

The Nordic Future Engineer.

Dr. Lena B. Gumaelius, KTH Royal Institute of Technology

Dr Lena Gumaelius has a background as a researcher in Biotechnology (Lena got her Master of Science in chemistry 1993 and her PhD in Environmental Microbiology in 2001.)

In parallel with her research, she worked for several years with development of experiments for students at House of Science. In 2006 Lena became the director of House of Science, which she remained until 2012. House of Science is a university based Science centre with about 40 000 visitors were the goal is to stimulate high school students' interest for the natural sciences, math and technology. During these years Lena developed her pedagogical skills and competence in the pedagogic field and besides leading the activities she organised pedagogical training for teachers, pupils and university students.

Between 2011 and 2016 Lena was the head of the new Department of Learning at the School of Education and Communication in Engineering Sciences (ECE), KTH. Lena was then responsible for building up a new strong research environment in engineering and technology education, K-12 to university level.

2016-2017 Lena was the Dean at the ECE school at KTH.

As this School was merged with another School in 2018, from January 2018 Lena has a research position as an Associate professor at KTH.

Prof. Anette Kolmos, Aalborg University

Anette Kolmos is Professor in Engineering Education and PBL and Chairholder for UNESCO in Problem Based Learning in Engineering Education, Aalborg University, Denmark. Guest professor at KTH Royal Institute of Technology and Guest Professor at UTM University Technology Malaysia 2011-2013. President of SEFI 2009–2011 (European Society for Engineering Education). Founding Chair of the SEFI-working group on Engineering Education Research. During the last 20 years, Dr. Kolmos has researched the following areas, primarily within Engineering Education: development and evaluation of project based and problem based curriculum, change from traditional to project organized and problem based curriculum, development of transferable skills in PBL and project work, and methods for staff development. She is Associate Editor for the European Journal of Engineering Education and was Associated Editor for Journal of Engineering Education (ASEE). Involved in supervision of 13 PhD projects and published around 200 publications. Member of several organizations and committees within EER, national government bodies, and committees in the EU.

The Future Nordic Engineer, Work in Progress paper

Abstract

What possible directions can we identify for engineering education in 2030? This question has been raised globally by a number of reports showing that today's engineering education does not deliver the engineers that tomorrow's employers will need. This study is part of the work conducted by the "Nordic Engineering hub" and the investigation will use a phenomenographic approach to describe the views expressed by faculty representing four major engineering disciplines in five universities in five different Nordic countries. These faculty will be interviewed during spring 2019, and the results of the interviews will be used to shape and discuss various possible directions for engineering education in the Nordic context.

Introduction

A growing gap between education and societal needs is reported, and it is imperative to close this gap to respond to future challenges [1]. Society demands engineers capable of co-creating a sustainable society. The need to integrate sustainable development as a red thread through all education has existed for a long time, and with the formation of the 17 sustainability development goals (SDGs) [2] in combination with the contemporary climate debate, this need is even more obvious regarding engineering education in 2030 than it is now.

In addition to the challenge of sustainability, another challenge is posed by the industry demand for engineers who are experienced in project management and who have the ability to learn and adapt quickly, given that career paths will change more rapidly in the near future [3], [4], [1]. Therefore, these future requirements for employability, including innovativeness and entrepreneurialism, constitute a second challenge considered in this study. A third challenge is digitalisation, which comprises the increased system understanding and process skills that are integral parts of the fourth industrial revolution [5] and that engineers must possess to handle the forthcoming industrial challenges [6]. The challenges that need to be met to enable tomorrow's engineers to meet society's needs are many, but the three challenges mentioned above have been chosen to frame this study on the future development of engineering education.

Background

To achieve the needs of future engineering education, both content and pedagogical methods must be reviewed. Today's engineering literature describes a variety of approaches that represent the forefront of this development, and some of the trends relevant to this study are described below. One of the current trends in content development involves the need for more multi-disciplinarily engineers and, therefore, the demand for inter-disciplinary programs [5], [1], [7], [8]. We also see a need for additional non-traditional engineering knowledge that strengthens the competences that makes it possible to be more entrepreneurial, innovative [9] or may strengthen the ability to handle the sustainable challenge. Because today's engineers must be able to solve more-complex problems, it is often stated that educational institutions should be places for practicing the competences needed.

