IFE Insights Reports

Teaching Engineering in the 21st Century:

4 Key Themes

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Prologue

Engineering needs to be rethought; it has never been clearer than now. I am sure that the COVID-19 pandemic is mentioned in thousands of prologues; nevertheless, without fear of sounding repetitive, such a remarkable situation that impacted the whole world is not easy to ignore and it is imperative to affirm that the world is no longer the same.

After four years, since March 2020, when everything stopped at a level that no one could have ever imagined, the lessons keep coming and surprising us. One of the most outstanding facts, undoubtedly, was the warm connection that was created among different industries, we are nothing without each other.

It would be simple for anyone to assume that, in the presence of a global health problem, only doctors and health care professionals could solve the obstacles. It was not the case. It was the alliance of hundreds and thousands of experts across the globe that allowed us to be here, at present, facing the upcoming difficulties that await us as humanity.

The path looks winding: climate change, poverty, water scarcity, gender gaps. We find ourselves at a point of no return, where the only way out to glimpse a promising future if collaboration and working for the common good are the standards of our course ahead. It is through the rich tapestry of connections and collaborations among individuals and businesses that we not only thrive but also foster a vibrant and inclusive community, celebrating diverse perspectives, cultures, and values, ultimately benefiting not only ourselves but also contributing to the betterment of the world.

In a panorama like this, it is up to international authorities and educators to decide whether to ignore or to undertake actions based upon the lessons learned from these difficulties.

The topics of the dialogues that were addressed at the WEEF & GEDC 2023 conference, a world-renowned event for engineering schools around the world, were carefully chosen through surveys and interviews with pro-

fessors prior to the summit, where trends were identified and thus, defined the program.

The conference aims to enable industry and humanity to collaborate and grow together. Being a dynamic congress that promotes meetings between leaders, different realities are observed and promotes empathy, paving the way to discussions in order to find solutions.It is time to embrace engineering to achieve sustainable flourishment, where everyone is welcome, in an environment where not only the world changes how it views engineering but where engineering changes how we see the world. It is a new transdisciplinary engineering offering transdisciplinary resolutions.

A new engineering arising from classrooms that faces inequity head-on and confronts it.

A new engineering that emerges from dialogue and understanding of a multifaceted civilization.

A new engineering like the one discussed in this report.

Dr. Feniosky Peña-Mora
Dean of the School of Engineering and Sciences
Tecnológico de Monterrey

Preface

Education is an entity that undergoes significant modifications at the end of every school cycle. On a more local scale, both teachers and students engage in activities that promote such changes, renewing the way they teach and learn from each other.

Classrooms have left behind higher-education institutions; universities and the workforce are aware of this. Engineering education has failed to break with its predominant tradition: it continues to be considered a hostile field undeniably dominated by men. However, it's also fertile soil with great potential.

Engineering has the ability to improve the quality of life of millions of people; nevertheless, challenges are becoming increasingly intricate with every passing day, and it seems that this reality is gaining more ground in education.

Encounters like this one are the first steps in shaping professionals who will face an unknown future. This space helps to set a precedent in different summits and meetings for leaders around the world, establishing a framework of reference. The congress received 399 attendees, 74 deans, 127 universities and 17 organizations. The event brought together people from 35 countries, including Mexico, Spain, Russia, Japan, Chile and the United States. In addition, it involved 347 authors and contributed 72 papers eligible to be published in the IEEE Xplore digital library and 28 workshops for deans and students.

The obstacles awaiting subsequent generations are uncertain, and issues such as climate change, population growth, and the increasing use of generative Artificial Intelligence tools are just glimpses of what we can expect in the near future. Right now, having all the answers is impossible, but we are certain of something that we can do within our grasp: providing engineers with the necessary competencies to face the future.

Thus, active collaboration between academia and enterprises is essential, bringing classrooms closer to real-life problems to develop the required skills beyond the shelter of higher-education institutions.

We must question ourselves how engineering education can be improved, starting by identifying which practices can benefit the relationship between academia and industry.

We must rethink the curriculum and reflect on the interdisciplinary qualities required in an evolving environment where change is the common denominator.

Beyond just questioning, it is time to attract and retain women in engineering. To create safe, attractive and rewarding spaces for girls interested in science.

Dialogues like those presented in this report show us that engineering has reinvented Earth, but it is time for this discipline to reinvent itself.

José Escamilla de los Santos, Associate Director of the Institute for the Future of Education (IFE)

Introduction

Engineering is a fundamental pillar in progress and innovation. Engineers are the architects of the future, as they are responsible for designing creative solutions to complex challenges, from sustainable infrastructures to advanced technologies. Their education involves not only technical knowledge but also critical skills such as analytical thinking, problem-solving, and interdisciplinary collaboration. These essential aspects should be considered throughout their academic career.

The World Engineering Education Forum (WEEF) has been held since 2010; however, starting from 2016, it has been jointly organized with the Global Engineering Deans Council (GEDC). This collaboration promotes the involvement of various entities such as representatives from educational and industrial institutions, non-profit organizations, and governments, aiming to "promote pedagogy and impact engineering education on a global scale."[1]

It has become the largest event in its field, changing its venue for each edition, visiting countries such as South Korea, the United States, Spain, among others.

In 2023, Tecnológico de Monterrey had the opportunity to host the event from October 23rd to 27th, coinciding with the 80th anniversary of the Mexican institution and the 15th anniversary of the GEDC.This edition's theme was "Convergence for a Better World: A Call to Action," inviting participants to work cooperatively during and after the workshops and conferences by sharing thoughts and ideas about tackling modern-day problems in the different engineering fields.

1 IFFES. (n.d.) World Engineering Education Forum. https://www.ifees.net/weef/

Gathering deans from different countries in order to discuss topics related to the improvement of engineering education and today's reality, such as the adversities of including Artificial Intelligence in the curricula, the benefits and disadvantages of different levels of transdisciplinary engineering education, the role of women in STEM, and the importance of having the industry work together with engineering schools, among others.

In addition, the Forum targeted engineering solutions for some of the United Nations' Sustainable Development Goals, as education is a crucial factor in achieving such goals. Hence, engineering education must aim to form graduate students who can "continuously think outside the box, improve their skills in emerging technologies, processes, and systems, while meeting the day-to-day demands of their jobs." [2]

Thus, WEEF featured the Educational Track as part of the International Federation of Engineering Education Societies (IFEES) Conference, covering three areas: Evolution, Innovations, and Educating for the Sustainable Development Goals. These topics were discussed in various panels, conferences, and workshops. Participants also had the opportunity to earn a microcredential validating their active learning experience.

Additionally, the Leadership Track, in collaboration with GEDC, employed an innovative dynamic where after the panels, directors from different institutions participated in a workshop to draw team conclusions. These conclusions were summarized and published in this report.

To embrace change, the workforce of the future needs skills aligned with environmental awareness, such as critical thinking, collaboration, self-awareness, and problem-solving, among many others.[3] Consequently, engineering education must aim for holistic approaches and the learners'

2 Euan, L. D., Hadgraft, R. G., Boyle, F., & Ulseth, R. (2023). Disrupting Engineering Education. In A. Johri (Ed.), International Handbook of Engineering Education Research (1st ed., pp. 115-133). Routledge.

3 UNESCO. (2017). Education For Sustainable Development Goals: Learning Objectives.

development of non-technical competencies, including communication, teamwork, creativity, and critical and ethical thinking.[4]

Engineering is essential for green development, and engineers play a vital role in addressing the various issues related to human needs. As a means to achieve the SDGs, engineers have to be prepared to encounter the multifaceted challenges that humanity faces now and in the near future.[5]

As technology evolves, so will engineering professional fields, as well as students and their education. Universities need to keep up with new and diverse technology trends to overcome the emerging obstacles hindering the improvement of ecology and humanity's well-being.

This report comprehensively examines the fundamental considerations in engineering education for the 21st century. It also delved into the notable insights of the WEEF & GEDC 2023 forum, with a specific focus on the Leadership Track Workshops. Lastly, the final recommendations derived from the GEDC dialogue are summarized, with its 2024 edition set to take place at the University of Technology Sydney in Australia.

4 Lavi, R. & Bagiati, A. (2022). The New Engineering Education Transformation Program at Massachusetts Institute of Technology: The Evolving Design and Implementation of a Programmatic Evaluation Study. In B. R., Moser, P. Koomsap & J. Stjepandić (Eds.), Transdisciplinarity and the Future of Engineering Proceedings of the 29th International Society of Transdisciplinary Engineering (ISTE) Global Conference, July 5–July 8, 2022, Cambridge, MA, USA (Vol. 28., pp. 658-667). IOS Press.

5 UNESCO. (2021). Engineering for Sustainable Development. https://unesdoc.unesco.org/ark:/48223/pf0000375644/PDF/375644eng.pdf.multi.

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Engineering Education for the 21st Century

In this day and age, it is the responsibility of institutions to transform the educational experience of the future workforce. In this regard, the words of the Royal Academy of Engineering stand out: "It's not that you've been doing something wrong, it's that the world is changing and we need to move with it.[6]"

As we enter the third decade of the 21st century, educators and institutions continue to question what engineering education should look like. Many of the modifications to be implemented have been discussed for more than a decade, whether it is the elaboration of a transdisciplinary curriculum, integrating well-known soft skills, or shaping lifelong learners.[7]

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6 Engineers Without Borders UK. (January 31, 2024). *Engineering education for the 21st Century: Insights from the Lab.* https://www.ewb-uk.org/engineering-education-for-the-21st-century-insights-from-the-lab/.

