectors, air conditioners and modernized screen are also still needed to be added to create convenient environment for students. Teachers' rooms are provided with enough space according to the specified space criteria. Teachers need private rooms to take a rest and prepare for advanced courses. Good environment can increase human interest in work.

(7) Quality Management System

Quality management system should be kept in line with the education organization. Therefore, the university QMS team and external QMS team check the Quality Management System of the program every 6 months. By following evaluators' comments, the program can be evaluated and improvement can be achieved. Therefore, the continual effort has to be exerted to meet the program vision, mission and objectives.

B. *Eight Components of the Qualifying Requirements*

There are 8 components of the qualifying requirements and each programme is expected to have all the components. These components are:

(1) Outcome-based Education (OBE) implementation

(2) A minimum of 135 Student Learning Time (SLT) credits of which 90 SLT credits must be engineering courses offered over a period of four years

(3) Integrated design project (IDP)

(4) Final year project (minimum six 6 credits)

(5) Industrial training (minimum of 8 weeks)

(6) Full-time academic staff (minimum of eight 8) with at least three (3) Registered Engineers with the MEngC or equivalent.

(7) Staff: student ratio 1: 20 or better

(8) External examiner's report (minimum of two reports over five years)

Seven engineering departments have prepared the qualifying requirements to be successful in the accreditation process of the program. By performing Integrated Design Project, students can improve their skill, group work and problem-solving skill. For final year projects, students and supervisors are allowed to go to industries to get real problems for solving. Then projects are chosen based on industrials needs. External examiner is also invited to review the accreditation process for the improvement in program outcomes.

C. *Challenges of Accreditation in Mandalay Technological University*

All engineering programs have faced many challenges during accreditation process in 2017 with preparing and following the guidelines. Some major challenges are presented in this section. Review after three years to be in line with country development plans, improvement in Graduate Attributes (GA) attainment, discovering a way to achieve a competitive advantage, improved remuneration for academic staff, keeping the quality management system to be in line with the education organization, shortage of academic staff, office staff and also lab technicians are major challenges in engineering programs.

D. *Achievements of Accredited Departments in Mandalay Technological University*

There are 7 engineering departments involved in the accreditation process in 2017. Many challenges including documentation preparation were overcome. Finally the following engineering programs achieved full accreditation in September 2017 in Mandalay Technological University. Achievement records of accredited departments are presented in Table 1.

Name of Department	Year	Period
Chemical Engineering, Electronic Engineering Mechatronic Engineering	3	2017-2018 to 2019-2020
Civil Engineering Mechanical Engineering Computer Engineering and Information Technology Electrical Power Engineering	2	2017-2018 to 2018-2019

Table 1. Achievement Records of Accredited Departments

E. ***Results of Overall GAs Analysis***

To analyse the achievements of program outcomes of departments, overall Graduate Attributes Analysis is done. Table 2 to Table 6 present overall GAs analysis results of one subject, Theory of Structures I (CE 31013) for civil engineering department from 2015 to 2020. All engineering departments analysed the student achievement for all subjects as in civil engineering department. Student achievements can be seen in overall GAs analysis results clearly. After investigating, the overall GAs analysis, improvement areas were predicted for future education.

	Engineering Knowledge	Problem Analysis	Design/ Development of Solutions	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	Project Management and Finance
	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA 10	GA 11	GA 12
GA - MAPPING												
GA - MARK DISTRIBUTION	20	20	20	40		20						
GA - STUDENT ACIEVEMENT	50	50	76.3	62		48						

Table 2. Overall GAs Analysis on Theory of Structures I CE 31013 (2015-2016)

	Engineering Knowledge	Problem Analysis	Design/ Development of Solutions	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	Project Management and Finance
	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA 10	GA 11	GA 12
GA - MAPPING												
GA - MARK DISTRIBUTION	20	20	20	36		20						
GA - STUDENT ACIEVEMENT	78	78	54.8	48		50						

Table 3. Overall GAs Analysis on Theory of Structures I CE 31013 (2016-2017)

	Engineering Knowledge	Problem Analysis	Design/ Development of Solutions	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	Project Management and Finance
	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA 10	GA 11	GA 12
GA - MAPPING												
GA - MARK DISTRIBUTION	20	20	20	36		20						
GA - STUDENT ACIEVEMENT	49	36	78.5	71		67						

