



EFFORTS TO IMPROVE ATTRACTIVENESS OF LOWER LEVEL ENGINEERING EDUCATION (CONCEPT)

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ABSTRACT

There are nine study programmes awarding the degree bachelor in engineering (högskoleingenjör) at the University of Gävle. Some of these have only a few applicants, even though the graduates are appreciated by a relatively large regional primary and secondary sector industry.

A major revision of the programmes is planned. One objective is to increase the attractiveness of the programmes. In the revised programmes, students are proposed to study most courses together during the first year of study, even if they belong to different engineering specializations. This is intended to improve the study environment. Students in programmes with low numbers of applicants will become part of a richer and livelier student collective. However, the attractiveness could further be problematized by asking to whom higher education is attractive. A special focus will be on increasing the admission of students from groups in society that have been underrepresented in higher education. More specifically this may be linked to individual factors such as the educational level of parents, family income,

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immigrational background and geography. There may also be societal explanations in traditions of gendered professions. Engineering programmes, and especially some of the specializations at the university, are dominated by male students.

This study focuses on how universities can take action to further increase the attractiveness of the engineering programmes, with a special regard to groups that are known to be underrepresented among the students.

1 INTRODUCTION

1.1 The growth of technological education in Sweden

In Sweden, the question of who or which groups in society are given the opportunity to take part in higher education, has a long tradition. For example, a governmental report 1965:11 stated that the number of students in tertiary level education at the three existing institutes of technology should increase from the 2001 admitted students in 1964 [1]. According to Statistics Sweden (SCB), there were 12051 admitted students in 2018, of which 4195 were students for a bachelor degree in engineering. The development of the proportion of the population has increased steadily. In 2020, 44.6% of the population between 18 and 64 had a degree in higher education [2]. It is above the OECD average (38.6%) but lower than countries such as Canada, Japan, and South Korea which are above 50% [2]. At the same time, there is also an objective to broaden participation in higher education. This has also a long history but the development has intensified in recent decades. Not least, the amendment to the Higher Education Act 2005 has clearly stated this change [3]. It stipulates that higher education institutions "actively promote and broaden recruitment to higher education". This is also connected with more general formulations in, for example, the global goals for sustainable development. This type of issue is also raised in the Bologna reform for a consolidated education platform within the EU. The London Communication 2007, for example, states that "the student body entering, participating in and completing higher education at all levels should reflect the diversity of our populations" [4]. In the bill text (Prop. 2001/02: 15), several measures are proposed that the higher education institutions should take to affect the new law. There are ideas about establishing local action plans, increasing the number of preparatory educations (so called "basical years", complimentary courses to secondary education programmes), increasing the number of distance education, enabling lifelong learning, and more. The purpose is stated as "to increase diversity and reduce social bias in recruitment" (Prop. 2001/02: 15). However, similar objectives already existed in the major higher education reform in 1977. In the new Higher Education Act of 1977, the objective was "to promote social equalization and increase access to higher education" [5]. An important part of the reform was to transfer several different post-secondary educations to the higher education sector. Among them are teacher and nursing educations that came to be those that included the large educational cohorts. However, the technical education



took on a different design. The technical education remained in the upper secondary school, having a duration of four years and leading to a high school engineering degree. As a complement, a two-year technical post-secondary education was developed that would lead to a university degree in engineering. These educations were placed in several newly established smaller colleges outside the traditional university cities (Prop. 2001/02: 15).

In summary, there are two parallel objectives for universities regarding admission to engineering programs. One is an increased number of students in total and the other is that these students should have a more heterogeneous background.

1.2 Previous studies of attractiveness in a national context

Programmes in engineering are known to attract mainly male students. The Rose project investigated attitudes to learning science and technology in several countries [6]. The results show that there is a big difference between boys and girls. In Sweden, almost 60% of boys express that they want to work with technology, but less than 20 % of girls. The situation is similar in other wealthy countries. This corresponds well with national statistics presented by Royal Swedish Academy of Engineering Sciences [7]. In 2016, only 25% of the admitted students at bachelor of engineering programmes on a national level were women. In certain specializations, e.g. chemical engineering, there are more than 50% women, but others have far fewer, e.g. specializations in electrical, mechanical, and computer science engineering, which all had less than 10% female students on a national level. In 2022 a thorough examination of broadening participation was published by the Swedish Higher Education Authority [4]. This study continues to pin-point at the lack of equality in recruiting students. The report also broadens the scope of attractiveness by addressing oblique recruitment of more social issues such as immigrant background, parental education level and geography.

1.3 Engineering education at University of Gävle

University of Gävle offers programmes on the level of bachelor in engineering. There are presently nine such programmes. The programs are often developed in close relation with industry and are given in Swedish. The level of internationalization in the programs are therefore low. The main rationale for the supply of programmes is to provide regional business and industry with qualified competence. However, many of the programmes have only few applicants, implying difficulties for the education as well as recruiting problems for the companies that employ the graduates.

