CAETS Discussion Group: Engineering Education
Monday, 10 September 2018
1:30 pm – 3:30 pm

Potential Questions regarding Engineering Education:

- Is it changing?
    - If so, what motivated the change? What are the barriers/impediments to change?
    - If so, who is driving the change? Faculty? University Leadership? Professional Organizations? Government? Other key stakeholders (e.g. Industry)?
- Is quality improving?
    - What are the relevant measures of quality?
- Are new techniques being used?
    - If so, what are the most widely used? Have measures of effectiveness been implemented?
- How are topics like project-based education, multi-disciplinary education, and innovation being integrated?
- Is your academy directly involved in stimulating change?
    - If so, how? What can you share with other CAETS members?
    - How could CAETS help facilitate the sharing of relevant information?
- Is there a role for CAETS to help motivate/facilitate evolution of engineering education from an international perspective?
    - If so, what is that role and what are the necessary next steps?

Potential Questions regarding Engineering Education:

- Is it changing?
    - If so, what motivated the change? What are the barriers/impediments to change?
        - Industrie 4.0 is bringing lasting changes in the workplace. Increasingly interconnected, flexible and complex processes are leading to new requirements in terms of the skills that companies possess and the training of their workforce. Industrie 4.0 is also transforming companies' structure, organisation, and the nature of people's jobs.
          → **Workplace training for Industrie 4.0** is thus the key to the success of industrial enterprises.
          → At the same time, however, Industrie 4.0 is making **new, digital continuing professional developement formats** available that allow training content to be precisely tailored to the knowledge and needs of staff and management.
          → The **constantly changing list of skills** required for Industrie 4.0 must be regularly updated so that the relevant adjustments in the education system can be made. In the future, the focus will be on interdisciplinary thinking and acting, cross-functional process know-how, and IT skills involving both specialized and more general application knowledge. In addition, the ability for self-management and self-directed learning, willingness to change as well as independent thinking and decision making will become more and more important.

        - **Future learning trends**
          1. Flexible learning
             Learning can take place anytime and anywhere, on a mobile device and just-in-time basis.
          2. Participatory learning
             By focusing less on "me" and more on "we", learning will increasingly become an expression of cooperation, co-creation and co-working.
          3. Learning in networks
             Networks will complement or even replace institutions as the learning environment of choice.

        - For a successful digital transformation of education we need a **change of mindsets**: a willingness to change, focus on agility and creativity are equally as important for the transformation of education, as are funding and technical equipment.

  - **Education for the digital age has to be rethought**: new learning technologies allow a greater individualization of learning and foster co-operation and networking skills. These skills are a cornerstone of success in the changing world of labor.
  - Therefore, decision makers in educational institutions should **encourage the digital literacy** of young people and ways of agile working that come with the digitization. Technical aspects of the transformation, such as adequate IT infrastructure, must be considered, but the most important prerequisite for the success of education in digital transformation is a lasting change in awareness by various relevant stakeholders, among them administrators, faculty and academic leader-ship.
  - Decisive impulses for competence development in Industry 4.0 come from training at colleges and universities. This requires an **adaptation of the existing curricula** to the requirements of industry 4.0 or the development of an industry 4.0 curriculum.
  - **Hybrid qualification** (e.g. dual study program) to answer increasing complexity within companies → professional skills and general management skills will supplement by technical and data skills
  - **Strengthening the training and further education of teaching staff:** In order for teachers to be able to impart the media and digitisation skills needed in the future, the courses of study must be adapted accordingly for future teachers. On the other hand, the trained teaching staff must be further trained on new train-the-trainer concepts and innovative offers.

- If so, who is driving the change? Faculty? University Leadership? Professional Organizations? Government? Other key stakeholders (e.g. Industry)?
  - Companies, employees, employer representatives, works councils and government **have to work together** to shape the transformation.
  - **State and private educational institutions, companies and society** must anticipate future competence needs at an early stage and address them accordingly in training and re-qualification programs.
  - **Adapt the education system to future requirements**: Schools and higher education institutions have to teach media and digitalisation skills in order to ensure that schoolchildren and students are properly equipped for Industrie 4.0. The training provided at vocational colleges and in companies under the dual training system should reflect the latest technological changes. This will require targeted training and professional development of teaching staff as well as the modification of study courses. Training and professional development for Industrie 4.0 should in general focus on the operational level.