7 Boston University. (2008). *Engineering Education for the 21st Century.*

However, even though these may seem repetitive and fruitless dialogues, they are necessary conversations because our vision of all these aspects has changed over time. Talking about a transdisciplinary approach in 2023 is not the same as talking about transdisciplinarity in 2000. While the essence is the same, the type of complications that society confronts at a given time in fact, are a call to transformation, shaping today's society into a new one in the future, and so on. In this sense, discussing about women in engineering has a different connotation today.

Within the context of engineering education, the inclusion and active participation of women promote diversity and excellence in engineering training. Educational institutions and companies in the sector must collaborate to provide inclusive and equitable conditions that foster access and retention of women in STEM (Science, Technology, Engineering, and Mathematics) careers. Furthermore, companies have the responsibility to support educational initiatives that encourage women's participation in engineering by offering internship programs, mentoring, and professional growth opportunities that can help close the gender gap in the field of engineering.

The United Nations Sustainable Development Goals (SDG) is a program that represents a call to action towards sustainable, universal and ambitious development with the objective of promoting prosperity in all societies, while protecting Earth.[8] These goals also provide the opportunity to see the path that communities must follow in pursuing the common wellbeing. Likewise, they can serve as a reference, of how certain educational circumstances must change because "all sustainability problems are multidisciplinary by nature, making them difficult to be solved efficiently."[9]

8 United Nations. (n.d.). *17 Goals to Transform Our World.* https://www.un.org/sustainabledevelopment/.

9 Orozco-Messana J, de la Poza-Plaza E, Calabuig-Moreno R. Experiences in Transdisciplinary Education for the Sustainable Development of the Built Environment, the ISAlab Workshop. *Sustainability*. 2020; 12(3):1143. https://doi.org/10.3390/su12031143.

Additionally, engineering education in the 21st century must emphasize active and practical learning, providing undergraduates with meaningful learning experiences through projects, laboratories, and internships. These practical exposures do not only strengthen the students' technical skills but also expand their soft skills, which are essential in today's workplace.

The integration of emerging technologies and digital tools is also elemental in engineering education in the 21st century. From simulations and virtual reality to online learning platforms, these tools offer new ways of teaching and learning that improve accessibility, flexibility, and effectiveness of the educational process.

Preparing engineers to devise solutions that are environmentally sustainable, socially fair, and economically viable requires integrating green principles into the curriculum, as well as fostering an ethical and service-oriented mindset among the school community.

Traditionally, engineers have been seen as problem solvers and active participants in the development of cultures.[10] This aspect represents the most significant change, as the line between different disciplines is increasingly blurred, and it becomes impossible to even imagine

10 Lucena, J., Schneider, J. & Leydens, J. A. (2022). *Engineering and Sustainable Community Development.* Synthesis.

the type of jobs that will exist in the future for which we are preparing our learners.

Future engineers should be capable of utilizing the various tools and technologies that emerge every day. Engineering education in the 21st century must be innovative, adaptive, and student-centered, preparing engineering graduates to seize the opportunities of a constantly changing society.

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WEEF & GEDC 2023

Photo: Tecnológico de Monterrey, Facebook

This year, the WEEF-GEDC forum was full of enriching speakers and panelists, who were able to convey the challenges and issues that engineering education and the industry are facing at present. Responding to the matters that are now accelerating the world is indispensable, so every event within the forum aimed to discuss the current situation and the future of engineering.

The first conference was reflective of this sentiment. In "Education Models for an Accelerated World," Dr. Michael L. Fung, Executive Director of Tecnológico de Monterrey's Institute for the Future of Education (IFE), highlighted the importance of rethinking the educational models, so they can fit in the current reality. Lifelong learning is a fundamental pillar for humanity, which needs to be promoted in order to improve the lives of millions of people and, therefore, ensure a better future for society, not only during the traditional academic years but throughout life. This is why institutions must ponder the importance of delivering education to non-traditional learners in order to narrow down the educational gap.

Following up on the current trends is a must in education nowadays. While traditional educational models can be effective, institutions and enterprises need to collaborate consistently to develop the necessary proficiencies in university graduates to solve current real-life problems. Having lifelong learning in mind, people have to be motivated to take alternative credentials to further enhance their education, instead of considering them replacements of academic degrees. It is also important to create alternative pathways to certify the development of the skills currently required by the work environment.

Photo: Tecnológico de Monterrey, Facebook

Dr. Michael L. Fung continued as moderator of the subsequent panel, "Program Accreditation of New Academic Models," with the valuable contribution of Dr. S.K. Ramesh, ABET President, together with Miguel Romero Ogawa, CACEI Academic Director. As changes in businesses, climate, communications, and many more areas are taking place all at once everywhere, institutions need to keep up with them through procedures and the implementation of laws, policies, and regulations.

Accreditation bodies are responsible for setting the standards, and educational institutions are responsible for complying with them, as well as rapidly embracing the changes needed for the future. After all approximately 65% of children born in 2016 will be employed as adults in jobs that do not exist yet.

The convergence of physical, digital, and biological disciplines is not only pushing for a change in accreditation bodies, but also in faculties. Therefore, joining efforts is also imperative. Transdisciplinarity and communication, along with other strategies, are key to reaching fast adaptability; thus, incorporating the understanding of social sciences and humanities into the engineering curricula or partnering up with those faculties are necessary actions to navigate a complicated ecosystem.

Accreditation bodies need to refine strategies in order to deal with current adversities, such as: being mindful and engaging in collaborative work with other faculties, instead of working in isolation; reinforcing awareness regarding sustainability and social responsibility in freshmen, so they can graduate with these important concepts in mind in whatever career path they decide to pursue; and incorporating social skills and emotional intelligence to learn how to work together with other faculties, as well as understanding the impact that AI will have in the near future. Still, it's important to point out that not only accreditation institutions are responsible, but also everyone else involved in the development of the future workforce.

Next up, Feniosky Peña-Mora, Dean of Engineering and Sciences

at Tecnológico de Monterrey, held a welcoming event for the deans that would later participate in several workshops addressing topics related to engineering education, in which they had the opportunity to learn more about Tecnológico de Monterrey's Engineering and Sciences faculty.

Tec de Monterrey is governed by three important axes based on concepts that will enhance the students' potential to decode society's most pressing issues:[11]

- **Innovation:** refers to the latest education model at Tec de Monterrey, Tec 21, which was implemented recently as a new way to educate the leaders of tomorrow.
- **Investigation (research):** providing students with the latest knowledge to apply said concepts in real-life situations is a must.
- **Internationalization:** making a positive impact on the whole world through the university's cooperation in the development of a workforce focused on sustainability and social responsibility .

Currently, Tec de Monterrey's School of Engineering and Sciences has engineering degrees in 20 campuses within Mexico. It has contributed 70% of the total scientific production of the university and cooperates with more than 70 universities on research projects in countries such as England, Chile, Malaysia, Japan and United States, among others.

Tec de Monterrey focuses on "human flourishing" at the community level, using innovative educational models and top-notch technologies to greatly enhance the academic journey of students and enrich their growth as professionals with a global, sustainable, social well-being vision.

The first workshop of the leadership track, "Networking Opportunities," took place during the afternoon. Deans participated at different round tables aiming to get to know each other first and then talk about the efforts they carry out at their universities.

11 Dirección de Operaciones de Investigación del Tecnológico de Monterrey. (n.d.). *Plan Estratégico 2025: Innovación, Investigación e Internacionalización.* https://operacionesdeinvestigacion.tec.mx/es.

Deans also addressed disruptive trends for engineering graduates, mentioning the importance of concepts such as problem-solving skills, schedule flexibility, ethics, sustainability, and honesty, among others. The participants were able to discuss these topics at a deeper level during other workshops that took place on the second and third days.

Later on, a "Dialogue Between Engineering Deans and Industry Partners" was carried out during the afternoon of the same day, with the participation of a great group of experts: P.J. Boardman, Global Director, STEAM Outreach and Workforce Development at Mathworks; Dora Smith, Senior Director, Global Academic & Startup Strategy at Siemens Digital Industries Software; Leopoldo Decillo, CEO Grupo Proeza and President to the Academic Board of the School of Engineering and Science at Tec de Monterrey; Xavier Fouger Senior Director, Global Academia Programs at Dassault Systèmes; and Blas Treviño, Project Leader in BTC Business Transformation Consulting company.

As expressed by the title, the group of experts discussed the importance of establishing a close relationship between universities and companies. At mere sight, this might seem like a linear process in which schools prepare their students to graduate so they can get a job related to their degree. While this premise is still true in part, the relation between industry and universities is not as simple and both need to work together consistently, in order to provide the knowledge and capabilities that enterprises require to contribute with jobs to our communities. Besides, new generations of engineers must provide fresh and novel insights to solve matters that have already been fixed with traditional technologies and methods.

Involvement of companies in the students' learning process is a very enriching experience. Practices such as internships help students to apply concepts learned in class, besides developing a series of skills based on real problems, as well as becoming familiar with the environment where they will be involved once they graduate.

Moreover, difficulties persist in the relationship between both types of institutions; the clock in the industry and the clock in the academia are the same, but one is ticking faster than the other. The difficulty lies in harmonizing both. The academia needs to accelerate the pace because companies won't slow down. So, they need to work together in order to deal with this issue, and the best way of doing it is by having constant and proactive communication, establishing clear expectations, and making a mutual commitment to the delivery of high-quality services to the students in order to promote their talents in their respective areas. Each type of institution can go fast alone, but together they can go even further.

