

From Building to Bildung - Engineering Students' Motivation Towards Interacting with Society

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ABSTRACT: In this study 567 engineering students are asked about their motivation for becoming engineers, and what non-technical topics engineers should know about. The study is conducted in connection with teaching the course "Introduction to the engineering profession", that incorporates Bildung-related topics into the engineering education. The data suggests that intrinsic motivations connecting to the engineering profession were common, and that many students have the prospect of building, creating or developing as a central motivational factor. The paper suggests using this as a starting point to raise perspectives of engineers as builders also of society and incorporating discussions around the societal role of an engineer, while also teaching subjects like ethics from a "technology and ethics" starting point. This seems the most fruitful way to dip into the intrinsic motivation of the engineering students when teaching topics where they themselves may not immediately see the connection to their role as engineers in making.

1 INTRODUCTION

Over the past years I have developed the course "Introduction to the Engineering Profession" (Ingeniørfaglig innføringsemne), and have amongst other things developed a textbook in history of science and technology, scientific method and ethics to cover the course (Kjelsberg, 2017). Several of these subjects can be connected to the idea of Bildung.

The course has previously been subject of discussion, focusing on engineering students initial lack of interest in subjects like history of science and technology (Thorvaldsen & Henne, 2017).

Internationally, research also suggest an engineering culture where "interest in jobs seems to greatly outweigh the inspiration of ideas" (Brint, Cantwell, & Hanneman, 2008, p. 398). An important question is thus how to engage engineering students in the non-technical topics within this course.

In this study I will attempt to answer this question by examining students' motivations, and see how they can be connected to the topics of this course, by attempting to answer the following research questions:

1. What motivates the students to become engineers?
2. How can the students best be engaged in learning Bildung-related subjects?

2 THEORY

2.1 Bildung

Attempts to define Bildung have been considered futile by many. Max Horkheimer famously declared, "Don't expect me to define it [Bildung]. There are areas in which clear and simple definitions are more than to the purpose, and the role of definitions in knowledge should not be underestimated in any way" (Siljander & Sutinen, 2012, p. 2), arguing that clear boundaries of concepts are not always necessary. Attempts to define it have however been made.

A useful operative definition of Bildung for this paper is as a process making an educated person able to operate within the "the everyday world" and the "everyday language", as opposed to the separation of the science in question into its own world and language (Hellesnes, 1992, p. 84). In a broad sense, Bildung thus connects science to society. This is also similar to the idea of Bildung as a process enabling you to become a *citizen* – an active participant in society, and not simply a vocational practitioner of a craft. This idea is found in both the tradition of classical Bildung and the Anglo-American tradition of

liberal education (Adler, 1952, p. 57; Hancock, 1987; Paxson, 1985). This also explains why some see science and technology as relatively less relevant to *Bildung*, as many other fields, like the humanities and the social sciences, directly research aspects of society. This has however not always been the view of engineers.

2 Engineering and society in Norway

The engineering profession in Norway has gone through several policy shifts during its more than a hundred years of history. In the 1930's the profession took a turn towards policy in both industrial and labor politics. This coincided with an idea in party political circles where engineers were seen as central to industrialization, which again was seen central to growth and welfare (Nygaard, 2013, p. 48). This continued far into the post war-era, where the Labor party was the dominant political force in Norway and engineering topics were prominent in their propaganda (Figure 1).



Figure 1: Left: Poster from the Norwegian Labor Party in 1945: “Build the country! Industrial development: Work and progress for all”. Right: Poster from the Norwegian Labor Party in 1953: “Progress must continue” (Arbeiderbevegelsens arkiv og bibliotek, 2012)

This partially coincided with a period where more academically *Bildung*-oriented approach gained ground in Norwegian engineering education, notably at the Norwegian Institute of Technology (NTH) (Nygaard, 2013, p. 216).

This view of industrialization was not isolated to Norway. Chandlers (1977) authoritative description of this period of active building of industry by professional managers was provocatively titled “The Visible Hand” as a contrast to Adam Smiths “invisible hand” of the market.

The *Bildung*-oriented view of engineers as a driving force in society was however challenged. Both environmental and economic concerns contributed to their gradual dethronement as leaders of industry in favor of economists from the late 1960's and onward (Nygaard, 2013, pp. 283-283). In 2013 economists lead twice as many of Norway's 500 largest companies as engineers and scientists (Amelie, 2013). Similarly, engineers lost influence in the political sphere. A study of Norwegian public committees between 1972 and 2018, showed that economists alone constituted 23.1% of all academics in the committees, while engineers contributed 3.9% (Hesstvedt, 2018).

2.3 Motivation

Motivation is commonly divided into intrinsic and extrinsic motivation. Intrinsic motivation is connected to the enjoyment you get from a task, extrinsic is connected to an external reward (e.g. monetary). Interest is also connected to intrinsic motivation (Weber, 2003).