  - Central and regional government should strengthen higher education institutions in their "third mission" and in the field of executive education in order to support knowledge transfer, particularly for SMEs, on issues connected with the digital transformation and to develop the relevant lifelong learning provision.

- Is quality improving?
  - What are the relevant measures of quality?
    - There are no generic, one-size-fits-all solutions – self-directed, needs-based learning will increasingly need to become standard practice.

- Are new techniques being used?
  - If so, what are the most widely used? Have measures of effectiveness been implemented?
    - Innovative, technology-supported teaching-learning solutions open up new opportunities to create working conditions that are conducive to learning across the board and to convey content precisely and **individually**. Methods and techniques of **Artificial Intelligence** for cognitive and action-oriented support play a central role here.
    - Learning and teaching need to change e.g. **e-learning** opportunities, **virtual learning communities,** opportunities for **participative learning (co-creation/co-working)**
    - Flexible and demand-oriented education towards relevant topics and future area of need
    - **Personalised digital learning nuggets** and learning opportunities offer the possibility to adopt knowledge and competence with a high degree of personalizability continuously (such as MOOCs) and support demand-oriented and self-determined learning of the employees.

- How are topics like project-based education, multi-disciplinary education, and innovation being integrated?
    - **Interdisciplinary** work, **innovation**, **lifelong learning** and **international network** need to be strengthened in the concept of universities in the future (e.g. connection of IT and engineering, network with industry and start-ups)
    - Enhancement of **shared professorships, part-time professorships** and **doctorate within a company**

- Is your academy directly involved in stimulating change?
  - If so, how? What can you share with other CAETS members?

- Since 2017, **Henning Kagermann** has advised Plattform Industrie 4.0 as **Global Representative and Advisor**. He represents the platform at international events and advises the platform in its international strategy.
- **HR Working Group** – a forum for Human Resources Directors and academic experts created in 2014 by acatech and the Jacobs Foundation → Representatives of **industrial companies** and **academies** work together to identify the key challenges and formulate proposals to achieve a successful digital transformation (Reference: Jacobs, J. C./Kagermann, H./Spath, D. (Eds.): Work in the Digital Transformation – Agility, Lifelong Learning and the Role of Employers and Works Councils in Changing Times. A paper by the acatech and Jacobs Foundation Human Resources Working Group – Forum for HR Directors on the Future of Work (acatech DISCUSSION), Munich: Herbert Utz Verlag 2017)

  - How could CAETS help facilitate the sharing of relevant information?
    - **Comparing the results** of the German HR Working Group with other national HR Working Groups focusing engineering
    - The exchange of ideas between all parties could generate sustainable growth through innovation.

- Is there a role for CAETS to help motivate/facilitate evolution of engineering education from an international perspective?
  - If so, what is that role and what are the necessary next steps?
    - Focusing on the **international network and exchange of the key stakeholders**
    - The content-related and methodological challenges for education and training in relation to Industry 4.0 should be further analysed through targeted basic and application-oriented research. Science can make an important contribution to assessing the effects on the world of work, defining central media and digitisation skills and promoting the development of innovative (online) solutions for training at (higher) schools and qualification in companies. Further research can contribute in particular to supporting the successful implementation of digital services in practice.

US National Academy of Engineering (Background Information)

The Engineer of 2020: Visions of Engineering in the New Century
Consensus Study Report (2004)
Download Free PDF at:
https://www.nap.edu/catalog/10999/the-engineer-of-2020-visions-of-engineering-in-the-new

Description: To enhance the nation's economic productivity and improve the quality of life worldwide, engineering education in the United States must anticipate and adapt to the dramatic changes of engineering practice. The Engineer of 2020 urges the engineering profession to recognize what engineers can build for the future through a wide range of leadership roles in industry, government, and academia--not just through technical jobs. Engineering schools should attract the best and brightest students and be open to new teaching and training approaches. With the appropriate education and training, the engineer of the future will be called upon to become a leader not only in business but also in nonprofit and government sectors.