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The following day, the event began with a conference titled "Avengers, Assemble!: Transforming Engineering Education through Artificial Intelligence," led by Dr. Uohna Thiessen, AI Solution Architect, together with Mark Thiessen, Senior System Analyst at NASA. Both lecturers portrayed engineers as Marvel superheroes through analogies as a way to explain how Artificial Intelligence can be used to acquire abilities similar to the superpowers of these characters.

Dr. Uohna Thiessen explained that just as superheroes are expert tacticians, engineers who follow these models should understand the fundamentals of what AI is, its potential, and its possibilities. Some of the capacities both experts suggested to take as an example for an engineer's repertoire are special sensory perception, strategic decision-making, enhanced pattern-recognition abilities, collaboration across disciplines, empirical thinking skills of the scientific mind, strong communication skills and the capability to envision and interact with complicated systems.

Through these illustrations, the speakers attested that Artificial Intelligence is fit to complement the basic principles of education. Just like electricity, AI operates as a general-purpose tool and it is part of our daily lives. Thereby, engineers must be prepared to adopt AI in numerous aspects of their lives.

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"We will not live to see all the manifestations of Artificial Intelligence, but the students you are preparing will definitely live in a world where everything will be AI-powered or AI-based."

Dr. Uohna Thiessen, AI Solution Architect.

Photo: WEEFGEDCofficial, Facebook

As an Artificial Intelligence Strategist, Dr. Uohna Thiessen, describes that in the branch of AI known as Machine Learning (ML), machines attempt to mimic human mentality. She invited the audience to reflect on the word "artificial" in AI because these devices just resemble intelligence, meaning that they are imitating "real" intelligence. Hence, AI gives technologies the capability to seem intelligent by learning, speaking, perceiving, and reasoning.

In addition, she mentioned that humans are the power line in Machine Learning (ML). Machines are probabilistic, not deterministic and they depend on a responsible human being to control them and set the thresholds required to overcome issues.

Nowadays, data is the most important new source of education. The lecturers shared that professionals need to be in touch with real problems in order to solve them. They ought to be data literate and proficient to harness valuable insights that can benefit society. Communication is the main problem but also the primary solution. Some of those challenges might have already been addressed by someone, but nobody else knows about it. "The work is about communicating the work," Dr. Thiessen added. Engineers need to find skills for communicating their work, and AI can help.

Subsequently, the "Critical Issues Facing Engineering Education in the AI Era" panel was conducted by Dr. Enrique Cortés-Rello, Director of the Artificial Intelligence Hub at Tecnológico de Monterrey. The panelists for this session included Dr. Tania Cristina D'Agostini Bueno, Chairman of the Scientific Council at the Institute for Electronic Government and Intelligence and Systems; Dr. Paloma Díaz Pérez, Dean of Escuela Politécnica Superior at Universidad Carlos III; Gaby Arellano Bello, Senior Applications Engineer in Education at MathWorks; and Ricardo Anaya, Qualcomm Qualcomm Latin America Project Manager.

The panelists discussed the key conundrums of Artificial Intelligence in engineering education and outlined that there's non-uniform access to AI tools. The goal is to incorporate AI into the curricula, but it is not as easy as it seems. Teachers are now learning how to use this technology, managing their faculty's learning curve, and balancing the use of AI by ensuring a good learning process. They described that the most difficult scenario is the lack of critical thinking, poor ethics and plagiarism concerns; as well as the slow pace of change, lack of flexibility of the stakeholders, the existing biases, and having non-mathematical background, which might result in people struggling. Professionals should also be cautious about using AI as a universal truth. Their recommendation is to change the vision regarding AI and teach its correct use, instead of prohibiting it.

Photo: WEEFGEDCofficial

Afterwards, a conversation called "Dialogue between Engineering Deans and Deans of Other Disciplines" was introduced by Joaquín Acevedo Mascarúa, Academic Associate Dean from Tecnológico de Monterrey, with the participation of Dr. Luis Gutiérrez, Vice Rector at TecMilenio; Dr. Jorge Valdés, Former Dean and International Strategic Director of the School of Medicine and Health Sciences; and Dr. Yadira Ornelas, Leader of Futures Design Lab and Leader of the School of Architecture at Tecnológico de Monterrey.

The speakers noted that companies won't focus on college degrees anymore; they will instead focus on people's skills coming from real-life experiences. Furthermore, reality isn't defined by just one discipline, a full understanding of a quandary requires a set of different disciplines. Competency-based education allows a practical approach in which time is not a relevant matter, as long as students acquire the necessary capabilities. Additionally, collaborating with people in other fields can help hone a new mindset that offers diverse solu-

tions. On the other hand, if we keep working with people who are similar to us, we might get the same answers.

They also pointed out that graduates are being trained to fit into a particular existing role, but education must go beyond to anticipate job opportunities that have not yet been created; and so, the learning community has to be seen as a continuum.

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The third day started out with a keynote conference about "Leadership of Women in STEM" hosted by Rovani Sigamoney from the UNESCO Education Programme. She stated that studies revealed that the presence of women in universities might be more palpable in high-income countries, but in middle-income countries there is a difference of 15.4% between men and women getting into Higher Education; and the difference in a lower-income country is 9.6%.

On top of that, in 2023, the gender gap in STEM is still significant, since women represent only 28% of the STEM workforce internationally. According to this information, Sigamoney proposes that Arts and Design are key disciplines for the upcoming employment landscape, as well as stimulating and attracting children to math and science at a young age. These are the required modifications to the system, in conjunction with the way engineering is being taught, in order to promote inclusivity.

To address the pipeline problem, she considers the need of empowering young women with knowledge and information about engineering and science so they can make informed decisions in the academic and professional careers of their choice. Similarly, it is important to make sure that there is no gender bias in technology and in the devices designed exclusively for girls or boys, especially when they are younger. Recruitment and promotion targeted systems, exclusive research funds for women in STEM, retention monitoring systems, and mentorship programs, are urgently needed to encourage girls into joining STEM careers.

The next panel, "Eco-Systems to Attract and Retain Female Engineers/Scientists in Industry and Academia," also highlighted the need for collaboration between universities and businesses. This panel had the participation of Inés Sáenz, Vice President of Sustainability and Equity at Tecnológico de Monterrey as moderator; Engineer Marianela Santos, Management Consultant and Entrepreneur; Dr. Fatima Alleyne, Chief Executive Officer and Founder of Beyond DEIBA (Diversity, Equity, Inclusion, Belonging, and Accessibility); and Dr. Renetta Garrison Tull, Vice Chancellor, DEI at the University of California, Davis.

The panelists explained that in order to innovate, new people's ideas must be included when making decisions in the academia and the workforce market. People from low-income communities who have not had many academic or job opportunities must be able to bring different experiences into a conversation that must happen as early as possible, at the point where educational decisions for the future are being made. Dr. Fatima Alleyne invited leaders in the audience to observe their institutions' current structures and systems to change what is required and make sure that every woman feels valued by providing safe and healthy conditions for them.

"You see from the data that women are here, we are ready, we are qualified."

Dr. Fatima Alleyne, Chief Executive Officer and Founder for Beyond DEIBA

The speakers agreed that collaboration could happen through the diversity of voices forming part of advisory committees and include people from enterprises in K-12 spaces. Likewise, institutions must focus on technical and non-technical skills, since both are essential to perform well, at any role in the future. Bridging that gap between industry and the educational system must happen as early as

possible, and investing in K-12 systems to support student success, particularly in Higher Education, must be part of the conversation. Women are leaving STEM's educational environment, so it's the institutions' duty to counteract this situation and contribute to women's professional growth in engineering disciplines.

Connected professionals who undergo hands-on experience through courses, internships, or activities rooted in the curricula will be able to detect palpable answers for intangible but substantial questions. A practical approach enables learners to apply theoretical concepts while getting familiarized with talents that will give them access to creativity and the discovery of different solutions.

Leaders belonging to the engineering and educational ecosystems must rethink the established systems to welcome new and virtuous opportunities that include everyone; in partnership with companies, so they can move forward together.

Leadership Track Workshops

The report will outline the discussions from multiple workshops focusing on the challenges faced by engineering and science schools. Deans from various countries convened to address issues related to engineering and propose solutions and best practices to overcome them.

During these workshops, deans were introduced to the main topic with the guidance of a moderator. Later, they were asked to discuss at their tables several questions regarding the main topic of each workshop.

Through post-it notes, deans were able to share their ideas with other participants, promoting opportunities to start a dialogue. By the end of each workshop, every table voted for the best proposed idea and explained it to the rest of the attendees.

Key Findings by Workshop

a. Workshop: Developing Industry-University Partnering Programs in Undergraduate Engineering Education

Collaboration between industry and academia is widely recognized as a cornerstone in shaping the workforce of the future, particularly in undergraduate engineering education. This symbiotic relationship plays a pivotal role in equipping students with the skills, knowledge, and practical experiences required to thrive in today's dynamic professional landscape.[12] As such, gaining insights into various successful programs implemented in different universities worldwide not only fosters cooperation, but also facilitates the improvement of these crucial initiatives.

12 Ahmed, F., Fattani, M. T., Ali, S. R., & Enam, R. N. (2022). Strengthening the bridge between academic and the industry through the Academia-Industry Collaboration Plan Design Model. *Frontiers in Psychology*, 13. https://doi.org/10.3389/fpsyg.2022.875940.