Studies over time and in several fields have shown that intrinsic motivation is positively correlated with better quality of work, but that extrinsic rewards may be counterproductive (Amabile, 1993; Bowles & Polania-Reyes, 2012; Deci, 1972; Glucksberg, 1962).

2.4 Introduction to the Engineering Profession

The three-year engineering education in Norway has been held to a national standard via a national curriculum that different educational institutions have had to adhere to (Kunnskapsdepartementet, 2018), and followed by national guidelines. In 2011 the guidelines were reworked, and one of the new items was the 10 ECTS-credits first year course “Introduction to Professional Engineering and Ways of Working” (National Council for Technological Education, 2011, p. 37). Most institutions eventually found the name a bit cumbersome and opted for shorter versions. Throughout this text I will use “Introduction to the engineering profession”.

The purpose of the course was that “exposing students to the whole range of engineering promotes a comprehensive, open, and curious approach to learning, and will motivate the students” (National Council for Technological Education, 2011, p. 37). Experiences with a course that was to a certain extent filled with topics like ethics, society and history of technology, have however been mixed. Thorvaldsen and Henne (2017, p. 158) describe teaching experiences where students’ expectations of “usefulness” connected towards their professional identity as budding engineers came in conflict with the more Bildung-oriented topics of the course.

3 METHOD

3.1 Thematic analysis

The data from this survey are mainly qualitative, but they are on the rather brief end of qualitative replies. In analyzing the data, I will use thematic analysis as a method, as discussed by Braun and Clarke (2006), searching for recurring themes or patterns within the data, and organizing and interpreting these patterns.

A theme in this context should both be capturing something important about students’ motivations and be recurring in a sense that makes it meaningful to consider it *patterned*. The analysis will give a description of the data set as a whole, but also provide more detailed and nuanced descriptions of themes of particular interest. The analysis will be theoretical in the sense that it will make use of the categories of intrinsic and extrinsic motivation, but within these categories the search for themes will be inductive.

3.2 The composition of the student group

As a consequence of the merger between three university colleges and NTNU, the course was in 2019 for the first time run in the same way across all study programs and campi (see Table 1), and I taught parts of the course to all ~1100 first year engineering students.

Table 1 Number of students in different study programs and campi. To complete the grid, data is combined from different sources counted at different times, both contacting individual administrators, comparing student lists and collecting data from the LMS so numbers will not add up exactly, but the overall picture will be correct.

Engineering study program	Campus Gløshaugen	Campus Kalvskinnnet	Campus Gjøvik	Campus Ålesund	Total
Construction		117	64 + 17 online	63	261
Data		92	39	54	185
Electro	168		35	54	257
Renewable	71		20	16	106
Mechanical	86		27+21 online	17	151
Ship design				6	6
Material technology		31			31
Logistics	59				59
Chemistry		40			40
Geomatics			11		11
Total	384	280	234	210	1108

3.3 Surveys

I used this opportunity to do a survey of all students (who attended the lectures) on a campus basis, using the student response technology iLike, enabling anonymous both open text- and multiple-choice questions.

First, the students were asked to answer in open text “Why do you want to become an engineer”? After that they were given a short introduction to the background of the course, via the following excerpts from the National Guidelines for Engineering Education (National Council for Technological Education, 2011, p. 37)¹:

The students are to get an insight to the **analytical, structured, goal-oriented, and innovative** work engineers do, and they must learn the importance of being conscious of the consequences technological solutions generate from a **social, environmental, and ethical perspective**.

[...]

Relevant topics that may contribute to meeting the learning outcomes include: **project work, writing reports, presentation techniques, history of technology, ethics, health, environment and safety, life cycle analyses, project economics, laboratory work...**

The students were then asked to discuss two and two, for two minutes what topic(s) are the most important for an engineer to know about apart from science and technology and give individual open text answers.

¹ Highlights in the quotes are mine. The students were given these sections from the Norwegian language version of the guidelines.

