

Engineera

How a programme for female students of Electrical Engineering and Information Technology leads to valuable industry cooperation

Y. Jeanrenaud

Dr.

Technical University of Munich, Gender Studies in Science and Engineering
Munich, Germany

E-mail: yves.jeanrenaud@tum.de

S. Ihsen

Prof. Dr.

Technical University of Munich, Gender Studies in Science and Engineering
Munich, Germany

E-mail: ihsen@tum.de

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INTRODUCTION

The student tutorial for female students in the department of electrical engineering and information technology of the Technical University of Munich (TUM) called “Engineera” was established nearly a decade ago, in 2007. It consists of excursions to industrial partners, practical projects, information events and discussion groups. This paper aims to present the motivation, goals and methods. Furthermore, the article will highlight the cooperation with firms from electrical engineering within the Engineera-tutorial and their impact on the tutorial’s performance.

1. ABOUT ENGINEERA

1.1 Goals and Motivation

Engineera was established in 2007 as a tutorial for female students of electrical engineering and information technology at the Technical University of Munich (TUM). It was set up as a strictly single-sex education whereas only female students are allowed to take part. This decision is justified via research which has shown the significant benefits of single-sex education for fields where one gender is underrepresented, especially in STEM education [1]. This approach promises to make gender specific self-knowledge and ability-self-concepts from the students themselves less accessible and therefore makes it easier for them to attribute their work, performance and success to themselves instead of their gender (e.g. [1], [2]).

Female students from all semesters may participate in the Engineera tutorial on a voluntary basis. During a semester, various activities are planned by the two female student tutors. They are supervised and guided by a teaching assistant at Gender Studies in Science and Engineering. The students themselves may opt in for every

individual activity during the semester on a volunteer basis without any obligations. Therefore, they do not get awarded ECTS credits. There are usually up to six activities in each semester comprehending excursions to firms related to the various study programmes of electrical engineering and information technology located in Munich and nearby towns. Furthermore, there are practical projects offered by the Engineera-tutorial for example building and programming LEGO® Mindstorms® educational robot kits or soldering small gadgets such as solar powered LED torches. Another important aspect of Engineera are their information evenings, discussion group and fireside chats. For these events the student tutors invite women engineers from academia or industry to talk about their professional experiences.

The tutorial wants to offer female students of electrical engineering and information technology a vast network with other students as well as female engineers. Additionally, its long-term objective is to keep female students in a male dominated subject.

The female tutors and a research assistant organize and maintain the tutorial. Both tutors are enlisted in electrical engineering and information technology whereas the research assistant is from Gender Studies in Science and Engineering. The tutorial programme itself is financed by reoccurring study grants funds. These finances have to be requested every year and are subject to evaluation.

1.2 Methods

The tutorial is based on mentoring and education-by-peers models [3] in order to increase the low percentage of female students in engineering fields (about 23.2% in 2013 [4]). This is also a goal for the department of electrical engineering and information technology at TUM which has only 14.6% female students enlisted in last winter semester [5]. One of the key factors to keep students in their fields, especially in engineering studies, is networking among peers [3] which is why the Engineera tutorial was installed in the first place.

As a technical university, the TUM accentuates the practical relevance of the knowledge taught and the hands-on skills included in her education. Because women tend to have less experience in tinkering, DIY and repairing [6] than men, hands-on experience besides the study programme is highly appreciated and therefore offered by the tutorial. Furthermore, hands-on experience help the students to improve and maintain a self-confident image of themselves also being capable of dealing with these topics their male colleagues talk about.

As core method the tutorial builds upon peer education. Students are empowered to teach other students about their specific knowledge, experiences and insights [7]. Two students from electrical engineering and information technology and a research assistant from Gender Studies in Science and Engineering organize and realise the events. The scientific employee helps the tutors in organisational and pedagogic means. This interdisciplinary approach has proven as the ideal combination of technical and methodical background [8].