Practices that Enhance Collaboration Between Academic Institutions and Industry Stakeholders

Industry Advisory Boards (IABs)	Forming IABs with representatives from diverse enterprises can provide highly valuable insights into current business trends, skill requirements, and emerging technologies. These boards can advise universities on curriculum development, research priorities, and internship opportunities, ensuring alignment with industry needs.[13]
Cooperative Education (Co-op) Programs	Implementing Co-op programs allows to alternate between academic studies and practical work experiences. These programs provide students with hands-on experience, valuable connections, and a deeper understanding of genuine engineering challenges, increasing their employability upon graduation.[14]
Industry-sponsored Research Collaborations	Collaborative research projects between universities and industry partners ease the advancement of knowledge and technology transfer. By jointly funding and conducting research initiatives, both parties can address multi-faceted engineering problems, foster innovation, and accelerate the elaboration of practical remedies with factual applications.[15]

13 Wire, A. (2022). *What is an Advisory Board (Overview, Roles, and Responsibilities).* https://www.onboardmeetings.com/blog/what-is-an-advisory-board/.

14 Wood, S. (2024). *Co-op vs. Internship: Know the Differences.* https://www.usnews.com/education/best-colleges/articles/co-op-vs-internship.

15 Bu Industry Engagement. (August 31, 2021). *How is Industry Sponsored Research Different from Government or Foundation Sponsored Research?* https://www.bu.edu/industry/2021/08/31/what-makes-industry-sponsored-research-different-from-other-sponsored-research/.

Industry-focused Capstone Projects	Engaging students in industry-focused Capstone Projects enables them to apply their theoretical knowledge to authentic engineering issues. Partnering with industry sponsors for these projects, fosters critical thinking and problem-solving skills, and offers companies innovative solutions to their technical needs.[16]
Internship and Work Placement Programs	Establishing internship and work placement programs allows students to gain pragmatic experience within Engineering sectors. These programs provide exposure to real projects, professional development opportunities, and networking connections, helping them bridge the gap between academia and the engineering professional field, while enhancing their employability.[17]
Entrepreneurship and Innovation Initiatives	Promoting entrepreneurship and innovation within engineering education encourages undergraduates to cultivate entrepreneurial mindsets. Universities can collaborate with industry partners to offer entrepreneurship programs, startup incubators, and innovation competitions, furnishing students with the needed resources and support to turn their ideas into viable ventures.[18]
Continuing Education and Professional Development	Offering continuing education and professional development programs, in collaboration with industry partners, allows interns to stay updated with the latest advancements in their fields. By providing relevant training and certification programs, universities can address skill gaps and support lifelong learning initiatives.

16 National University. (n.d.). *What is a Capstone Project? https://www.nu.edu/blog/what-is-a-capstone-project/.*

17 Wood, S. (2024). *Co-op vs. Internship: Know the Differences.* https://www.usnews.com/education/best-colleges/articles/co-op-vs-internship.

18 Sieg, P., Posadzińska, I., & Jóźwiak, M. (2023). Academic entrepreneurship as a source of innovation for Sustainable Development. *Technological Forecasting and Social Change*, 194, 122695. https://doi.org/10.1016/j.techfore.2023.122695.


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Best practices for the industry-school relationship in undergraduate engineering training

One exemplary program that underscores the significance of industry-academia collaboration is the Cooperative Education (Co-op) model. Originated in the United States, Co-op programs have gained international traction as effective means that integrate classroom learning with realistic work experiences. Universities such as Northeastern University in Boston, Massachusetts, have pioneered Co-op programs that provide alternating periods of academic study and full-time employment in relevant sectors.[19]

Similarly, the concept of Industry Advisory Boards (IABs) has emerged as a strategic mechanism fostering collaboration between academia and engineering lines of work. IABs comprise representatives from various industries who provide valuable insights, guidance, and feedback to academic institutions on curriculum development, research priorities, and trends. For instance, the University of Waterloo in Canada has established successful IABs for its engineering programs,[20] ensuring the harmony between the academic offer and the workforce needs, while simplifying partnerships for research and innovation.

Furthermore, initiatives such as Industry-sponsored Capstone Projects introduce students to the opportunity of authentically exploring their field in collaboration with industry partners.

Universities like the University of California in Berkeley, have implemented Capstone Projects in partnership with leading companies, allowing learners to apply their knowledge and abilities on real projects. Said projects not only enrich the learning experience, but enterprises also receive the benefits of the innovative

19 *Undergraduate Co-op.* Northeastern University College of Engineering. (2024, January 25). https://coe.northeastern.edu/academics-experiential-learning/co-op-experiential-learning/co-op/undergraduate-co-op/.

20 *Industrial Advisory Committee. Engineering Cases.* (2023, July 10). https://uwaterloo.ca/engineering-cases/about/people/industrial-advisory-committee.

contributions that students provide to their companies.

In addition to structured programs, initiatives such as Industry-Academic Research Collaboration, push forward knowledge and innovation at the intersection of both institutions. Collaborative research projects enable academic researchers to learn and find answers for tangible concerns while leveraging on the workforce expertise, resources and funding from the industry. Institutions like the Massachusetts Institute of Technology (MIT) have established successful partnerships with industry leaders through research centers and consortia,[21] driving advancements in various engineering disciplines while stimulating technology transfer and commercialization.

Moreover, the initiatives promoting Entrepreneurship and Innovation in engineering education collaborate by preparing future engineers for the evolving demands of the global economy. Entrepreneurship programs, such as those offered by Stanford University's Stanford Technology Ventures Program (STVP),[22] empower their community to cultivate entrepreneurial mindsets, explore startup ventures, and drive technological innovation. These programs cultivate an entrepreneurial culture that nurtures students to pursue innovative proposals and generate positive impact in the marketplace.

Working with professional Engineering operations can favor learners' training, as it prepares them for fundamental work on-site. Besides the joint construction of curricula and the active participation inside companies, these actions also promote the creation of scholarships that support underserved students, while providing benefits to the industry and the educational community. However, these initiatives require an outstanding commitment from all parties.

By examining successful programs implemented in universities in dif-

21 *MIT & Industry*. MIT Facts. (n.d.). https://facts.mit.edu/mit-industry/.

22 *About Us.* Stanford Technology Ventures Program. (2024, February 9). https://stvp.stanford.edu/about#vision.

ferent countries, stakeholders can strengthen their cooperation with universities and improve initiatives that are substantial to confront current and upcoming predicaments. Through strategic partnerships, innovative programs, and collaborative research endeavors, the industry-academia collaboration continues to play a pivotal role in driving excellence, innovation, and societal impact through engineering education and beyond.[23]

23 Ahmed, F., Fattani, M. T., Ali, S. R., & Enam, R. N. (2022). Strengthening the bridge between academic and the industry through the Academia-Industry Collaboration Plan Design Model. *Frontiers in Psychology*, 13. https://doi.org/10.3389/fpsyg.2022.875940.

b. Workshop: Artificial Intelligence in the Curricula

At present, Artificial Intelligence is profoundly changing every profession, particularly engineering. The Institute of Electrical and Electronic Engineers describes that more than 25 major specialties in different areas, including biomedical, civil, manufacturing, chemical, mechanical, environmental, industrial, aerospace, electrical and computing, belong to the field of engineering,[24] meaning that these professions will be influenced by AI.

Universities that are committed to renewing their curricula are able to deliver professionals who will thrive in a technologically advanced future. Educational institutions must prepare proficient students seeking to contribute to the design of solutions for intercontinental issues. Hence, graduates with expertise in AI will have an advantage over other candidates.

With the rise of AI, it's essential to train students to identify how and where to apply the newest models and tools offered by technology. In today's AI-driven landscape, updated engineering programs provide graduates with strong foundations. Throughout their education, engineers must become familiar with AI algorithms and frameworks to properly integrate AI capabilities into any required scenario. Therefore, it is necessary to assess how to educate the upcoming generations in these modern technologies.

In this specific workshop, faculty heads were asked to record the most significant AI dilemmas that they had found in engineering education. Initially, each table discussed and chose the most substantial issue. Subsequently, every group recorded the key actions aiming to deal with that issue, as well as the difficulties, in order to take advantage of AI when educating engineering students. Those difficulties and the proposed strategies to overcome them are described hereunder.

24 Institute of Electrical and Electronics Engineers. (n.d.). *How will you change the world?* https://tryengineering.org/wp-content/uploads/18-EA-381-InfographicEngineering_R2-6.pdf.

1. Risk of ethical & critical thinking loss

The combination of critical thinking and ethics considers the social aspects of a certain circumstance, along with the related biases. While ethical reasoning is a practical critical thinking skill, higher-education institutions and employers concur that both are indispensable competencies to hold and be able to apply in real-life situations.[25] In a global context, these capabilities allow learners to recognize the complexity of issues and make informed decisions. Accordingly, it is relevant to understand that critical thinking helps to use technology in a better way. This approach could be achieved at different levels:

i. Faculties, aligned with accreditation boards, should include a syllabus of humanities courses that students need to complete throughout their program, with the purpose of improving abilities such as empathy and interpersonal skills.

ii. Trainers need to provide professors with comprehensive Artificial Intelligence knowledge, as well as social sciences and ethics; subjects that cannot be neglected.

iii. It is important to cooperate with the workforce and the government in order to move in the same direction, focusing on, and aligning with, common values.