Table 4. Overall GAs Analysis on Theory of Structures I CE 31013 (2017-2018)

	Engineering Knowledge	Problem Analysis	Design/ Development of Solutions	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	Project Management and Finance
	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA 10	GA 11	GA 12
GA - MAPPING												
GA - MARK DISTRIBUTION	19.0	19.0	23.0	23.0		16						
GA - STUDENT ACIEVEMENT	95	95	91.4	76		72						

Table 5. Overall GAs Analysis on Theory of Structures I CE 31013 (2018-2019)

	Engineering Knowledge	Problem Analysis	Design/ Development of Solutions	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	Project Management and Finance
	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA 10	GA 11	GA 12
GA - MAPPING												
GA - MARK DISTRIBUTION	22.0	22.0	20.7	20.7		14.7						
GA - STUDENT ACIEVEMENT	84	84	65.3	70		80						

Table 6. Overall GAs Analysis on Theory of Structures I CE 31013 (2019-2020)

In Table 2, improvement area is noticed based on student achievement in each Graduate Attribute for 2015- 2016 academic year. It is obviously seen that GA1- Engineering Knowledge shows low contribution. Therefore, course leader should give more emphasis (more exercise) on problems with engineering knowledge (GA1-Engineering Knowledge). Moreover GA2-Problem Analysis and GA6-The Engineer and Society are also with weak contribution requiring more support (exercises and examples) on problem analysis and engineering society. Based on Table 3 results, problems based on design/ development of solutions and industrial visit experiences are necessary to emphasize the improvement of GA3- Design/Development of Solutions. Students should be allowed to give chances to participate in industrial visits for improving GA4-Investigation. Improvement of student achievement can be seen clearly in Table 4, Table 5 and Table 6.

F. *Continual Quality Improvement (CQI) and Improvements in Future*

To maintain engineering education with accredited programs, Continual Quality Improvement (CQI) is necessary. Figure 1 shows continual quality improvement summary for engineering departments. In some subjects, there was increase in student achievement after some improvements have been made. It is still needed to be improved in teaching plan including delivery methods and assessment system in some subjects.

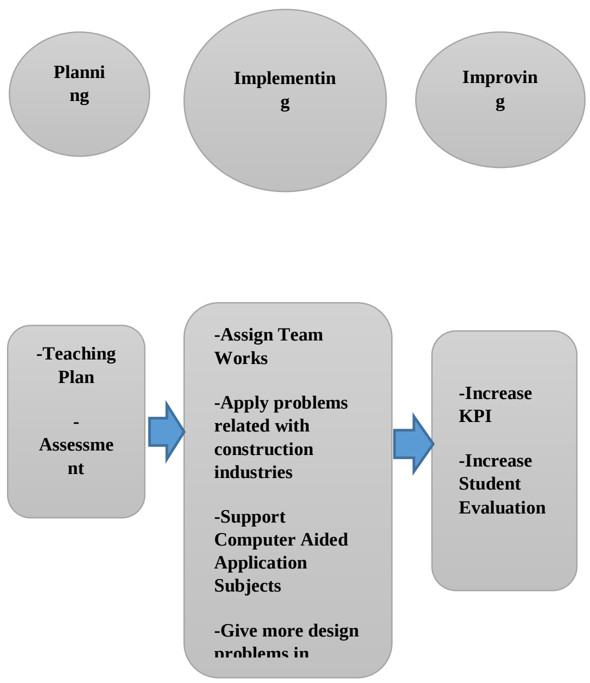

Fig. 1 CQI Summary Diagram

In order to maintain education quality in the university, some areas are still needed to be improved in future. We have to invite expert lectures/talks by guest lecturers from industries including construction industries. The university needs to give more chances for academic staff to have more industrial experiences by allowing them to go on field trips, to make industrial visits and internship training locally and abroad. Courses on professional ethics and code of conduct are also necessary to upgrade for continual professional development. Industry visits and Industry-based projects are essential to upgrade industry-university relationship. Regular use of a logbook in which industrial experiences are recorded is necessary and it must be prepared for use during students' field trip. Alumni Survey is essential to achieve the quality of program outcomes in industries. Based on their feedback, improvements of weak areas can be achieved. Another important thing, Benchmarking System, is also necessary to perform with other high ranking universities to upgrade curriculum and syllabus. Academic and Support staff should be allowed to participate in trainings in both local and foreign industries. Facilities and Infrastructures including recreation center, library and football stadium are already added. In future, safety regulations and guidelines will also be important things to apply in industries and organizations.