Regarding pedagogic methodology, for years the trend has been that traditional lecture-based methodology is becoming more activity-based. *Student-centred learning methods* is a broad

concept covering learning approaches where the students influence their own learning process (such as active learning, collaborative learning, team-based learning, design-based learning, inquiry-based learning, challenge-driven learning and problem- and project-based learning (PBL)). in various forms. Snowden and Boone [10] define a model of complexity in which they describe some problems as simple, some as complex and some as complicated. Hadgraft and Kolmos [11] emphasise that education needs to provide practice in solving problems at all levels of complexity. One example of a student-centered activity based model is Challenge Driven Education (CDE), a term for learning experiences that address open ended societal challenges [12]. A CDE project begins by introducing a challenge defined by a societal group or external stakeholder and continues with students working in multi-disciplinary teams together with the stakeholder to find solutions that are preferable in a sustainable society.

Effective partnership between reality, most often represented as industry, and higher education is described as a key feature for building a successful exemplar of engineering education [6] [13]. This is confirmed by Graham [8], who found that universities seen as emerging leaders in engineering education most often have established programmes that includes a close connection to industry.

In this investigation the aim is to find out the anticipated role of those educational trends in future engineering education.

The Nordic Engineering hub

Until now, the Nordic countries have applied various strategies for meeting these challenges, but we believe that a common knowledge base and collaboration among its countries will empower the Nordic region and eventually also strengthen global progression. In all Nordic countries, the general understanding is that education is a crucial part of the responses to contemporary engineering challenges. However, the Nordic countries face challenges in terms of identifying future competence profiles and developing adequate capacity within innovative and sustainable competences across traditional discipline boundaries.

In 2018, the Nordic Engineering hub was established, with the aim of empowering the Nordic region regarding STEM education (science-, technology-, engineering-, mathematics-education). The start-up phase of this initiative included participation by universities representing each country: Aalborg University, Denmark, Aalto University, Finland, KTH-Royal Institute of Technology, Sweden, Stavanger University, Norway and Reykjavik University, Iceland. Two other engineering organisations are participating, Nordtek representing Nordic Engineering Institutions, and ANE, representing Nordic Engineers. The present study on the future of engineering education is part of a larger study that will enable the Nordic Engineering hub to present a vision of tomorrow's engineering education, as designed by experts in the Nordic countries.

The aim of this study

The aim of this study is to answer the following question: How do faculty members at Nordic universities express their vision for the development of engineering education in their discipline, and how can a framework be shaped for this development, cross-nationally and cross-disciplinarily.

Faculty from five Nordic universities will provide their views of what is needed to meet the challenges in the engineering profession, and their perceptions will be interpreted using a

phenomenographic approach. The outcome will be used as the foundation upon which to shape the core of the framework for the Future Nordic Engineer.

Methodology

Four high stake professors at each partner university have been selected to participate in a one-hour semi-structured interview [14]. In addition, each university's Dean of Education will participate in the study. The professors represent the following four engineering disciplines.

1. Biotechnology engineering
2. Mechanical, (or industrial economy, or production) engineering
3. Energy engineering
4. Civil engineering

The interviews will be conducted by two persons: one main interviewer and one representative from the investigated university.

A phenomenographic approach will be used because it provides an unconditional starting point for analysing the phenomenon, Engineering Education 2030, according to the criteria presented by Ashworth and Lucas [15]. The study will be exploratory and the interviewees will be asked to give their personal perceptions of how they see the phenomenon and also regarding how and why they have developed those viewpoints.

One week before the interview, the interviewees will receive the interview protocol, including the questions and short texts presenting the three contemporary challenges the informants are supposed to reflect upon. The following questions will form the basis for the interview.

1. How do you think these challenges affect the development of your discipline and the educational program(s) you are involved in?
2. What do you expect the situation to be 10 years from now?
3. How do you prepare your students for the future with today's educational resources?
4. How will students learn engineering in the future?
5. Are there other challenges ahead that we have not mentioned?

The study aims to gain insights from participants' views regarding both the content of the disciplines and the pedagogic development. Follow-up questions will be asked about how and why the participants perceive the future of engineering education in the ways they describe.

The interviews will be transcribed verbatim. In addition to analysing the transcripts, attempts will be made to capture the moods and interruptions inherent in them, which can strengthen their interpretation. Analysis of the transcripts will include identifying categories and addressing variations within the cohort of 20 participants representing the various disciplines and countries. This number of participants is considered sufficient to reach an acceptable level of trustworthiness.

Results

The interviews of faculty are ongoing during spring 2019. By March 2019, four interviews had been conducted at the first university. By the time of the ASEE conference in June, all interviews and a first round of analysis will have been completed, enabling presentation of preliminary results.