2. Understanding the limitations and the potential of AI

It is important to realize the limits and possibilities of Artificial Intelligence. Universities, as role model entities, have the task of instructing their community on the responsible use of AI, besides involving their educators and administrative staff. Training university personnel

25 Hart, V. (2018). Developing critical thinking and ethical global engagement in students. *European Association for International Education*. https://www.eaie.org/blog/developing-critical-thinking-ethical-global-engagement-students.html.

and nurturing the frameworks that will set a precedent are crucial steps in defining the parameters to take the best advantage of this technology. As this endeavor comprises a broad spectrum of aspects, the group considered relevant to address it through five strategies:

i. Establishing a regulatory and data privacy framework at an institutional level to serve as guideline on how to use AI resources, together with a code of ethics on AI that takes into account data privacy. Such regulations have to be devised with the support of the different stakeholders and constantly updated to move towards a common objective.

ii. Due to the increasing concern about AI's use of personal data, an alternative would be to provide courses or seminars on ethical issues related to AI use, in which students would learn how to use and handle personal data safely.

iii. Exploring the use of custom models that don't share data to the cloud. There should be more ways to explore models where data can be introduced privately by the institution without sharing it publicly. Participants included the example of TecGPT,[26] a conversational generative Artificial Intelligence model of Tecnológico de Monterrey, which leverages Microsoft Azure platform's technology to safeguard information within the university's ecosystem.

iv. Active learning about AI is crucial. Students should be able to observe and participate in activities to experience and identify biases, unlawful results, or reliability issues through real-life examples that involve ethics.

v. Lastly, participants in the last table agreed that educating data scientists on data integrity is a requirement, since reviewing data several times to make the proper corrections is crucial.

26 Treviño, R. (2023). Tec de Monterrey creates TECgpt, Latin America's first proprietary generativeAI model. *Observatory IFE.* https://observatory.tec.mx/edu-news/tec-de-monterrey-creates-tecgpt-latin-americas-first-proprietary-generative-ai-model/.

Photo: Mariana Sofía Jiménez

3. Applied ethics

Ethical reasoning involves decision-making, including concerns about several arising issues in specific surroundings. Aside from one's personal values, structured curricula granting a framework with detailed principles can serve as guideline to perform any given role. Considering the ethical aspects of using AI from the educators and the students' perspective, different approaches should be implemented:

i. A course on ethics at the undergraduate level is essential.

ii. Enforcing strict policies, laws, and regulations for the ethical use of AI, not only at the governmental level but also inside academic institutions, with broader policies at the university level and a subset of policies at the course or instructor level.

iii. Courses for the proper use of AI are a necessity.

iv. Faculty training in ethics.

v. Defining the bandwidth of originality.

vi. Initiating the ethics' touchstone; do applications favor the less privileged?

4. Better understanding of prompt engineering

Prompt engineering means designing and redefining questions or instructions,[27] however, it ultimately represents the bridge that guarantees effective human-AI communication. Nowadays, learning how to ask good questions has become imperative, and the enhancement of critical thinking aptitudes in faculty members and students is significantly complex. Overcoming the fear of uncertainty and unfamiliarity related to these technology tools is crucial, as well as helping faculties embrace them through the following suggestions:

i. Teach how AI works, including its ethics and limitations.

ii. Sensibilization through courses about the correct use of these tools. Help to enhance critical thinking skills focusing on asking the right questions iteratively.

iii. Provide continuous education to faculty members.

iv. Foster faculty discussions, symposiums, and spaces for dialogue.

v. Provide incentives to faculty members for curricula development, dissemination and accreditations.

vi. Organize projects in groups by mixing data science, IT, and applied engineering, together with other multidisciplinary teams.

vii. Problem-based learning in AI is a suitable strategy where undergraduates would be able to encounter AI in real-life situations, instead of just learning about the theory.

27 Crabtree, M. (2024). What is Prompt Engineering? A Detailed Guide For 2024. *Datacamp*. https://www.datacamp.com/blog/what-is-prompt-engineering-the-future-of-ai-communication.

5. Finding the best way to adopt AI to enhance engineering education

Incorporating AI is not a paradigm shift but a cultural one, as this is relevant not only for engineering education but also for Higher Education in general. The accelerated evolution of Artificial Intelligence is imminent; therefore, it is necessary to embrace its adoption instead of impairing it. Moreover, deans explained that AI cannot be a top-down approach; it has to be a bottom-up approach. Participants shared different paths to achieve that goal.

i. Give workshops to educate faculties, building their confidence and their understanding regarding the impact of education.

ii. Promoting openness to accept change.

iii. Faculty awareness and collaboration to identify what would be a priority regarding the needs of their students and act to improve all the issues involved.

iv. Ensure access to education in AI tools.

v. Encourage, incentivize, and provide support to faculty members, by offering a bottom-up proposal.

6. Data verification

Critical thinking is an essential ability when managing AI technologies, but it is equally important when working with verifiable and reliable data. Data verification entails a process of validating the accuracy and completeness of information.[28] Ergo, data is compared against a reliable source to confirm its veracity, so its purpose implies detecting errors, alterations, or inconsistencies to guide the

28 Aspena Solutions. (2023). *The Importance of Data Verification and Validation for Accurate Insights.* https://aspenasolutions.com/the-importance-of-data-verification-and-validation.

user towards the correct insights and decisions. Participants stated during the activity that data analysis needs to be protected, and to do so, we must reinforce ethics by:

i. Creating community outreach with the educational institutions and society involved, tapping into K-12, middle school, high school, and so forth.

ii. Training in critical and computing thinking, hands-on training, and algorithms in software programming.

iii. Implementing stronger finance policies to make a change.

iv. Carrying out a challenge-based education, application-oriented learning in AI, and Capstone projects.

v. Applying a flipped classroom model to stimulate conversation and strengthen values and ethics.

vi. Demistifying AI in quantum computing to recognize the potential of combining both technologies. Quantum computing originates from quantum mechanics, the behavior of atoms and subatomic particles.[29] The computers with this tech use qubits, meaning they process information with 1 and 0 as classical computing, but processing happens simultaneously. This implies that quantum computers could have the ability to be a million times faster than current computer microchips.

7. How to include ethical and critical thinking in the curricula and the faculty

People shouldn't act out of fear, but rather out of opportunity. Engineers make an ongoing impact on society and on the direction that it takes, since they are perceived as the drivers of social change. Ethics is not far away from engineering, because it is very useful in social

29 Reichental, J. (2023). Quantum Artificial Intelligence Is Closer Than You Think. *Forbes*. https://www.forbes.com/sites/jonathanreichental/2023/11/20/quantum-artificial-intelligence-is-closer-than-you-think/?sh=4a5cbe944818.

media or biotechnology, for example. Deans said that it is important to start with the tools available to make catalytic changes. Some actions they considered were:

i. Academia must define clear critical thinking rules about how to manage ethics.

ii. Train faculty in real cases applying critical thinking and ethics.

iii. Faculty awareness of potential problems and the need to provide continuous support.

iv. Faculty development of curricula material or AI content examples that incorporate ethical and critical thinking.

8. Reflection and self-management

Fostering critical thinking requires reflection and students' self-management, vital aspects to teach learners to understand and use AI in a responsible manner. It's not necessary to teach specialized subjects like algorithms, but general concepts such as embedded biases, environmental effects, and teaching to think critically. Participants agreed that one educator would have a hard time teaching critical thinking effectively to everyone, unless they harness some additional tools. Their recommendations included:

i. Use of the Socratic method.

ii. Use of case studies.

iii. Understand concepts, implications, and potential uses of AI.

iv. Ask students open-ended questions.

v. Use of AI tools to help getting more individualized instructions for critical thinking. An example presented by the table was Khanmigo, an AI-powered tool from Khan Academy that generates questions instead of answers.

vi. Train faculty in the use of AI and neuroscience. Universities need to use their resources to train their teachers.

vii. Redesign curriculum by adding AI tools. Create a task force in every school, in charge of designing strategies to include AI in education.

viii. Work with instructional design teams to include Problem- Based Learning (PBL), Challenge-Based Learning (CBL), and Problem-Oriented Learning (POL) within AI courses.

9. Balance the use of AI tools versus the development of key skills

Engineering schools need to keep a good balance between the use of AI tools and the fundamentals of each engineering discipline. Therefore, it is important to understand that institutions are not teaching AI specialists in engineering schools; in fact, they are teaching students that will become engineers. This concept is crucial, because professional engineers require the basic principles that the field provides. AI courses might help them to learn how to apply AI as a part of a program, but this learning must not overpower the curricula; otherwise, the essence will be lost. In this regard, participants submitted a proposal for the following key actions:

i. Submit the students to an early demonstration of cases where AI provides "incorrect" or "inaccurate" information.

→ Create a Model for freshman students to learn the appropriate use of AI as a problem-solving tool, built on basic principles.

ii. Determine the best practices to keep the balance between learning AI tools and engineering fundamentals.

→ Train instructors on how to keep that balance.

→ Implementation of actions in the curriculum.

iii. An administration committed to providing financial, human and material resources for the curricula's improvement at the faculty level.

→ Faculty must be open-minded and understand that it is not necessary to be an expert in AI to teach it.

→ Faculty needs time to inform about the required fine tuning to the updated curriculum.

iv. Understand AI better by analyzing the future and moving in that direction.

v. Curriculum with AI's basic principles' implementation. Identify the basic principles in the discipline and use that knowledge to improve the curriculum.

vi. The curriculum's design should include the use of AI as a tool during class activities.