The book finds that the next several decades will offer more opportunities for engineers, with exciting possibilities expected from nanotechnology, information technology, and bioengineering. Other engineering applications, such as transgenic food, technologies that affect personal privacy, and nuclear technologies, raise complex social and ethical challenges. Future engineers must be prepared to help the public consider and resolve these dilemmas along with challenges that will arise from new global competition, requiring thoughtful and concerted action if engineering in the United States is to retain its vibrancy and strength.

Attributes of Engineers in 2020 (Chapter 4):

- Strong analytical skills
- Practical ingenuity
- Creativity
- Communication
- Business and Management
- Leadership
- High Ethical Standards
- Professionalism
- Dynamism, Agility, Resilience and Flexibility
- Lifelong Learners

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Educating the Engineer of 2020: Adapting Engineering Education to the New Century
Consensus Study Report (2005)
Download Free PDF:
https://www.nap.edu/search/?term=Educating+the+Engineer+of+2020&x=0&y=0

Major Recommendations:

1. The baccalaureate degree should be recognized as the "preengineering" degree or bachelor of arts in engineering degree, depending on the course content and reflecting the career aspirations of the student.
2. ABET should allow accreditation of engineering programs of the same name at the baccalaureate and graduate levels in the same department to recognize that education through a "professional" master's degree produces an AME, an accredited "master" engineer.
3. Engineering schools should more vigorously exploit the flexibility inherent in the outcomes-based accreditation approach to experiment with novel models for baccalaureate education. ABET should ensure that evaluators look for innovation and experimentation in the curriculum and not just hold institutions to a strict interpretation of the guidelines as they see them.
4. Whatever other creative approaches are taken in the four-year engineering curriculum, the essence of engineering—the iterative process of designing, predicting performance, building, and testing—should be taught from the earliest stages of the curriculum, including the first year.
5. The engineering education establishment, for example, the Engineering Deans Council, should endorse research in engineering education as a valued and rewarded activity for engineering faculty as a means to enhance and personalize the connection to undergraduate students, to understand how they learn, and to appreciate the pedagogical approaches that excite them.
6. Colleges and universities should develop new standards for faculty qualifications, appointments, and expectations, for example, to require experience as a practicing engineer, and should create or adapt development programs to support the professional growth of engineering faculty.
7. As well as delivering content, engineering schools must teach engineering students how to learn, and must play a continuing role along with professional organizations in facilitating lifelong learning, perhaps through offering "executive" technical degrees similar to executive MBAs.
8. Engineering schools introduce interdisciplinary learning in the undergraduate environment, rather than having it as an exclusive feature of the graduate programs.
9. Engineering educators should explore the development of case studies of engineering successes and failures and the appropriate use of a case-studies approach in undergraduate and graduate curricula.

10. Four-year engineering schools must accept it as their responsibility to work with their local community colleges to ensure effective articulation, as seamless as possible, with their two-year programs.
11. U.S. engineering schools must develop programs to encourage/reward domestic engineering students to aspire to the M.S. and/or Ph.D. degree.
12. Engineering schools should lend their energies to a national effort to improve math, science, and engineering education at the K-12 level.
13. The engineering education establishment should participate in a coordinated national effort to promote public understanding of engineering and technology literacy of the public.
14. NSF should collect and/or fund collection, perhaps through ASEE or the Engineering Workforce Commission, of comprehensive data by engineering department/school on program philosophy and student outcomes such as, but not exclusively, student retention rates by gender and ethnicity, common reasons why students leave, where they go, percent of entering freshman that graduate, time to degree, and information on jobs and admission to graduate school.

Infusing Ethics into the Development of Engineers (2016)

Download Free PDF:
https://www.nae.edu/Activities/Projects/CEES/CEESReports/InfusingEthicsReport.aspx

Ethical practice in engineering is critical for ensuring public trust in the field and in its practitioners, especially as engineers increasingly tackle international and socially complex problems that combine technical and ethical challenges. This report aims to raise awareness of the variety of exceptional programs and strategies for improving engineers' understanding of ethical and social issues and provides a resource for those who seek to improve ethical development of engineers at their own institutions.