The initial analyses made so far have identified the disciplines themselves as important factors in the variations noted. The more science-dominated engineering disciplines, including biotechnology and in one case energy, seem to expect less future change, whereas engineering disciplines such as mechanical and production engineering anticipate huge changes especially due to digitalization and Industry revolution 4.0. Sustainability is most often seen as a challenge that has been on the agenda for long. Some professors expect education to take on an even more holistic approach in order for the students to be able to handle this challenge, whereas others claim that the trend of being more holistic and broader as a single engineer, may cause knowledge drainage in some areas.

Discussion

This study is still in its infancy, and the study as a whole, which will include interviews with stakeholders as well as faculty, will not be completed until spring 2020.

The study aims to learn how faculty express their visions of the phenomenon Engineering Education 2030. To further explore the variations identified by this qualitative study, a follow-up quantitative study may be appropriate in order to either confirm or refute the qualitative statements obtained in the interviews, enlarging the picture of how this phenomenon is perceived by a wider group of people.

Although some preliminary results will be addressed, this WIP will mainly focus on the methodology used, and the discussion will be about the methodological approaches available to best characterise the future needs of engineering education. By discussing the alternative approaches, and possibly obtaining a consensus on how such qualitative studies can be conducted, we increase the possibility that others will conduct similar investigations in other countries and/or at other universities. These studies would be very valuable contributions to a comprehensive vision of how the engineering disciplines will evolve in the future.

References

- [1] W. Sunthonkanokpong, "Future Global Visions of Engineering Education", *2nd International Science, Social-Science, Engineering and Energy Conference 2010: Engineering Science and Management*. Procedia Engineering 8, 160–164, 2011.
- [2] United Nations, "General Assembly, 21 October 2015". Seventieth session Agenda items 15 and 116 15-16301 (E) *1516301*, 2015. Available: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E,
- [3] R. Hadgraft, "Transforming Engineering Education: DESIGN must be the Core". *Paper presented at the SEFI Annual Conference 2017*, Azores, 2017.
- [4] OECD, "Enabling the next production revolution: A summary of main messages and policy lessons", *Meeting of the OECD Council at Ministerial Level Paris, 7-8 June*, 2017.
- [5] K. Schwab, "Shaping the Fourth Industrial Revolution", January 11, 2016. In World Economic Forum.
- [6] M. Lorenz, M. Rübmann, R. Strack, K.L. Lueth, and M. Bolle, "Man and machine in Industry 4.0: How will technology transform the industrial workforce through 2025",

The Boston Consulting Group. 2015. Available: <https://www.bcgperspectives.com/content/articles/technology-business-transformationengineered-products-infrastructure-man-machine-industry-4>

- [7] Royal Academy of Engineering, “Engineering graduates for Industry”, 2010. Available: www.heacademy.ac.uk/system/files/graduates-for-industry-loughborough.pdf
- [8] R. Graham, “The global state of the art in engineering education” 2018. Available: <https://jwel.mit.edu/assets/document/global-state-art-engineering-education>
- [9] S.G. Walesh, “More Coaching—Less Osmosis: Teaching Soft Skills to Hard Scientists”, *Journal of Management in Engineering*, Vol.13, Issue 4, 1997.
- [10] D.J. Snowden & M.E. Boone, “A Leader’s Framework for Decision Making”, *Harvard Business Review*, 69-76. 2007.
- [11] R. Hadgraft & A. Kolmos, “Emerging learning environments in engineering education”, *European Journal of Engineering Education*, In progress, 2019.
- [12] A. Rosén, A-K. Högfeltdt, A.Lantz, L. Gumaelius, R. Wyss, M. Norell Bergendahl, J. Vasell and S.K. Lujara, “Connecting North to South through Challenge driven education,” *Proceedings of the 14th International CDIO Conference, Kanazawa Institute of Technology*, Kanazawa, Japan, June 28 – July 2, 2018.
- [13] Royal Academy of Engineering, “Educating Engineers for the 21st Century” 2007. Available: http://www.raeng.org.uk/news/publications/list/reports/Educating_Engineers_21st_Century.pdf
- [14] S. Kvale, *Den kvalitativa forskningsintervjun. (The qualitative research interview.)* Lund: Studentlitteratur, 1997.
- [15] P. Ashworth and U. Lucas, “Achieving Empathy and Engagement: A practical approach to the design, conduct and reporting of phenomenographic research”, *Studies in Higher Education*, 25(3): 295-308, October 2000.