The most mentioned challenges were critical thinking and the ethical aspects of integrating Artificial Intelligence into the curricula. Teacher training and guiding students to identify how to employ AI tools are also crucial for preparing the future workforce. If engineers take advantage of these resources with due assessment, they will be able to foster a culture where change is embraced in order to help overcome major barriers and improve society's living standards.

C. Workshop: Transdisciplinarity in the Engineering Curricula

Nowadays, being an expert with only a bachelor's degree is not enough, so faculties and their communities must push beyond their zone of comfort to learn subjects outside their regular areas of expertise by fostering a permanent transdisciplinary state of mind in engineering students.

Many universities consider including transdisciplinary subjects to help develop different valuable social, economic, political, and intrapersonal competencies in their students. Said integrated disciplines would be able to help future professionals harvest a humane and problem-solving vision with a broader outlook in a creative way, considering other disciplines, while working towards the well-being of society as a whole.

Communication is key to incorporating transdisciplinarity in engineering areas, which can bring a lot of benefits to researchers and scientists; but not without bearing in mind some disadvantages. Still, constructing a perfect balance between the knowledge of someone's area of expertise and the interdisciplinary abilities and connections is relevant to keep moving forward and focus on the continuous improvement of both students' and graduates' professional careers.

It's well known that relevant knowledge such as metacognition, emotional intelligence, and communication abilities are not usually part of many engineering programs.

Moreover, in this particular workshop, deans gathered across different tables to ponder over the event's main objective: discussing the benefits and disadvantages of high and low levels of transdisciplinarity in the curricula. The following chart shows the main concepts that participants considered to be important and must be taken into account:

	Pros	Cons
High level of transdisciplinarity	• Expands capabilities across disciplines. • Devises similar experiences to those of the professional field. • Trains students into understanding, addressing, and solving real complications. • Eliminates knowledge boundaries and increases knowledge. • Inspires diverse perspectives. • Improves innovation and research values for students. • Hones a holistic personality of graduates with skill sets to face realistic situations. • Competency for complexity. • Students expand their skill sets. • Boosts holistic thinking.	• Implementation requires more investment and resources in current curricula development. • Failure to engage students in these kinds of subjects. • Learning different codes and cultures can be complicated and requires additional effort from students. • More challenging for teachers to evaluate. • Requires more involvement from faculty and students. • Dealing with a high threshold of discomfort when having to remove course material. • Reduced time for course-related topics. • Difficulty for students to see different angles of the same problem. • Lack of faculty expertise.

	Pros	Cons
High level of transdisciplinarity	• Provides communication tools that enable better communication with the mainstream public. • Encourages a renaissance mindset.	• Administrative issues: enrollment, grading systems, diplomas, etc. • Not enough facilitators/teachers with the required abilities. • Lack of focus on "main" discipline subjects. • Could not have clear conclusions. • Saturated curricula, which would lead to high burnout and no work-life balance.
Low level of transdisciplinarity	• Opens more opportunities for collaboration. • Increases inclusion. • Focuses on discipline depth to shape excellence in a specific area. • Strong skills and knowledge on the subject. • Specific and easier to manage. • Analyzes different ways to study a problem.	• Centralizes non-negotiables in the course. • Can have no relevance or impact on students. • Maintain knowledge / stay updated with multiple disciplines. • Superficial understanding. • Reduced perspective. • Reduced capabilities to sort out problems.

	Pros	Cons
Low level of transdisciplinarity		• Creates the opportunity to have "narrow minded" students. • Students ill-equipped to participate in activities and teams working on most important issues. • Unable to be agile. • Might not have enough time to cover these subjects.

Despite the disadvantages regarding the addition of transdisciplinary subjects in engineering programs, deans agreed that they are important in their students' educational paths. After talking over the first question, faculty heads decided which were the main capabilities that universities should include in their engineering programs (in no specific order):

- **Emotional intelligence:** it is an interpersonal ability that helps identify, understand, and manage one's feelings not only in everyday life but also when dealing with strong emotions in critical situations and learning to control them. It also eases communication processes with other people, by strengthening social relations. People who are knowledgeable on emotional intelligence "are self-aware, openly expressive and healthily assertive."[30]

- **Empathy:** refers to the ability to understand and sense other people's feelings; being an inter-

30 Whitener, S. (2022). Why Is Emotional Intelligence Important? *Forbes.* https://www.forbes.com/sites/forbescoachescouncil/2022/12/30/why-is-emotional-intelligence-important/?sh=19ce18b53289.

personal skill, it is related to emotional intelligence. Empathy allows better communication with others and enhances teamwork skills.

- **Social responsibility:** focusing on current social problems and addressing them is a necessary capability to solve them. Social matters are usually left out of engineering programs and students should be able to confront issues from different points of view to tackle societal adversities.

- **Global/political understanding:** social studies provide students with an important outlook on what's going on in their surroundings with the purpose of fostering in them the need to contribute to the well-being of their communities through meaningful actions.[31] Being aware of what is going on in the world also enhances other important attributes such as: critical thinking, rational optimism, among others.

- **Cultural competence:** requires studying, learning and analyzing other people's cultures to communicate ethically and effectively with them; consequently, making respectful and mindful choices that embrace and respect diversity.[32]

- **Cultural humility:** although this concept and the one above may seem similar; they are not the same. Cultural humility refers to carrying out an insightful process in which individuals recognize their own biases, beliefs, and cultural identities as a way of gaining a better understanding of others.[33]

- **Wellness:** some students may feel a lot of pressure and stress throughout their academic journey, having to manage multiple projects at once; the same has to be said about their performance on the field after graduation. "Engineering students who learn to prioritize mental health during

31 Asia Society. (n.d.). *Five Reasons Why Global Competence Matters.* https://asiasociety.org/education/five-reasons-why-global-competence-matters.

32 The University of Sydney National Centre for Cultural Competence. (n.d.). *What is cultural competence?* https://www.sydney.edu.au/nccc/about-us/what-is-cultural-competence.html.

33 Yeager, K. & Bauer-Wu, S. (2013). Cultural humility: essential foundation for clinical researchers. *Appl Nurs Res*; 26(4):251-6. https://doi.org/10.1016/j.apnr.2013.06.008.

their education can develop better coping mechanisms and resilience, leading to improved career prospects."[34]

- **Communication skills:** effective verbal and written communication is an inalienable ability needed to interact, as well as to work on intricate concepts with the support of other disciplines, along with the public in general. Learning to articulate ideas correctly strengthens group collaboration, effective public speaking, risk management, and fosters better interaction among stakeholders.[35]

- **Leadership:** a universal skill that needs to be reinforced in students to enhance their abilities for the common good.[36] Learning to speak up, share advice, motivate, influence positively and lead when needed is the best way to showcase and apply one's knowledge in order to prevent mistakes and accidents.

For the final part of this workshop, once the advantages, disadvantages, and main non-engineering skills were identified, deans discussed the strategies they could use as means of incorporating transdisciplinary subjects in their corresponding institutional programs:

Project-based learning

Developing projects that are rich learning resources will not only give students knowledge of their own discipline, but will also potentialize their transdisciplinary abilities, by having to create ethical solutions that lead them to "think outside the box" and incorporate new ideas and methodologies.[37]

34 Utilities One. (n.d.). *Addressing Mental Health Supporting Well-being in Engineering Students.* https://utilitiesone.com/addressing-mental-health-supporting-well-being-in-engineering-students.

35 Kettering University. (2023). Why is Communication Important for Engineers? *Kettering Global.* https://online.kettering.edu/news/communication-important-engineers.

36 Rice University George R. Brown School of Engineering. (2023). *Why Are Management Skills Important for Engineers?* https://engineering.rice.edu/academics/graduate-programs/online-meml/blog/importance-of-engineering-management-skills.

37 PBL Works. (n.d.). *What is PBL?* https://www.pblworks.org/what-is-pbl.

Hiring non-engineers as faculty members

Having faculty members from different disciplines would help propagate their knowledge among the students, which could result in them wanting to learn more or feel inspired to learn and acquire new abilities.

Professional development for students

Students gain so much from fostering their transdisciplinarity and it is so necessary to prepare them best for the future that transforming the current program is a must. Granting a place for competencies such as entrepreneurship, negotiation, stress management, communication, among others is now a necessity.

Providing opportunities in the curriculum to exchange credits for activities, innovation events, research stays, hackathons, volunteering programs

Planning different events, projects, and activities throughout the school year is an innovative way for learners to discover and use their transdisciplinary skills, as well as learn from their team members. It's good practice for students to observe how the knowledge of their discipline intertwines with others to decode a problem. This wouldn't have to modify the current curricula, and it's a way to get extra credits.

Embedding skills in current courses

Non-engineering competencies in the curricula are a necessity, so to avoid disturbing the current programs, these topics should be included in the students' classes.

Concentration in the curricula of 7th semester

Involve offering several subjects that are not directly related to an engineering discipline such as public speaking, business, marketing, among others. In their final semesters, students could choose from this pool of subjects the ones that they're most interested in and include them in their curricula.

Professional skills courses

Another important way to strengthen transdisciplinary skills, would be providing students with non-engineering courses, where

they could have the opportunity to attend whichever subject attracts them more. This could be an obligatory subject in the curricula or have these courses as options to gain extra credits.