This publication presents 25 activities and programs that are exemplary in their approach to infusing ethics into the development of engineering students. It is intended to serve as a resource for institutions of higher education seeking to enhance their efforts in this area.

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Grand Challenges Scholars Program

Reference: https://www.nae.edu/Activities/Projects/169108.aspx

Motivated by the National Academy of Engineering's 14 Grand Challenges for Engineering and increasing calls for a new engineering education paradigm, Duke's Pratt School of Engineering, The Franklin W. Olin College of Engineering, and the University of Southern California's Viterbi School of Engineering proposed a new education model to prepare engineers to be world changers. The program was endorsed by the National Academy of Engineering in February 2009.

The GCSP is a combined curricular, co-curricular, and extra-curricular program with five competencies that are designed to prepare the next generation of students for addressing the grand challenges facing society in this century. Each institution creates their own specific realization of how the competencies are implemented, which are approved by the GCSP steering committee.

GCSP Competencies

1. **Talent:** Mentored research/creative experience on a Grand Challenge-like topic
2. **Multidisciplinary:** Understanding the multidisciplinary nature of engineering systems solutions developed through personal engagement
3. **Viable Business/Entrepreneurship:** Understanding the necessity of a viable business model for solution implementation, preferably developed through experience
4. **Multicultural:** Understanding cultural differences to ensure cultural acceptance of proposed engineering solutions, preferably developed through multicultural experiences
5. **Social consciousness:** Understanding these engineering solutions should primarily serve people and society

Input for Engineering Education Discussion Group from AcTI - The Netherlands

(1)
The four **Universities of Technology** ("4TU") in the Netherlands (Engineering Universities) in Delft, Eindhoven, Enschede and Wageningen are jointly committed to strengthening and pooling technological knowledge with the aim of producing sufficient and well-trained engineers and technical designers, of carrying out outstanding and socially relevant research of an international standard, and of promoting cooperation between research institutes and businesses.

The 4TU.Federation cooperates in the field of education in the 4TU.Education management committee. 4TU works closely together in five Master study programmes and provides twenty Professional Doctorate in Engineering study programmes through the Stan Ackermans Institute. One of the most important activities takes place in the Center for Engineering Education (4TU.CEE).

For more information: **https://www.4tu.nl/en/education/**

(2)
The P**latform Bèta Techniek (Platform Science & Technology)**
PBT was established in 2004 by the Ministries of Economic Affairs and Climate, Education, Culture and Science and Social Affairs and Employment with the aim of stimulating qualitatively and quantitatively sufficient beta technicians.

Our mission is to stimulate enough good science technicians for the Dutch economy. In doing so, we have been given ample room by ministries to come up with unorthodox approaches. We opt for an integrated approach in our approach. Throughout education as far as the workplace we stimulate attention for technical and ICT skills and we work on education that meets the needs of the regional labor market. The most important elements of our approach are regional networking with education and industry, connection through the chain, and knowledge development and dissemination.

In recent years we have gained a lot of experience with various interventions at the intersection of education and the labor market. The choice for the deployment of an intervention depends on the phase in which the theme is located. PBT plays an advisory role in the choice of interventions and can contribute to its (initial) implementation. Key concepts for the role of PBT are (triple-helix) cooperation, independence and lack of commercial interest.

For more information: **https://www.pbt-netwerk.nl/** **(only in Dutch)**

(3)
Techniekpact (Technology Pact)
The Technology Pact must improve the connection of education to the labor market in the engineering sector and thus reduce the shortage of technical staff. The Technology Pact includes concrete agreements between the business community, education and government.

National Technology Pact 2020

The Netherlands counts in the world. When it comes to competitiveness, innovation and scientific research, we still belong to the top internationally. We owe that excellent position to our well-educated workforce.