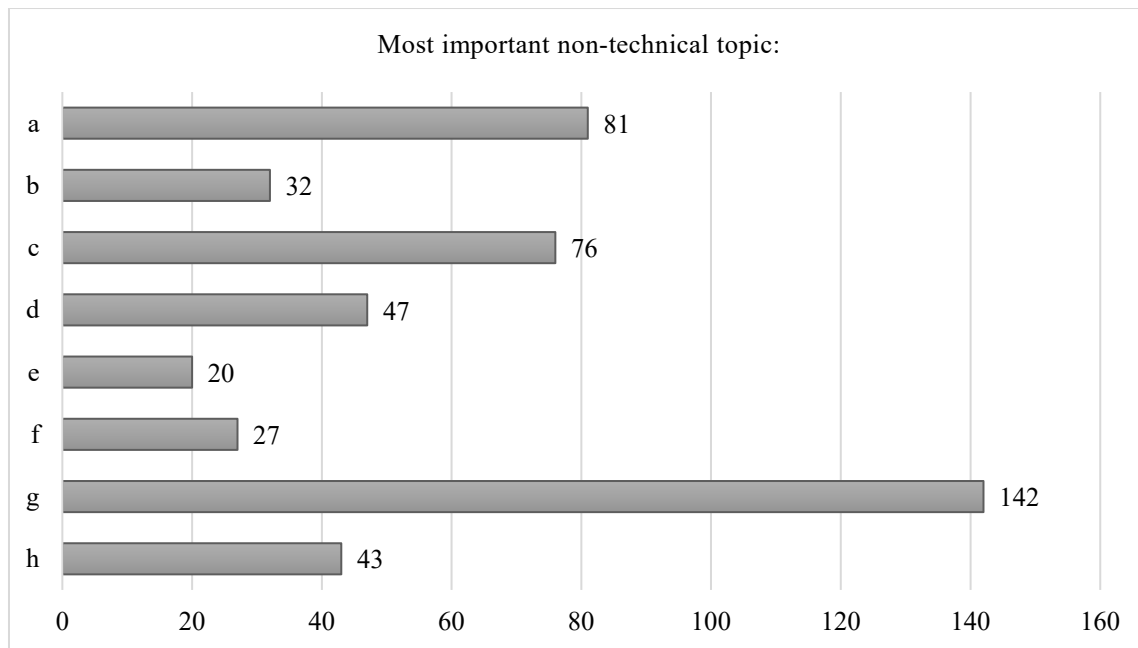


Figure 4: Students responses to which of 8 topics from the course curriculum they considered most important for engineering students ($N=468$). a) Climate / Environment, b) History of technology / science - long perspective, c) Recent history of technology / science (technological revolution ->), d) Scientific method, e) Pseudoscience (how to reveal), f) General ethics, g) Technology and ethics, h) Workplace ethics.

Here we have subdivided the ethics-category and we can see that the topic deemed by far the most important is Technology and ethics. The second and third most important subjects are Climate / Environment and Recent history of technology /science respectively, however these two are very close. There is little discrepancy between campi apart from one campus (Gløshaugen) switching 2nd and 3rd place. However, g was number one and g, a and c top three on all campi.

5 DISCUSSION

From the first question we can identify that 89 % of engineering students report forms of intrinsic motivation. This is good news, as intrinsic has shown to consistently provide better results than extrinsic motivation.

An intrinsic motivation for becoming an engineer, does however not necessarily imply an intrinsic motivation for the Bildung-related content in the “Introduction to the engineering profession” course. As we have seen much of their intrinsic motivation is connected to the job as an engineer. This is also in line with the referred previous research (Thorvaldsen & Henne, 2017). It would follow that an important success factor for the Bildung-related topics about different aspects of society, is to connect them to the engineering profession.

The fact that “ethics and technology” was deemed by far the most important subject by the students support this idea. Their engagement with ethics in general and workplace ethics (which is also work-oriented) is much smaller. The ethical dilemmas that are based on technology are the most effective gateways into discussing ethics.

As few aspects of our society are untouched by technology, this should enable teaching Bildung-oriented topics to engineering students based on their professional identity of engineers.

To further this discussion, we can look closer into the responses to see where such connections between engineering and Bildung-oriented topics could be made for the overarching subjects of the course. In analyzing the focus on developing, creating etc. that is prominent in many students’ motivations for becoming an engineer one might form the question: Could the key to *Bildung* for engineers be in *building*? Their motivation for building and creating could be expanded into not only building a machine or a structure, but to (contributing to) building a society - a perspective we can see already is prominent among a large minority of the students.

As we have discussed this is not an image of the engineer without precedence. Both in Norway and internationally the image of the engineer as a builder of society and a brighter future for all was prominent until a few decades ago. As part of the course is about history of technology, it thus makes sense to teach this aspect of the history of the engineering profession and promote critical discussions around the contributions to society of different professions historically, and in the present.

Based on the data from this survey, this seems the most promising path towards bridging the gap of perceived lack of “usefulness” some teachers struggle with in teaching these and similar Bildung-oriented topics to engineering students.

In developing bachelor engineering education, one should however also be careful not to make the education too academically oriented, keeping in mind the large subgroup of students who appreciate the mix of theoretical and practical work.

6 SUMMARY

Engineering student’s motivations are heavily connected to their profession, while many express some extrinsic motivational factors, 9/10^{ths} report some form of intrinsic motivation, and 1/4th a wish to contribute to society. Topics of building, developing and creating are recurring in the students replies, and along with their general profession-oriented attitude, this makes it meaningful to build on the image of the engineer as a builder of society in making Bildung-related topics relevant to engineering students. In doing so an engineering education could be developed, where students see themselves at citizens, also in their professional roles.

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