V. CONCLUSIONS

If the organization is directed to meet the criteria of accreditation by following the reformulated practices and having adequate preparations, the output quality of the accredited program will always improve. ***IN ANY CASE, THE ENGINEERING DEPARTMENTS NEED TO FOLLOW THE ACCREDITATION GUIDELINES***. The accredited programme ensures the graduates to meet the satisfactions of the industry. With new staff recruitment and the training given to them to be familiar with the Quality Management System (QMS) and the accreditation procedure, the human resource shortage problems can be solved. Awareness seminars and workshops in the area of Health and Safety are also important to be included in future education programs. Modern tools usage is also emphasized to upgrade laboratory experiences for future practices. Digital application, software application, programming skills, advanced technology application and real-time monitoring techniques are the areas required to be improved for the accreditation process in the university. Adding computer-aided application subjects and giving more design problems in design subjects will call for the implementation of new teaching methodology and methods.

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Curriculum Benchmarking Towards the Quality of Electronic Engineering Programs

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Abstract–Curriculum benchmarking is crucial for a program's curriculum to be redesigned or revised in engineering education. Higher education institutions are required to use benchmarking practices to improve the quality of their respective programs. By contrasting the university's performance or standards, or both, benchmarking is a competing tool. Since there are numerous areas and sub-disciplines within electronic engineering technology, the program curriculum can vary. While some institutions have more of a focus on a certain subfield, others do so on a more general strategy. Curriculum benchmarking is needed for not only the improvement and enhancement of the curriculum design but also the breadth and depth of the sub-disciplines within a given program's curriculum. The paper describes the curriculum benchmarking of the Bachelor of Engineering program, B.E (EC), of Technological Universities (TUs) in Myanmar with the Bachelor of Engineering program, B.E (Hons) (ECE), of the Myanmar Institute of Information Technology (MIIT) in Mandalay. The same program of different institutions is compared for eight subject groups, Social Science Subjects, Basic Science Subjects, Engineering Basic Subjects, Engineering Major Subjects, Elective Subjects, Industrial Practice & Internship, Lab Courses, and Research & Development Projects. According to curriculum benchmarking, the total number of subjects in TUs is slightly larger than that in MIIT. The total credit points awarded for a Bachelor of Engineering degree in TU and MIIT are almost the same. The six-year curriculum of the B.E (EC) degree program in TUs corresponds to the five-year curriculum of the B.E(Hons) (ECE) degree program in MIIT. The curriculum in TUs has more specialization areas related to microwave engineering, electromagnetic wave engineering, and electrical machines. MIIT's curriculum has more sub-disciplines related to, robotic, artificial intelligence fields, and computer architecture and organization. Moreover, the students in TUs are taught deeper in the basic engineering subject group and the students in MIIT study more broadly in that subject group. The goal of systematic curriculum benchmarking for electronic programs is to realize the equality and diversity of sub-disciplines in electronic engineering among institutions. The program curriculum is revised by the faculty members, the stakeholders from the industry panel, and the professors who are experts in the specialization area at the meeting before opening the university. According to the continual quality improvement process, the curriculum of the respective program is redesigned in the sub-disciplines to meet the more appropriate level that is aligned with the standards of a particular profession for the next semester. So, benchmarking, the competition tool is provided to enhance the quality of academic curriculum systematically among the institutions.