ADDITIONAL TECHNICIANS REQUIRED

The Netherlands would like to continue participating in the top, but this requires sufficient smart and skilled technicians. Because technology is the biggest engine of our economic prosperity. The crossovers of technology in other sectors such as healthcare, the food industry, energy and sports are only growing and will have a major impact on the working environment. The demand for knowledge and skills for the application of technology in non-technical professions will only increase in the coming years.

In spite of all efforts and results achieved since the signing of the Technology Pact in May 2013, the effort on the flow of technicians from education to the technical labor market and on the retention of technical talent - from professionals in the workplace - remains of great importance. Some vacancies in the technology are still difficult to fill. Shortages in the medium term in the technical and ICT labor market can still be expected.

Given the rapid technological developments, it is necessary to respond adequately to the dynamics of the labor market. Educational institutions, employers, employees, young people, top sectors, regions and central government have therefore presented an updated National Technology Pact with 12 goals on 18 April 2016. These twelve goals, partly newly formulated and in line with the agreements already made in 2013, provide the basis for all the partners involved to continue and initiate targeted actions in the coming years, to achieve results and to achieve further cooperation.

The Technology Pact uses three lines of action to realize its ambition:
• Choosing technology: more students opt for a technical training.
• Learning in technology: more pupils and students with a technical diploma will also get to work in a technical job.
• Working in technology: people who keep working in technology for technology, and people with a technical background who are threatened with dismissal or who are already on the sidelines are using technology elsewhere.

For more information: **https://www.techniekpact.nl/** **(in Dutch)**
National Technology Pact 2020 (attached)
National Technology Pact 2020 Summary (attached)

(4)
JET-NET (Youth and Technology Network Netherlands)
Bringing technology to life together!

In Jet-Net & TechNet, the youth and technology network of the Netherlands, companies and schools work together to make more young people consciously choose a technical follow-up training, so that an answer can be given to the challenges of the future!

New technologies, innovations and digitization have an effect on the way we live and work. In this way, plenty of job opportunities will continue to arise in the area of technology, technology and ICT in the coming years. Within Jet-Net & TechNet, companies and schools work together to make more young people consciously choose a technical follow-up program, so that an answer can be given to the challenges of the future.

A conscious choice for technology

Together we ensure that young people can orient themselves with a realistic and positive image of future professions and on that basis can make a conscious choice for a technical profile, advanced education and career. We bring pupils and teachers into contact with business contexts, to let them experience how inspiring, challenging and fascinating a job in technology, technology and ICT is!

Effective cooperation at national & regional level

The National Bureau Jet-Net & TechNet helps hundreds of companies and schools that have joined the network since 2002 in order to achieve effective cooperation. This by acting as a central point in the network, providing structural support in the region, facilitating the network with tools and meetings and by organizing large-scale national activities. Strengthened by years of effort and experience, the network jointly achieves a higher intake of technical profiles and courses. Together we come into action to give young people a good picture of the labor market of the future!

For more information: **https://jet-net.nl/** **(in Dutch only)**

Potential Questions regarding Engineering Education:

Question 1:

Is it changing? If so, what motivated the change? What are the barriers/impediments to change? If so, who is driving the change? Faculty? University Leadership? Professional Organizations? Government? Other key stakeholders (e.g. Industry)?

Answer 1:

Engineering education is certainly changing, both in terms of content and pedagogy.

Importantly, there is widespread and universal recognition that the education of an engineer must extend far beyond the technical. This is reflected through the adoption of a series of graduate attributes (https://engineerscanada.ca/sites/default/files/Graduate-Attributes.pdf) by Engineers Canada and their integration into the accreditation process for undergraduate engineering programs across the country. This change was driven by Engineers Canada and their Accreditation Board, driven by the needs of provincial regulators, and was implemented in consultation with higher education institutions. Beyond this, there is a strong and growing movement on the part of educational institutions to work within the accreditation program to improve pedagogical practices, enhance mobility of students, broaden their education through exposure to other disciplines, and to take advantage of the modern tools (e.g., distance learning) that can be used to improve the quality and impact of the educational process.