3-minute thesis to improve communication capabilities

3-minute thesis presentations are commonly held in universities, where participants must talk in front of a group of people about their research in under three minutes.[38] Incorporating this practice will encourage students to learn how to explain their findings in non-specialized terms, summarize, and talk in front of a crowd, valuable talents that are very useful in their professional careers.

Students cannot rely on a linear approach to untangle problems, since modern hurdles demand sophisticated solutions. Institutions need to stimulate the motivation to gain and expand undergraduates' knowledge in other areas so they're able to keep up with their surroundings; thus, transdisciplinarity is no longer an option but an obligation.

Participants concluded that non-engineering strategies should be integrated into the students' curricula as a means of working together with other areas, which would enhance, in the end, everyone's results. Learning about other subjects would support greater findings, projects, etc., and engineers would learn to express their ideas and communicate better with other areas, reinforcing their teamwork efforts and connections while learning to work together towards a common goal.

38 Principles of Scientific Communication. (n.d.). *The 3 Minute Thesis.* https://ecampusontario.pressbooks.pub/scientificcommunication/chapter/the-3-minute-thesis/.


Dean

d. Workshop: Role of Deans in Attracting and Maintaining Women in the Schools of Engineering and Science

iStock.com/rudall30

Unfortunately, women take up a very small percentage of the engineering education and work domains due to a great variety of reasons. According to a study by Fictiv,[39] the presence of women taking over engineering and technical roles has decreased in North America, where only 16% of engineers are females. However, it's important to notice that while the number of women getting a bachelor's degree related to engineering has increased over the years, the pace has been slow. The Conversation[40] points out that 1 out of 5 bachelor's degrees given by universities are obtained by women.

39 Evans, C. (2024). Women in Engineering Statistics: 32 Notable Facts. *Fictiv.* https://www.fictiv.com/articles/women-in-engineering-statistics-32-notable-facts.

40 Ireland, D. (2022). Only about 1 in 5 engineering degrees go to women. *The Conversation.* https://theconversation.com/only-about-1-in-5-engineering-degrees-go-to-women-185256.

The absence of diversity means that not only women are missing opportunities to develop their talents in STEM but also companies. This workshop was created to identify and discuss the causes and strategies needed to retain women in engineering areas so they achieve their bachelor's degree, have a significant presence in the workforce, and be successful in their professional careers.

Moreover, institutions need to pay close attention, and even feel uncomfortable sometimes, in order to expand the comfort zones and reach everyone involved in STEM education.

Creating the right environment for women to grow in engineering areas and diversifying the faculties and the workforce would result in a richer atmosphere, where ideas and proposals from different points of view would be shared.

Faculty heads were divided into teams to discuss three questions. Everyone gave their input about the main impediments, required actions and the current status of their institutions regarding the recruitment and retention of women in engineering areas. Participants were asked to write down and present to their peers what they considered to be the main issues for women leaving engineering schools after a certain time. Once the discussion time was over, everyone at the table talked about effective practices that could be considered to deal with that problem. The following proposals were presented by the teams, in no particular order:

Protect junior female faculty from service assignments

Most of the time, women are tasked with many more assignments than their male counterparts, which creates an excessive workload for them. Society tends to stick to traditional gender roles within academic and workplace settings, overburdening women until they see no other option but to resign.

In reality, junior faculty members should be protected at all times from doing these kinds of over-

burdening assignments. Still, sometimes institutions let it slide specifically for women, which should not happen and there should be more control to avoid these practices.

According to McKinsey's 2022 report on Women in the Workplace,[41] women leaders focus on improving retention and employee satisfaction by fostering equity and inclusion, but they are very seldom rewarded for those efforts by their respective companies. This situation makes it harder for women to advance in their professional path making them feel burned out and unacknowledged.

Time-flexibility policies

Institutions should empower women and build a more equitable environment through the establishment or enhancement of their time-flexibility policies, so women can adapt easily to carry out their educational and work responsibilities without compromising their personal and family matters. Commitment and expertise in the field should be prioritized above the completion of rigid academic and work schedules.

A study published by "International Workplace Group" in March 2023 has unveiled interesting results regarding flexibility for women in work environments.[42] These findings were based on the answers of 1,008 women who have full-time, hybrid jobs within the United States:

- 88% think that a hybrid working system represents an equalizer in their places of work.
- Currently, 72% prioritize the flexibility of hybrid work so much that if it were taken away from them in their current workplace, they would look for a new job position.

41 Thomas, R., Cooper, M., Cardazone, G. *et al.* (2022). Women in the Workplace. *LeanIn.Org and McKinsey & Company.* https://www.mckinsey.com/~/media/mckinsey/featured%20insights/diversity%20and%20inclusion/women%20in%20the%20workplace%202022/women-in-the-workplace-2022.pdf.

42 International Workplace Group. (2023). *IWG Women Hybrid Workers Sentiment Survey.* https://docs.google.com/document/d/1ZJ1Z3NR8F8LkGOcWUNWVYasPnlZYIa3L/edit?pli=1.

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- 73% of the surveyed women claimed that a flexible workplace enhances their efficiency.
- 63% consider a job that offers flexibility as a caregiving benefit.

For institutions, prioritizing the well-being of women and their families through flexible schedules can serve as an efficient magnet to attract these talented females without them having to struggle to maintain the perfect balance of preserving and succeeding in their personal lives and jobs.

Promoting the positioning of women in decision-making jobs, as well as creating a growth-focused, life-long learning culture

It's important to notice that most of the time, women are not given the same opportunities as men. For example, in an engineering project, a male may be given the lead because they tend to be more "work-focused" since their predominating role in society is providing for their family. On the other side, women would not be given the lead, but instead they are being given positions with fewer responsibilities or positions focusing on social relations, a much more nurturing role.

Women should not miss the opportunity to hold decision-making positions because of the concepts enforced by society. Institutions should break this barrier with the objective of promoting equity and providing an empathetic perspective regarding gender; teaching students and employees that they are able to occupy leadership roles despite their gender.

Encouraging a lifelong learning culture within institutions would also empower not only women but everyone else to continue learning throughout every stage of their lives, aiming to reach their full potential. In this way, women would get new knowledge, abilities, and competencies that allow them to enrich their academic and professional careers while feeling inspired to reach new goals.

Intentionally hiring, mentoring, and building communities of women leaders

The fundamental adversity is the mindset from both sides: recruiters should focus on looking for fe-

male talent to increase their teams' diversity. According to LinkedIn's Gender Insight Report, recruiters are 13% less likely to click on a woman's profile, thus, favoring men.[43] Institutions can solve this issue by providing training to their recruitment teams on topics such as unconscious biases, formulating criteria checklists, and using a neutral voice when posting job descriptions, among others. Another strategy could be having at least two recruiters present at interviews during the hiring process. A person's expertise should be prioritized over gender, race, personal life, etc.

On the other hand, women may be self-conscious and start doubting their capabilities just because of their gender when applying for a job position or an academic role. LinkedIn's research also points out that women only apply for a job when they meet 100% of the required criteria in the job description, while men apply if they meet at least 60%, which results in females applying for fewer positions.[44] Institutions can support female students and graduates by providing mentorship to prevent underestimation of their capabilities and encourage them to demand a deserving salary based on expertise rather than undervaluing themselves due to their gender.

Another important aspect to consider is building women's leadership communities so they can be inspired to take over decision-making positions, wich would open new perspectives leading to higher performance and innovation. This would also promote their career development in their respective professional fields.

Adopt a more transparent attraction process and cohort hiring

Institutions need to outline and define what it means to be a successful candidate to their recruiters, starting from a precise job description that includes the core institutional values. As mentioned before, women are less likely to apply for a role, so being mindful I

43 Tockey, D. & Ignatova, M. (n.d.). Gender Insights Report: How women find jobs differently. *LinkedIn Talent Solutions.* https://business.linkedin.com/content/dam/me/business/en-us/talent-solutions-lodestone/body/pdf/Gender-Insights-Report.pdf.

44 Ibidem.

when describing a job position is critical. Focusing on performance targets and emphasizing the use of inclusive language are great places to start.

Cohort or cluster hiring is another alternative in which universities and companies can join forces to attract diverse talent into the workplace.[45] This strategy works by having a college or university group of people from the same faculty but with different disciplinary backgrounds, boosting diversity in the different engineering fields. This can also help companies to reduce the hiring process time by employing a group of people instead of hiring them individually.

Improving gender diversity in institutions is a matter that has to be constantly assessed and reassessed in order to be successful. Recruiters need to be constantly thinking of new strategies to attract and retain women. Another aspect that can be improved is to voice out and state very clearly that the institutional values are related to having a workplace where women can feel comfortable and protected.

Bridge to faculty post-doc program for diverse candidates

Bridge to Faculty (B2F) programs are another strategy to increase diversity, as it mitigates the obstacles that under-represented groups may encounter when joining a faculty position. "Bridge to Faculty is designed to recruit scholars with the goal of transitioning them to become faculty members after two years."[46]

Institutions could also work on constructing an appropriate progression model when integrating new faculty members, where since day one, new recruits are aware of the available packages that would lighten their personal lives, such as maternity leaves, daycares,

45 Morse, M. (2020). What Is Cluster Hiring? *HR Daily Advisor.* https://hrdailyadvisor.blr.com/2020/02/06/what-is-cluster-hiring/.