***Keywords** - curriculum benchmarking, equality and diversity, quality improvement, sub-disciplines, systematically.*

I. INTRODUCTION

Accreditation may be a review method to see if academic programs meet the minimum level of quality. Certification isn't permanent-it is revived at irregular intervals to make sure that the standard of the academic program is maintained. [1] certification in teaching may be a collegial method provided by self-assessment and peer assessment. Its purpose is the improvement of educational quality and public answerability. This continued internal control method happens sometimes each 5 to 10 years. [2] The goal of certification is to check that establishments of higher education meet acceptable levels of quality. [3] The conception of quality in teaching has been drawing the attention of all the interested parties in this specific sector throughout a previous couple of decades. Since quality improvement has been one of the foremost vital options of higher education establishments, it's of equal importance to know the contribution of benchmarking as a way to repeatedly improve and keep competitive. Universities around the world embrace the concept of benchmarking and develop transformational strategies and practices to enhance their organizations. [4] Moise Ioan Achim, Lucia Căbulea, Maria Popa, Silvia - Ştefania Mihalache discuss the importance of benchmarking within the educational activity quality assessment. [5] Prof. Alexandre Lyambabaje highlights that the benchmarks can offer a vital method of harmonization of the Bachelor's degree in education and may be useful to any or all the participants in the instruction sub-sector. [6]

II. AIM

The goal of the paper is that the curriculum of the electronic engineering program is redesigned the course subject to meet the standards of the particular profession based on the equality and diversity of the sub-disciplines by comparing the electronic engineering programs in different universities.

III. PPOBLEM STATEMENT

Electronic engineering has many specialization areas that include semiconductors, nanoelectronics, photonics, image processing, etc. It includes a variety of sub-disciplines, such as applied design, electronics, embedded systems, control systems, instrumentation, telecommunications, and power systems. A program syllabus of any institution couldn't be able to design or create all sub-disciplines for the undergraduate to get a bachelor's degree in engineering education. The curriculum of the electronic engineering program is difficult to meet the appropriate level based on the specialization area.

IV. METHODOLOGY OF CURRICULUM BENCHMARKING

A. Electronic Program in Technological Universities

The electronic engineering department of the Technological Universities (TUs) provides technical and practical training using modernized equipment. The electronic programme makes sure students are qualified to continue their careers as systems engineers, research engineers, controls engineers, communication engineers, and electronic engineers, as well as researchers and university professors. The department of electronic engineering of TUs for undergraduate students awards a Bachelor of Engineering degree, B.E (EC) degree. It is a full-time program and takes 6 years.

B. *Electronic Program in MIIT*

The students interested in joining the department of the electronic engineering program at the Myanmar Institute of Information Technology (MIIT) must successfully complete the university's entrance examination. MIIT awards a Bachelor of Engineering degree, B.E (Hons) (ECE) degree. It is a full-time programme and takes 5 years. The electronic engineering programme in MIIT may be a sub-discipline of engineering that utilizes active elements like semiconductor devices to amplify and manage current flow in conjunction with passive electrical elements, whereas electrical engineering solely uses passive devices. [7]

C. Curriculum Benchmarking for Electronic Engineering Programmes

Curriculum Benchmarking for electronic engineering programmes in TUs and MIIT relies on the subsequent subject groups: Social Science Subjects, Basic Science Subjects, Engineering Basic Subjects, Engineering Major Subjects, Elective Subjects, Industrial Practice & Internship, Lab Course, and Research & Development Project.

(1) Social Science Subjects: The Social Science Subjects offered at the two universities are shown in Table 1. The curriculum of the MIIT program has 6 more Social Science Subjects than that of the TUs program.

No.	TUs	MIIT
1	Myanmar	Myanmar Language and Culture
2	English	English
3		English- Advanced
4	Humanities and Social Sciences	World History in Perspective
5		Principles of Economics
6		Social and Business Etiquette
7		Principles of Management
8		Technical Communication
9		Presentation Skills

Table 1 Social Science Subject

(2) Basic Science Subjects: For Basic Science Subjects, the whole number of subjects of the two universities are almost the same. The detailed Basic Science Subject of these two universities is shown in table 2.

No.	TUs	MIIT
1	Engineering Mathematics	Mathematics
2	Engineering Chemistry	Chemistry
3	Engineering Physics	Physics

Table 2 Basic Science Subjects

(3) Engineering Basic Subjects: For Engineering Basic Subjects, the number of subjects in the TUs program is about two times that of the MIIT program. The detailed Engineering Basic Subjects of these two universities are shown in Table 3. In TUs' curriculum, engineering drawing and electrical machine subjects are taught more and circuit analysis are trained in detail. In the MIIT curriculum, computer field subjects are taught thoroughly and extensively.