Ironically, and as reflected by the views expressed by the National Council of Deans of Engineering & Applied Science (with 44 members institutions from across Canada), the single biggest impediment to rapid and effective change appears to be the accreditation process itself, which overly emphasizes the importance of lectures (as opposed to tutorials, independent learning, labs), creates barriers to student mobility, is focused on inputs (e.g., total time spent in lectures, tutorials and labs) as opposed to outputs (i.e., learning outcomes), and discourages experimentation with modern approaches to teaching and learning (e.g., active, distance or independent learning or immersion experiences such as co-op placements and internships). Over and above this, there is significant concern that the accreditation process has driven a significant increase in the content of programs over time that leads to workloads that are not conducive to effective learning and, in fact, appears to be detrimental to the mental health of students. This has also resulted in the situation where students graduating within the normal prescribed period of a degree program (i.e., 4 years) is no longer the norm.

And, finally, an important question that remains to be addressed concerns the roles of universities in terms of the education that they provide. That is, in recognition that a surprisingly small proportion of graduates go on to become licensed professional engineers in Canada, it begs the questions as to whether curriculum content and practices limit the career development of students who often (or predominately) take up careers in arenas other than the profession of engineering. This represents both an important opportunity and a challenge for engineering schools. It is an opportunity as far as one could argue that engineering education could become one of the preferred pathways for those who wish to acquire the kind of educational foundation that will best prepare them to thrive in the 21st century society, whether they practice as engineers or not. However, some might tend to argue that the low licensure uptake can justify reducing the capacity of Canadian engineering schools and, as a result, attempt to restrict enrolment to those who will become licensed engineers (similar to the situation that exists in medical schools).

Question 2:

Is quality improving? What are the relevant measures of quality?

Answer 2:

Overall, the current accreditation process involves measures of individual student accomplishment under the prescribed graduate attributes. This is a very positive development because it means that the quality of the education of our students is being measured using a set of metrics/rubrics that will identify areas where attention is required. Furthermore, it is hoped that these metrics in conjunction with a process of continuous improvement (as mandated by the accreditation process) will lead to positive change over time.

Question 3:

Are new techniques being used? If so, what are the most widely used? Have measures of effectiveness been implemented?

Answer 3:

There are many approaches to teaching and learning that are being explored or implemented at Canadian institutions. These include active learning strategies, reflective learning, flipped-classrooms, integration of technologies for student feedback during lectures, problem- and project-based learning. Other initiatives to enhance student learning that are widespread (and growing) include community engagement, internship and exchange experiences, entrepreneurship experiences, and extracurricular activities focused on developing personal/professional skills (e.g., design teams). While no inventory of such techniques has been created as of yet, such an inventory is likely to be accomplished through the work of the Engineering Change Lab (https://www.engineeringchangelab.ca/) in Canada that has launched a project that will lead to the sharing of best practices between institutions and, furthermore, will work to create a community of engineering education researchers, and will collect data on the effectiveness of new pedagogical practices. Anecdotally, the introduction of project-based education appears to be the dominant form of alternative pedagogy that is being introduced in programs across Canada. This is coupled with increasing growth in the application of active learning strategies by individual professors within programs.

Question 4:

How are topics like project-based education, multi-disciplinary education, and innovation being integrated?

Answer 4:

This is a difficult question to answer given the absence of specific data on these techniques. However, it can be stated that the approach used by institutions is, for the most part, essentially driven at the level of individual programs (often at the grass roots level of individual professors) and is *ad hoc* at present.

This is essentially because the accreditation system used for engineering programs in Canada does not promote such strategies and, moreover, specifically requires exceptions to be requested/granted at each accreditation visit where strategies other than lectures, tutorials and laboratory sessions are incorporated into programs. In other words, the input measures used in the current accreditation process has not caught up with modern (or alternative) forms of pedagogy. Moreover, because of the compressed nature of programs, little room is available in curricula to introduce new subjects that would create a better-rounded education of graduates (e.g., innovation, business, humanities, policy, entrepreneurship). These are issues that are foremost in discussions between the National Council of Deans of Engineering & Applied Science and the Canadian Engineering Accreditation Board.