The tutorial is on a voluntary basis and the students can decide which event is of interest for everyone. No registration is needed, but the students can put themselves on an e-mail list so that they get informed about upcoming meetings. On the other hand, the events are also announced on the institute's website and via Facebook. Later is to reach the students easier in their daily online environment. Also colourful posters are designed and produced for each event and distributed all over the university whereas female students are most likely to be reached. Due to limited amount of available seats or cooperating firms who need to know about the amount of non-

employees on their grounds, specific events might require to send an email to register prior to these events.

A typical semester is structured as follows: about every other week a meeting takes place in the evening when other classes are over, except for the excursions which may be a full working day or mornings, depending on the location of the firm and the firm's opportunity.

The first Engineera event of every semester is always introductory. Here, students are informed about the tutorial and the upcoming events. The following events thereafter do differ each semester, but at least one excursion and one practical project is included every time. It depends mostly the dates that firms provide for excursions which are aligned with regards to the classes of the students if possible. Excursions to firms are closely coordinated with specific contact persons within the firms. These firms are from the fields of electrical engineering and/or information technology and usually located in nearby towns or in Munich itself to keep travel time short and costs low. Examples for such firms would be MAN SE, KuKa AG, BMW AG, National Instruments Germany GmbH, Infineon Technologies AG, Rohde & Schwarz GmbH, Daimler AG and Texas Instruments. Most firms have been contacts to Gender Studies in Science and Engineering for a long time. Others come from the networks of the students or their relatives as well as requests by the students participating in the tutorial themselves.

In winter semester, the practical project usually is a soldering project. The tutors check up on electrical projects that might be realised within a few hours. After manufacturing a prototype the instructions are compiled consisting of a Power Point presentation as well as handouts. For the soldering project, two or a maximum of three appointments are scheduled. The circuits are explained on a basic and in-depth level before the soldering and other work begins. Examples for these projects are: a liquid crystal display with control board, solar cell operated LED torch, a binary dice.

Every summer semester, Engineera offers a hands-on project where students have the opportunity to improve or even earn their first programming skills by using LEGO® MINDSTORMS® robot kits. These projects are installed to deal with the somewhat implicit demand towards electrical engineering students to have at least basic programming skills even though the curriculum at TUM does not justify the need for these, at least in undergrad studies. The LEGO® MINDSTORMS® robot kits used in the Engineera tutorial are derived from Fraunhofer "Roberta" kits [9]. For this, a programming language derived from C is used, which is introduced in the first evening session of three up to four hours where the robot models are built, too. The following sessions deal with finding solutions for specific problems, e.g. avoiding random obstacles while communicating with other robots in the field via infrared beams, and programming these into the robots software.

The other events usually also take up to four hours and take place in the evening:

A discussion group event consists of a podium of two or three female engineers from various industries linked to the study programme. They introduce themselves and their professional background and talk about the occupational development of engineers. Furthermore a Q & A session finishes the event. These events help the participating students to grow their networks further and get early contacts to industry. Most important for students has shown to be the direct contact to role models, so that they may realize their own future professional situation.

Information events are based upon prior suggestions by the students. These questions might be on how to prepare for a certain exam or even on specific knowledge, techniques and skills linked to the studies. The tutors try to answer and discuss these questions or invite persons connected to the topics for these evenings.

Similar networking events are being held, whereas the topics might be e.g. study funding, career and family perspectives or internship abroad, where the students and the tutors discuss their estimation and thoughts.

For didactics, Engineera tutorial bases on inputs to introduce the various topics by presentations and hand-outs, but as students' independent contributions are highly desired the focus always is on hands-on and/or discussion. This helps to improve the independence and self-confidence of the female students.

1.3 Evaluation

The tutorial is evaluated every semester in a standardised online questionnaire which is anonymous and voluntary using EvaSys [10]. The items aim to evaluate all areas of the tutorial and to identify strengths and weaknesses of the semester bygone. All questions are graded by a five-point Likert-Scale [11] from 1 (very bad resp. completely disagree) to 5 (very good resp. completely agree). Besides these scales, there are free text fields to capture the students' expectations towards the tutorial. This helps the organizers to improve the individual events and the tutorial as a whole in a sustainable manner.