In Swedish, the name of the degree is *högskoleingenjör*. This is a first cycle degree (undergraduate) awarded to students after three years of dedicated engineering studies. The programs normally extend over three academic years, i.e. 180 credit points (cr) according to the ECTS (European Credit Transfer System).

Our engineering programs aiming at the degree of *högskoleingenjör* correspond to what in Anglo-American countries sometimes is called bachelor of engineering in <major> (B.E. in <major M>) and sometimes bachelor of science in engineering (B.Sc.E. in <major M>).



The framework is regulated by the Swedish Higher Education Ordinance (1993:100), Annex 2 – System of Qualifications [8]. However, the scope or specialization of the studies is to be decided locally at each university. At the University of Gävle, the major field of studies of these programmes comprises a minimum of 90 cr, including a 15 cr degree project. Depending on the field of studies, the curricula include 15-37.5 cr of mathematics. The remaining third of the study programme includes relevant courses required to give the student the knowledge and skills required to work autonomously as a graduate engineer in their respective fields.

1.4 Rationale for the work

At the University of Gävle, there is an ongoing strategic revision of education. Regarding all existing study programmes, the following perspectives are focused: (1) attractiveness of the programmes in terms of number of applicants, (2) the capacity for the University to offer a complete study environment in the subject, from undergraduate to Ph.D. level, and (3) utility of the study programmes in terms of demands from society and employability. In the revision, all bachelor in engineering programmes at the university have been suggested for a major reform, with the objective to strengthen connection to research and improve student recruitment. A desire that the number of engineering programmes should be reduced has been expressed.

The authors of this paper are all involved in reforming the engineering programmes. In this paper, we focus on attractiveness. We wish to elaborate on what can be done to improve student recruitment. Our purpose of presenting this at SEFI is to share experiences with others who are interested or involved in similar situations or processes.

Attractiveness could be problematized by asking to whom higher education is attractive. Initially, the authors took a broader approach when studying admission data of students from groups in society that traditionally have been underrepresented in higher education. More specifically this is linked to individual factors such as age, the educational level of parents, family income, immigrational background and geography. However, the pre-study concluded that in these cases the University of Gävle did not stand out in comparison to other universities in Sweden. Although showing skewed distribution, it was not different from society as a whole. However, one criteria stood out as slightly different and interesting to further elaborate on. This was gender and the attractiveness for female students to choose technical disciplines. Gender issues may be interesting, as several of the programmes have a very low proportion of female applicants.

2 METHODOLOGY

2.1 Measuring attractiveness

Attractiveness depends on many factors and can be measured in different ways. A review is presented by Widiputera et al. [9]. In our context, in order to effectively monitor the present situation and the future development, we have chosen to focus

on three measures: Limits regarding admission, number of applicants, and presence of underrepresented groups, in our case women.

In Sweden, a commonly used measure of attractiveness of study programmes is the limits regarding admission. These limits concern the grades for students coming from upper secondary school as well as results from the Swedish Scholastic Aptitude Test (SweSAT), in Swedish *Högskoleprovet* [10]. The limits are defined as the lowest score among the admitted applicants. The values of previous years are of high interest to prospective students and they have an impact on what programmes students choose. The values are often seen by students as an indicator of the status or quality of a study programme. Students tend to apply for programmes where they get “use” for the grades or results that they have received.

The number of applicants is another significant measure of attractiveness. In cases where all applying students are accepted, the number of admitted students equals the number of applicants. As the number of admitted students may be restricted by other factors unrelated to attractiveness, we argue that the number of applicants is a more valid measure of attractiveness than the number of admitted or enrolled students. This measure is more important for the study environment and the economy of the education than the above described limits regarding admission.

Attractiveness can also be measured by what groups of students that are attracted by a programme. A way of increasing attractiveness, in this sense, would be to attract groups of students that are underrepresented on the programme. If only the gender balance is considered, this measure may be represented by a value, e. g. the percentage of women.

2.2 Data collection

To monitor attractiveness of the bachelor in engineering programmes at University of Gävle, we have examined data from the Swedish Council for Higher Education (UHR), Statistics Sweden (SCB), and the local university administration. These data are publicly available and can provide a picture of the present state and a point of reference for future comparisons when we wish to evaluate implemented efforts to increase attractiveness. In some cases we have used data only for 2021, but to get a more solid background description regarding women, we have used data for 2008-2021.

3 RESULTS

3.1 The present state

Regarding the bachelor in engineering programmes at University of Gävle in 2021, all applying students that fulfill the requirements were admitted. This implies that the study programmes presently don't have limits regarding admission, and thus are likely to be perceived as low status. In order to increase attractiveness, a first goal could be to obtain values for the admission limits. This would require that some, or at least one, applicant is rejected. If the University chooses to take actions in this

direction, we hope to be able to elaborate these ideas and study the effects on attractiveness in a future paper.