It should be noted that there are grass-roots initiatives underway across Canada to enhance engineering education based on research and sharing of best practices. This is being accomplished through a growing community of scholars from engineering faculties that have come together as the Canadian Engineering Education Association (https://ceea.ca/en/). The CEEA is a member-driven organization whose mission is to "enhance the competence and relevance of graduates from Canadian Engineering schools through continuous improvement in engineering education and design education." This organization grew out of previous efforts of the Canadian Design Engineering Network (CDEN) and the Canadian Congress on Engineering Education (C2E2). Specifically, the goals of the CEEA are to:

- Encourage and support the development and sharing of best practices between Canadian engineering educators.
- Interact with the Canadian Deans of Engineering and the CEAB to facilitate alignment of objectives and mutual support.
- Support all areas of engineering education including design, problem solving, leadership, communications, teamwork and global citizenship.
- Engage students and student groups broadly for input and feedback.
- Develop a sustainable organizational structure and operations for the CEEA.

We feel that this is a model organization that could benefit from international connections established with the support of CAETS.

Question 5:

Is your academy directly involved in stimulating change? If so, how? What can you share with other CAETS members? How could CAETS help facilitate the sharing of relevant information?

Answer 5:

To-date, the Canadian Academy of Engineering has played a very limited role in this regard. However, the CAE recently held a panel discussion on the issue of the "The Future of Engineering in Canada" at one of its annual national meetings which was primarily focused on the education of engineers. The panel included representatives from the higher education sectors and industry. The audience was clearly engaged in the topic. Follow up indications are that the CAE can take a very important and active leadership role in discussions of how engineering education can adapt to the changing nature of the profession, the needs of society, and to better support the long-term careers of engineering graduates.

CAETS could play a pivotal role in identifying common issues and approaches to engineering education across the world. At present, it appears that many conversations and debates are occurring on this topic that are too inwardly focused and based on local experiences. Shared perspectives from across the world are required to better shape the discussions, inform them, and identify best practices.

Question 6:

Is there a role for CAETS to help motivate/facilitate evolution of engineering education from an international perspective? If so, what is that role and what are the necessary next steps?

Answer 6:

CAETS could help motivate/facilitate the evolution of engineering education by developing an informed position on the basic learning outcomes must be achieved through an effective and modern engineering education in order to prepare graduates for careers that will inherently require (1) their mobility in an international setting; and (2) their adaptability in a world where developments in information technology are disrupting careers as we now know them. Moreover, CAETS could also develop a position on the role of employers in the continuing education of engineers, reflecting the fact that no engineer is fully formed through their undergraduate education, but must undergo a process of continuous education over the course of their careers. It is suggested that CAETS could provide an international perspective on important questions such as:

- What are the implications of globalization and developments in information technology in terms of the educational needs and qualifications of engineers?
- Is the potential of the engineering profession currently underutilized? How can this potential be realized?
- Should universities train engineers (i.e., preparing them to be licensed engineers) or provide an engineering education (i.e., preparing them for careers where engineering skills and approaches are of immense value)? Alternatively, can we work collectively to achieve both objectives to the ultimate benefit of the profession and society?
- Are we attracting/retaining the diversity of people in the profession that we need in terms of backgrounds, interests and capacity?
- What are the “fundamentals” that all engineers should know?
- Can the structure and content of programs be better aligned with the variety of interests and strengths of students and the demands of industry?
- What role must industry play in the education of the engineer?
- What is preventing the development of a more adaptive, flexible and efficient education for engineers?

And, finally, as noted above, CAETS could support the development of an international version of the Canadian Engineering Education Association in which best practices and research in engineering education could be shared more broadly. It could also become a mechanism for collaboration on priority areas of engineering education research.