No.	TUs	MIIT
1	Basic Engineering Drawing I	
2	Basic Engineering Drawing II	
3	Electrical Machines I	
4	Electrical Machines II	
5	Communication Principles I	
6	Communication Principles II	
7	Fundamentals of Electronic Circuits I	Basic Electric Circuits
8	Fundamentals of Electronic Circuits II	Basic Electric Circuits
9	Electronic Engineering Circuit I	
10	Electronic Engineering Circuit II	
11	Engineering Circuit Analysis I	
12	Engineering Circuit Analysis II	
13	Digital Electronics I	Digital Design
14	Digital Electronics II	
15	Microelectronics I	Electronic I
16	Microelectronics II	
17	Integrated Electronics I	Electronic II
18	Integrated Electronics II	
19	Advanced Electronics I	
20	Advanced Electronics II	
21	Technical Programming I	Programming II
22	Technical Programming II	
23	Industrial Management II	
24	Industrial Management I	Principles of Management
25		Sensor, Actuators, and Mechatronics
26		Arduino Base System
27		Foundations of Web Programming
28		Programming I
29		Programming IV
30		Data Structures and Algorithms
31		Computer Organization

Table 3 Engineering Basic Subjects

(4) *Engineering Major Subjects:* For Engineering Major Subjects, the number of subjects in the TUs programme is about two times that of the MIIT program. The detailed Engineering Major Subjects of these two universities are shown in Table 4. In the TUs curriculum, the control field and the microwave field are taught more and in the MIIT curriculum, the communication and computer field is taught more in detail.

(5) *Elective Subjects*: There are no Elective Subjects in TUs' curriculum. In MIIT, the student must take 9 Electives Subjects from among a total of 12. The Elective Subjects of electronic engineering in the MIIT curriculum are shown in Table 5. In addition, the image processing field, robotic field, artificial intelligence field, and embedded field are taught in more detail.

No.	TUs	MIIT
1		Computer Architecture
2		Operating Systems
3		Wireless Sensor Network
4	Digital Communication I	
5	Digital Communication II	
6	Computer Communication I	Wireless Communication
7	Computer Communication II	
8	Modern Electronic Communication Systems I	
9	Modern Electronic Communication Systems II	
10		Embedded System I
11	Digital Design with HDL II	Embedded Systems II
12	Digital Design with HDL I	
13	Modeling and Control II	
14	Modeling and Control I	Control Systems
15	Modern Control System II	
16	Modern Control System I	
17	Computer Networking	Computer Networks
18	PLC Programming Methods and Techniques, I	
19	PLC Programming Methods and Techniques, II	
20	Digital Control System I	Microprocessor and Interfacing
21	Digital Control System II	Arduino Base System
22	Digital Signal Processing I	Signal and Systems
23	Digital Signal Processing II	Digital Signal Processing
24	Microwave Engineering I	
25	Microwave Engineering II	
26	Engineering Electromagnetic I	
27	Engineering Electromagnetic II	
28	Industrial Electronic & Control I	

Table 4 Engineering Major Subjects

(6) *Industrial Practice and Internship:* After the second semester examination in the second year, the third year, the fourth year, and the fifth year, students in TUs have to take the industrial site visit 4 weeks each while the students in MIIT have to carry out a year special term (Lab Courses) in the university campus. Moreover, the student in TUs goes to industries as an intern for a minimum of two months after the sixth year first or second semester examination.

(7) *Research & Development Project:* In both universities, students have to complete their individual projects.

No.	Subject Name
1	Computer Graphic
2	Image Processing
3	Data Analytics
4	Robotics II
5	System Programming
6	FPGA Based System Design Laboratory
7	Advanced Control Systems Laboratory
8	Data Mining
9	Natural Language Processing
10	Artificial Intelligence
11	Social Issues in Computing
12	Computer Oriented Numerical Methods

Table 5 Elective Subjects in MIIT

V. RESULTS AND DISCUSSION

1st year to 6th year B.E (EC) degree program in TUs corresponds to 1st year to 5th year B.E (Hons) (ECE) degree program in MIIT. The 1st to 2nd year in both curriculums are the engineering foundation courses for the two universities.

According to the benchmarking process, the proportion of each subject group in TUs and MIIT is shown in Figures 1 and 2. The Social Science Subjects in TUs are 15 % of the total subjects, Basic Science Subjects are 17% of the total subjects, the Engineering Basic Subjects are 33% of the total subjects and Engineering Major Subjects are 35% of overall subjects. There are no Elective Subjects in TUs.