During the semester course, between 20 and 40 students participate in the tutorial. Some students also take part of Engineera events several semesters consecutively. The following data show as an example the evaluation results for summer semester 2015. A total of ten of the 26 students participating in the tutorial during the semester completed the survey. All of whom were studying in electrical engineering and information technology at Bachelor's level. Nine students were in the second semester, one in her fourth.

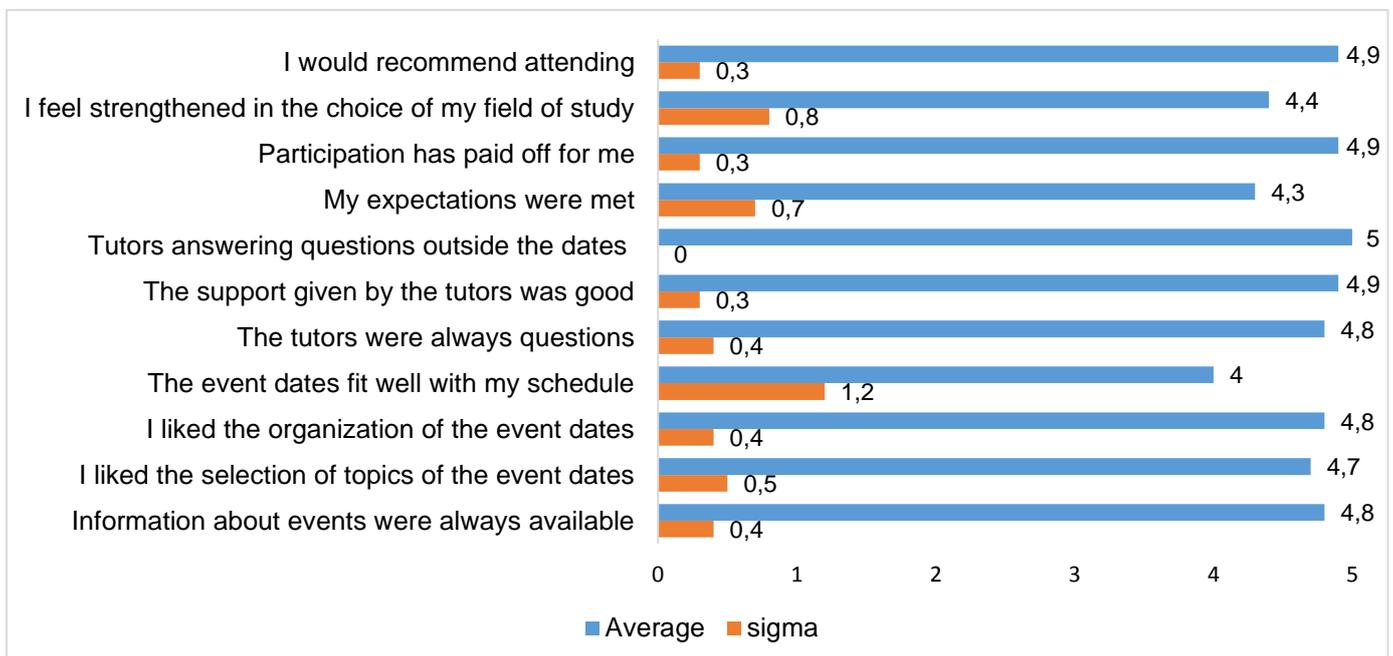


Fig. 1: Results of the evaluation for Engineera for the summer semester 2015 (1="very bad", 5="very good", N=10)

As figure 1 above illustrates, the semester was rated very good by the participating students. They heavily recommend attending the Engineera tutorial and think it paid off to attend the tutorial, both in average with 4.9 out of 5 points and a relatively low root mean square derivation (σ) of 0.3. Also the participating students' expectations

were met very well with an average of 4.3 and a sigma of only 0.7. The most controversially rated within the evaluation was the fitting of the event dates with the students' individual schedules. But here still the average is with 4.0 very good and a sigma of only 1.2 does not weaken it that much. The students also liked the organisation of the events, the selection of the topics for them and the support by the tutors a lot (4.7 to 4.8 averages and sigma 0.4 to 0.5). Of most interest is the assessed impact on the students' individual confidence to have chosen the right field of study for them. Here, an average of 4.4 with a sigma of 0.8 is also a great result justifying the tutorials concept and approach as an affirmative action. The major expectations voiced by the students towards the Engineerera tutorial are listed below:

- "Insight into firms"
- "Networking with students of higher semesters"
- "Developing/strengthening a corporate feeling"
- "Get to know other female students of electrical engineering"
- "Practical experiences relevant for the studies"
- "Insights into the professional environment"

As side effect of the tutorial the students participating in the Engineerera tutorial also take part in other elective courses offered by Gender Studies in Science and Engineering such as the single-sex course "life and career planning". This might advocate for the topics and methods chosen for the tutorial being highly relevant and suitable for female engineering students at TUM.

2 INDUSTRY COOPERATION

2.1 Types of cooperation

Firms in electrical engineering and information technology are interested in recruiting female engineers because of the forecasted demographic change and skills shortage in these fields but also because of the innovative effects of mixed teams [12]. This may also motivate them to offer support for the tutorial by excursions and sponsorships.

For the Engineerera tutorial, there are four types of industry cooperation:

1. Contacts to firms for excursions
2. Industrial guests for discussion groups and networking events
3. Industrial invitations to Job fairs and industrial fairs
4. Sponsorships

Most of the contacts grew over the years and are stable relationships to TUM and the professorship. Some other companies get into contact by their HR offices because they offer early recruiting programmes and maintain a relationship from the firm to students in order to show their attractiveness as future employers. A third group is checked up and contacted because of the students' suggestions.

Guests for discussion groups and networking events are on one hand derived from the firms where the tutorial does excursions to. On the other hand, contacts from the students and from the network of Gender Studies in Science and Engineering are represented here. There are also some former tutors who are now following a successful career in the electronic engineering industry who are invited for the discussion groups and networking events from time to time.

Job fairs and industrial fairs are a way for Engineerera tutors as well as participating students to act as multipliers and role models themselves. They attend fairs or even join podiums on them to discuss and inform about women in the electrical engineering professions and try to break up some stereotypes.

Sponsorship by firms is a way of financing or donating material and goods which may otherwise be hardly or even unavailable in the tutorial.

2.2 Impact

One of the strong motivations of female students to join Engineera is their chance to meet female engineers more than once during their studies. This links the programme to industry co-operation. And one of the strong motivations of industry to support Engineera is the link to future female engineers. The students learn a lot about industrial thinking and industry learns a lot about recruiting and personnel development female future engineers. The most direct impact of industry cooperation with the tutorial Engineera may be observed for the sponsoring. This support is not exclusively financial and enables Engineera to offer a broad range of different events and projects each semester. Also the excursions are only possible via industry cooperation and proven to be crucial for the tutorial. They are very welcomed by the participating students and the firms are warmly receiving them as well. These contacts, which then pass on from the tutors and the professorship to the students led to various ongoing benefits for both sides. Examples would be students doing internships or working on their thesis at the firms as well as joining the firms' workforce after their graduation. All this is enabled by the close cooperation of the tutorial to the firms.

3 CONCLUSIONS

The tutorial is a very successful format co-created by female students of electrical engineering and information technology. It enables female students at TUM to network with women from higher semesters as well as female engineers from industry. Both networking opportunities highly contribute to an increasing motivation for the study fields and orientation aid, especially for first semester students. Aside, it sensitises the department of electrical engineering and information technology for the belongings of women in engineering study programmes: The evaluation results are reviewed by the dean every semester and the yearly report is part of the application for funds. Every personal change in the decision making board initialises discussions about the necessity of women-only programmes and the situation in the own department. Even though the developers of the tutorial have to discuss therefore every second year about gender balanced education in engineering education.

The results presented in this paper may be limited to the extent of single-sex education where possible, as not all universities and/or engineering departments may be willing to implement such programmes. Furthermore, it is limited within its scope upon a technical university in Germany with its peculiar environment in regards of engineering culture [12] and job market [13].

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