46 Department of Communication, University of Illinois at Chicago. (2024). U Illinois Chicago: Bridge to Faculty Postdoctoral Research Associate: AI & Minority Representation (USA). *Center for Intercultural Dialogue.* https://centerforinterculturaldialogue.org/2023/12/23/u-illinois-chicago-bridge-to-faculty-postdoctoral-research-associate-ai-minority-representation-usa/.

schedule flexibility, among others. Making value propositions based on priorities makes women feel supported and just as valued as their male counterparts.

Change the minds of boards and leaders into making new policies about flexibility, schedules, salary equality, and a balanced representation of women

Making sure women occupy leadership positions on boards is a way to create awareness about the fact that diversity is a way to bring in new ideas and creativity, no matter if they have family responsibilities or not. In this way, gender biases can slowly disappear, and women can start taking over more leadership roles; changing leaders' minds is a way to change engineering for women.

Currently, there are many reasons for women to drop out of their education and engineering careers. It's crucial that universities are aware of this so they can work collectively to help women unleash their great potential in the field and work towards a better future for everyone.

By the same token, at the end of these workshops, deans were able to share anonymously the commitment they have to this cause and contribute to women's growth in their engineering faculties. Some of these were:

- Establish a task force to expand supportive initiatives and make visible this priority.
- Arrange multiple "check-in" coffee/tea gatherings with female faculty members in order to get their input.
- Monthly women's faculty meetings.
- Promote a more transparent process with clearer job definitions and clearer expectations.
- Set realistic goals for women's representation in the current plans and programs.
- Create spaces for dialogue to foster awareness.
- Workshops for women in leadership roles.
- Provide intentional support and mentorship support to junior female faculty members.

- Construct a culture of growth in our departments.
- Implement inclusion and diverse policies to intentionally attract women into engineering.

Obstacles remain for attracting and retaining women in engineering and science faculties, but as time goes by, institutions are starting to evolve and generate new opportunities for women to prosper in these areas that are commonly occupied by men. Fortunately, the authorities are aware of those issues and many of them are preparing strategies as well as collaborating with their respective institutions to increase their efforts towards encouraging diversity and establishing platforms for women in this field.

Future Remarks

Engineers are agents of change with the ability to solve various societal difficulties. However, transformation is a task that they cannot achieve alone since building systems that aiming to help society requires continuous cooperation with all the stakeholders, including other disciplines.[47]

47 Hirsch, J., Yow, R., & Wu, Y. (2023). Teaching students to collaborate with communities: expanding engineering education to create a sustainable future. *Engineering Studies*. 15:1, 30-49, DOI: 10.1080/19378629.2023.2176767

Cross-disciplinary associations integrating different sets of expertise will allow to obtain benefits[48] such as enhanced problem-solving, efficient resource utilization, improved decision-making, innovation catalyzers and transdisciplinary knowledge sharing; aptitudes that facilitate joint-work with key partners.

Furthermore, besides the Fifth Industrial Revolution which requires different actions to produce goods and services for profit, other social and economic factors are affecting the upcoming generations that require to be trained for a future of change and uncertainty. In view of this, experts recommend different strategies to support higher-education institutions in re-designing and adapting their programs to remain relevant.[49] For instance making emphasis on lifelong learning and transdisciplinary education, hands-on data fluency, management courses, as well as sustainable, resilient, and human-centric design modules.

"The Future of Jobs Report" by The World Economic Forum indicates that 44% of the workers' skills will be disrupted in the next five years.[50] Cognitive abilities were revealed to be developing rapidly, along with complex problem-solving skills in the workplace. Moreover, six out of ten workers will need training before 2027, and only half of them will receive educational opportunities sponsored by their employers.[51]

Another significant adversity to be faced by the engineering education community involves the constant shift in requirements of knowledge and proficiencies,

48 Utilities One. (2023). *Bridging Disciplines The Power of Multidisciplinary Engineering Collaboration.* https://utilitiesone.com/bridging-disciplines-the-power-of-multidisciplinary-engineering-collaboration.

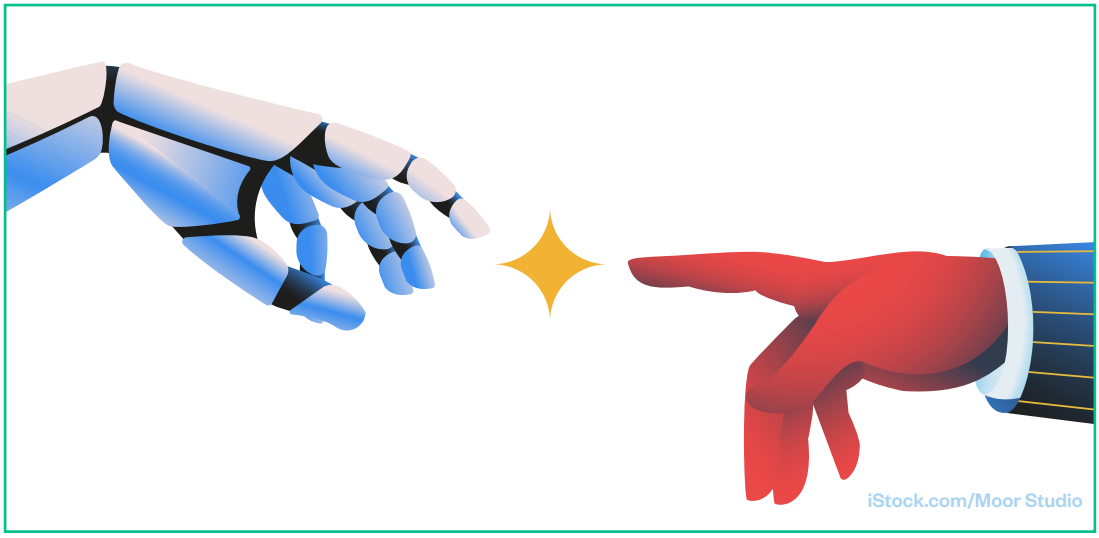
49 Broo, D., Kaynak, O., & Sait, S. (2022). Rethinking engineering education at the age of industry 5.0. *Journal of Industrial Information Integration.* https://doi.org/10.1016/j.jii.2021.100311.

50 The World Economic Forum. (2023). *The Future of Jobs Report 2023*. https://www.weforum.org/publications/the-future-of-jobs-report-2023/.

51 Frontiers. (n.d.). Continuing Engineering Education for a Sustainable Future. https://www.frontiersin.org/research-topics/61351/continuing-engineering-education-for-a-sustainable-future.

which is complicated to predict.[52] Furthermore, climate change mitigation and adaptation demand from engineers to learn new skills and adjust to the everchanging sustainability requirements. The under-representation of women, racial and ethnic minorities, as well as people with disabilities continue creating differences in opportunities, proving to be another obstacle for institutions to overcome. For all these difficulties, educational programs must be prepared, through transition-mentorship programs that promote inclusion.

Interaction with the industry is fundamental, not only because it is helpful to keep up with the trends and the job market expectations, but by virtue of practical experience, students can learn through research projects conducted inside companies, dealing with real-life exposure.[53] Technology tools may be changing all the time. Nevertheless, professionals who can manage themselves within a collaborative environment and consider that searching for solutions implies working together with partners and other disciplines, will succeed.



52 Ibidem.

53 Engineers Ireland. (2023). *The Future of Engineering Education.* https://www.engineersireland.ie/News/the-future-of-engineering-education.

iStock.com/metamorworks

Conclusion

WEEF-GEDC 2023 once again succeeded in providing a safe space for the heads of engineering faculties to get together, talk about, and discuss the current and upcoming challenges and opportunities that their students will confront in the unknown near future. Networking during these events empowers participants to learn about new trends and methodologies that other institutions are using, so they can implement them in their own universities.


Photo: WEEFGEDCofficial, Facebook

Engineering is an ever-changing discipline that will keep on evolving as the modern world keeps moving forward. Engineers nowadays need to expand their knowledge and integrate skills from other fields to get a better un-

derstanding and enhance their communication with other disciplines. This communication will lead to better results and will enable the different areas of Engineering to develop products and services that will benefit society's quality of life. Critical thinking, empathy, social responsibility, and leadership are aptitudes that must be included in the graduates' toolkits, as they embark on their professional careers and prepare themselves for an erratic and uncertain future.

With every passing day, people are relying more on digital technologies to carry out their daily processes, activities, and life in general. Being one of the most popular tools nowadays, Artificial Intelligence has a strong influence on the development of new engineers. Universities should incorporate and learn to coexist with AI, which is here to stay and will keep impacting everything. It's the institutions' role to promote AI good practices and ethical management to make a positive impact on the well-being of society, and to see AI as an ally in the innovation of their educational strategies and methodologies, supporting their efforts to enhance their students' academic journeys.

Social matters such as the inclusion of women in a field dominated by men were a recurring topic throughout the numerous events of the conference, proving that engineering faculties need to retain women in STEM areas in order to include different points of view and increase diversity in these areas. Engineering faculties and the job market should support workers by promoting women to higher positions, creating flexible policies, and implementing inclusive hiring processes. This will help make engineering a more inclusive discipline, focusing on a person's expertise rather than their background, ethnicity, gender, or personal life.

In the dynamic landscape of engineering, even if technical prowess is a requirement for any engineering student, success is achieved by collaborating with others and acting as bridges spanning across disciplines and the workforce market. In addition to technical knowledge, the synergy of several perspectives propels the field of engineering to stride towards a brighter path for everyone, working together to solve the most relevant issues of today and tomorrow.

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