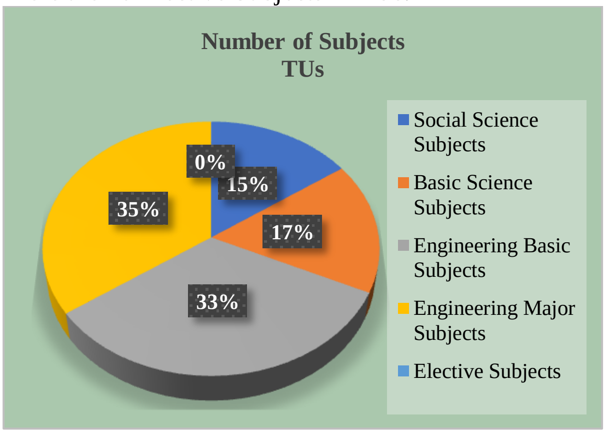

Fig. 1 Proportion of Subject Groups in TUs

The number of Social Science Subjects, Basic Science Subjects, Engineering Basic Subjects, Engineering Major Subjects, the Elective Subjects are 29%, 18%, 19%, 19%, and 15% respectively of the total subjects in MIIT.

The comparison of the total number for each subject group in TUs and MIIT is shown in Figure 3. Social science subjects in MIIT has significantly greater than in TUs. Basic Science Subjects in TUs and MIIT are nearly the same. Engineering Basic and Major subjects in TUs are significantly more than in MIIT. Elective subjects are only for MIIT.