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2. ABET should allow accreditation of engineering programs of the same name at the baccalaureate and graduate levels in the same department to recognize that education through a "professional" master's degree produces an AME, an accredited "master" engineer.
3. Engineering schools should more vigorously exploit the flexibility inherent in the outcomes-based accreditation approach to experiment with novel models for baccalaureate education. ABET should ensure that evaluators look for innovation and experimentation in the curriculum and not just hold institutions to a strict interpretation of the guidelines as they see them.
4. Whatever other creative approaches are taken in the four-year engineering curriculum, the essence of engineering—the iterative process of designing, predicting performance, building, and testing—should be taught from the earliest stages of the curriculum, including the first year.
5. The engineering education establishment, for example, the Engineering Deans Council, should endorse research in engineering education as a valued and rewarded activity for engineering faculty as a means to enhance and personalize the connection to undergraduate students, to understand how they learn, and to appreciate the pedagogical approaches that excite them.
6. Colleges and universities should develop new standards for faculty qualifications, appointments, and expectations, for example, to require experience as a practicing engineer, and should create or adapt development programs to support the professional growth of engineering faculty.
7. As well as delivering content, engineering schools must teach engineering students how to learn, and must play a continuing role along with professional organizations in facilitating lifelong learning, perhaps through offering "executive" technical degrees similar to executive MBAs.
8. Engineering schools introduce interdisciplinary learning in the undergraduate environment, rather than having it as an exclusive feature of the graduate programs.
9. Engineering educators should explore the development of case studies of engineering successes and failures and the appropriate use of a case-studies approach in undergraduate and graduate curricula.

10. Four-year engineering schools must accept it as their responsibility to work with their local community colleges to ensure effective articulation, as seamless as possible, with their two-year programs.
11. U.S. engineering schools must develop programs to encourage/reward domestic engineering students to aspire to the M.S. and/or Ph.D. degree.
12. Engineering schools should lend their energies to a national effort to improve math, science, and engineering education at the K-12 level.
13. The engineering education establishment should participate in a coordinated national effort to promote public understanding of engineering and technology literacy of the public.
14. NSF should collect and/or fund collection, perhaps through ASEE or the Engineering Workforce Commission, of comprehensive data by engineering department/school on program philosophy and student outcomes such as, but not exclusively, student retention rates by gender and ethnicity, common reasons why students leave, where they go, percent of entering freshman that graduate, time to degree, and information on jobs and admission to graduate school.

Infusing Ethics into the Development of Engineers (2016)

Download Free PDF:
https://www.nae.edu/Activities/Projects/CEES/CEESReports/InfusingEthicsReport.aspx

Ethical practice in engineering is critical for ensuring public trust in the field and in its practitioners, especially as engineers increasingly tackle international and socially complex problems that combine technical and ethical challenges. This report aims to raise awareness of the variety of exceptional programs and strategies for improving engineers' understanding of ethical and social issues and provides a resource for those who seek to improve ethical development of engineers at their own institutions.

This publication presents 25 activities and programs that are exemplary in their approach to infusing ethics into the development of engineering students. It is intended to serve as a resource for institutions of higher education seeking to enhance their efforts in this area.

Grand Challenges Scholars Program

Reference: https://www.nae.edu/Activities/Projects/169108.aspx

Motivated by the National Academy of Engineering's 14 Grand Challenges for Engineering and increasing calls for a new engineering education paradigm, Duke's Pratt School of Engineering, The Franklin W. Olin College of Engineering, and the University of Southern California's Viterbi School of Engineering proposed a new education model to prepare engineers to be world changers. The program was endorsed by the National Academy of Engineering in February 2009.

The GCSP is a combined curricular, co-curricular, and extra-curricular program with five competencies that are designed to prepare the next generation of students for addressing the grand challenges facing society in this century. Each institution creates their own specific realization of how the competencies are implemented, which are approved by the GCSP steering committee.

GCSP Competencies

1. **Talent:** Mentored research/creative experience on a Grand Challenge-like topic
2. **Multidisciplinary:** Understanding the multidisciplinary nature of engineering systems solutions developed through personal engagement
3. **Viable Business/Entrepreneurship:** Understanding the necessity of a viable business model for solution implementation, preferably developed through experience
4. **Multicultural:** Understanding cultural differences to ensure cultural acceptance of proposed engineering solutions, preferably developed through multicultural experiences
5. **Social consciousness:** Understanding these engineering solutions should primarily serve people and society