The engineering programmes at University of Gävle have few students. The numbers of admitted students are presented in Table 1. Several of these students are admitted through the preparatory educations (“basical year”), which implies that they don’t contribute to providing the programmes with limits regarding admission, as described above.

The third column of Table 1 presents the percentage of women on average during the period 2008 - 2021. A star (*) after the percentage of women indicates that two different programmes have been offered during the period. In these cases, the value represents the average for students from both programmes.

In the fourth column, the number of years that the programmes have admitted two or less female students is presented. In parentheses, the number of years that the programme(s) have been offered is presented. That is, for the programme in Automation engineering “9 (of 10)” means that the programme has been offered for ten years during the period, and during nine of these there has been at most two female students among the admitted.

Table 1. Number of admitted students, percentage of women, and number of years when two or fewer female students were admitted to the bachelor in engineering programmes at University of Gävle.

Study programme	Students admitted in September 2021	Percentage of women, average during 2008 - 2021	Number of years with two or less women admitted
Industrial Engineering and Management	26	35%	0 (of 2)
Automation Engineering	9	10%	9 (of 10)
Building Engineering	49	33% *	0 (of 14)
Computer Engineering	43	11%	7 (of 14)
Electrical Engineering	12	14% *	9 (of 12)
Energy Systems Engineering	26	23% *	1 (of 12)
Environmental engineering	20	57% *	0 (of 5)
Land Management and Engineering	11	21%	3 (of 4)
Mechanical Engineering	25	15%	7 (of 14)

3.2 Findings in existing data and proposed actions

In the revision of education at the University, we have so far investigated the situation, identified problems, and started suggesting possible solutions. The reformation process will probably go on for some years. We will here share some of our findings.

Table 1 shows that the number of admitted students in 2021 varies between 9 and 49. Seven of the nine programmes admitted less than 30 students. Here, the value 30 is chosen arbitrarily as it represents a typical class size in some contexts. During the education, several students quit their studies prematurely. Most that quit do so during the first year of study. This implies that classes in the programmes will be small, unless students from several programmes can participate in the same courses. In the present programmes, many courses are associated to a unique programme. In the reform of the engineering programmes, we propose that the revised programmes would share courses to a large extent especially during the first year of study. This would provide a richer and livelier study environment.

A low number of students in connection with an uneven gender balance may worsen the difficulties for the minority. In table 1, the third and fourth columns indicate that 25% women seems to be a suitable limit in this context for when there is a risk of having two or less women admitted to a programme in a year. In our context, six of the nine programmes have an average of less than 25% women. As seen in the fourth column, there are two or less women among the admitted students in half of the years or more frequently when there are 15% women or less. In these situations, a woman has at most one fellow female student, which is a vulnerable position as the risk of being left alone is obvious, temporarily due to e.g. illness, or permanently if the fellow female student quits. In many of these cases, the woman is the only admitted student from the start of the studies, or there is actually no admitted female student. Larger classes would help to build a more sustainable study environment for women, where the risk of being alone is smaller. Therefore, class sizes matter. If women would feel less vulnerable, the gender balance may improve, which could further reduce the risk for women to be the only female student in class and improve the study culture regarding gender equality in the programmes. This could further increase the attractiveness of the programmes, for both men and women.

3.3 Conclusions and a proposed rule of thumb

Higher education in Sweden today has a clear goal to increase broader participation. This is about increasing the attractiveness of education for groups that have traditionally been outside of higher education. The rationale of this may be linked to both societal and industrial needs of competence development but also from a more democratic stand point that participation in higher education should reflect the constitution of the general population as a whole. Focus in this study has been to examine the gender distribution between different engineering programs at the University of Gävle. In order to increase attractiveness in the sense of broader participation, all programmes should strive to attract men as well as women.



One proposed action is to share courses between different engineering specializations. We have been working with an idea that a majority of courses in the first year of all engineering programmes are shared. It may contribute to a livelier study environment and improve economy, but it may also contribute to more gender balanced study courses. It reduces the risk of being the only female student in class.

We can observe two significant limit values in the average percentage of women. The first limit is 25% women, below which we can see a risk for having two or less admitted women on a study programme in a year. The second limit is 15% women, where having two or less admitted women on a study programme seems to be the normal situation, occurring at least every second year.

We must point out that these limit values depend on the number of admitted students. However, it may still be useful to keep these values in mind as a rule of thumb. The values are easy to obtain which is an advantage if they are to be used as indicators. They may guide e.g. programme directors and directors of study for when care must be taken regarding admission and gender equality.

We propose the following formulation as the rule of thumb for when actions regarding course sizes may need to be considered:

- When there are 25% women on average on a programme, the risk arises that women may be left without fellow female students.
- When there are 15% women, they are often left without fellow female students.

This model, or rule of thumb, will also provide a scheme for evaluating the need for more changes within the study programmes.

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