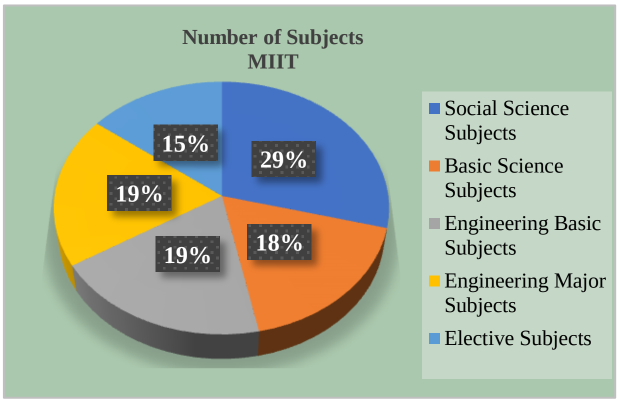

Fig. 2 Proportion of Subject Groups in MIIT

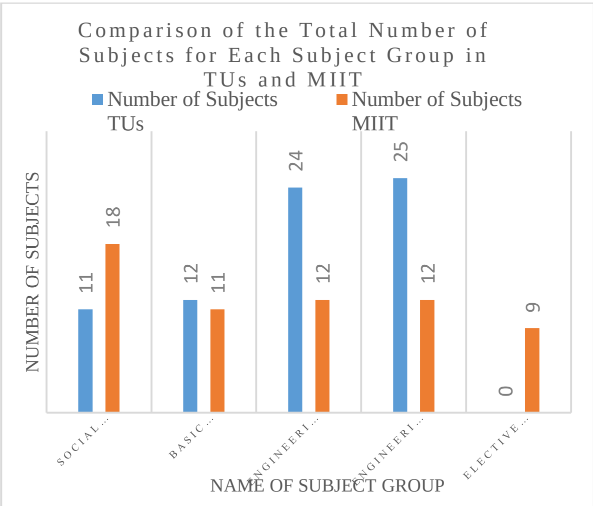

Fig. 3 Comparison of The Total Number of Subjects in TUs and MIIT

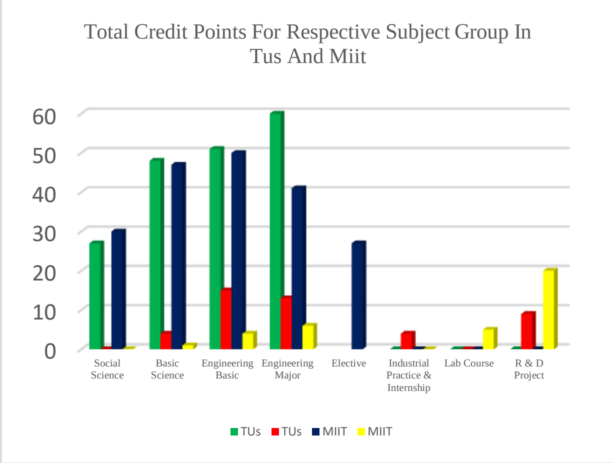

Fig. 4 Credit Points in TUs and MIIT

Figure 4 shows the total credit point in TUs and MIIT. The total credit points for lectures on Social Science Subjects, Basic Science Subjects, and Engineering Basic Subjects in TUs are nearly the same as that in MIIT. The total credit points for lectures on Engineering Major Subjects in TUs are more than that in MIIT and the total credit points for lectures on the Elective Subjects in MIIT are significantly greater. There are no credit points for practice on Social Science Subjects in both TUs and MIIT. The total credit points for practice on Basic Science Subjects, Engineering Basic Subjects, and Engineering Major Subjects in TUs are greater than that in MIIT. The credit points of Industrial Practice are only for TUs and Lab Courses are just for MIIT. The total credit points for practice on R and D projects in MIIT is significantly greater than that in TUs.

To award a Bachelor of Engineering degree, 231 credit points are required for students in TUs and MIIT. In these two universities, the total number of credit points are the same as shown in figure 5. The total number of subjects for the EC program in TUs is 74 and that in MIIT is 63. So, the total number of subjects for these two universities differs a little. TUs' curriculum has 11 more subjects than MIIT. The students in TUs have to study the lessons from the series of reference books year by year but the students in MIIT have to study the lessons not from the series of reference books.

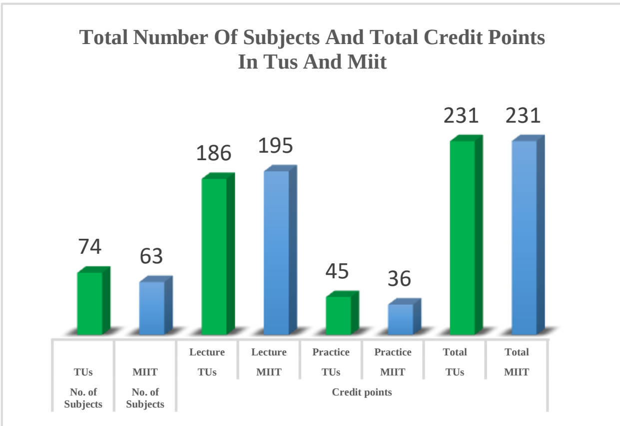

Fig. 5 The Total Number of Subjects and Credit Points in TUs and MIIT

VI. CURRICULUM DEVELOPMENT

A process called "Continuous Quality Improvement" makes sure that the curriculum is being improved by programs intentionally and systematically. The contributions from program stakeholders, including external assessors, an Industry Advisory Panel (IAP), students, and an accreditation panel, should be considered and applied as the department views suitable for implementing CQI processes. The process of developing a curriculum entails design, development, implementation, monitoring, assessment, and review. The system loop will be closed by improvements based on evaluation comments, and the procedure will continue year by year. Teachers are crucial to the creation, execution, evaluation, and revision of the curriculum. With their knowledge, abilities, and experience, teachers are essential pillars in the teaching process and at the canter of any efforts to improve the curriculum. At the end of the semester, the teachers in the department revised the syllabus and curriculum of the respective course. After discussing with the industrial panel and the professors who have experience within the specialization space, the department decides on a draft paper, which is then sent to the faculty level. When a faculty is satisfied, the document is sent to Dean’s committee before being delivered to the University Senate. The final permission is granted by University Senate.

VII. CONCLUSIONS

The equality and diversity of sub-disciplines in the electronic program among institutions must be achieved from curriculum benchmarking. The course leader of the faculty member revised and changed the subject to meet the excellent level of higher education at the end of the semester. The program curriculum is revised by the faculty members, the stakeholders from the industry panel, and the professors who are experts in the specialization area at the meeting before opening the university. According to the CQI process, the curriculum of the respective program is achieved in the sub-disciplines to meet the more appropriate level that is aligned with the standards of a particular profession for the next semester. So, Benchmarking, the competition tool is provided to enhance the quality of academic curriculum systematically among the institutions.

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