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A Workplace Equality Workshop for the Control Engineering Classroom

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Abstract: Engineering, in general, is a non-diverse profession around the globe. Women are one group of minorities in engineering. Despite the fact that control engineering is heavily based on mathematics, which has a larger number of female students, it has the same proportion of women as other engineering disciplines. To address the issue of low female participation in engineering disciplines both at university and, more importantly, in career, we have developed a workshop that can be carried out in a 90-minute-lecture in the classroom. In this paper, we first explain the context and need for such a workshop and then present the contents of the developed material as a resource for colleagues in the control engineering community.

Keywords: Control engineering education, diversity and inclusion, gender, equality

1. INTRODUCTION

After graduation, students should expect an equal workplace environment. However, this is still not the case despite many companies publicly committing to better gender equality at all levels (Barton et al., 2015). The gap remains wide and open, and it is clear that this is a complex problem with many facets contributing to it. Women and minorities have negative experiences or are side-lined in their careers.

Diversity is beneficial to everyone. The business case for diversity is well established, researched, and documented, see for example https://www.raeng.org.uk/diversity-in-engineering/business-benefits-key-facts/the-business-case-for-diversity. We refer to the literature (Robinson and Dechant, 1997; Herring, 2009).

While many women have an excellent career in engineering and never experience discrimination in any form, many systemic challenges in the work environment have been reported (RAEng report, 2016). In particular, the gender pay gap is a topic that has been highlighted in recent years. Forced publication of salaries in countries like the UK have revealed that women often get paid less for the same work (Blau and Kahn, 2003).

So why conduct a diversity workshop in the control Engineering classroom? While there are programs in many universities, such as the authors' academic institutions, these programs are addressed to first- or second-year students to ensure a good environment at the university. Later in the curriculum, students are focused on specialised technical subjects. However, the more advanced students are about to start their professional careers. The students may also have experienced their first working stint in the form of an internship or part-time job.

Including workplace equality is particularly important for engineering students, who sometimes are not as exposed to soft skills as other disciplines and are often unaware of issues outside the engineering domain. Moving this into the classroom makes it clear that diversity and inclusion are items that students need to be familiar and comfortable with when they enter the work environment.

In particular, the pandemic has worsened women's situation (Madgavkar et al., 2020). Now more than ever, do we need a clear and open-eyed guidance on how to make the workplace inclusive for everyone.

In this paper, we describe the material of a workshop that can be conducted as part of the undergraduate control engineering course. We hope it inspires other control engineering lecturers to carry out a similar workshop with some of the material provided here. The aim is to prepare students entering the workforce to contribute to an equal environment and recognise situations that undermine this.

We carried out the workshops in combination with a career talk by a guest lecturer (in our case, one author while the other author acted as moderator), not necessarily by a person with a diverse background but certainly with a colleague who is aware if not involved in diversity and inclusion initiatives.

2. WORKSHOP CONTENT

Before diving into the workshop's contents, we first describe the circumstances. The workshop was conducted several times as part of a 90-minute lecture of the control course module at Lund University and at HAW Hamburg. The material was slightly adjusted for each iteration. Here presented is the version of the last workshop, which by no means is not the final version. As long as there the workplace

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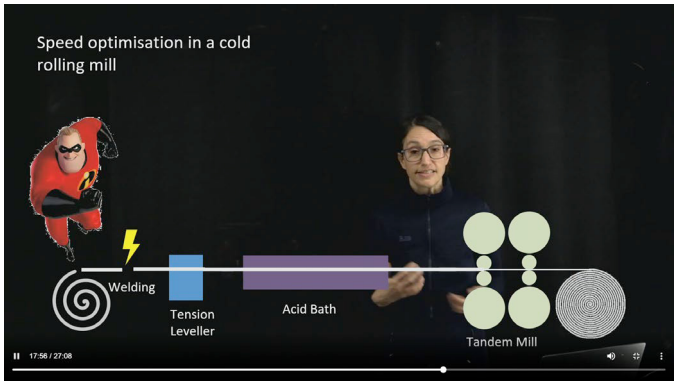

Figure 1. Pre-recorded video lecture on control in the process industries1.

is not as diverse as it could be, the material will change and adapt.

The students were in higher years (third or fourth year) of studies. The number of participants ranged from ten to 30. Naturally, the drawback was that there was one lesson less to cover course content. However, the students did not feel it impeded their learning experience. The lecturer also felt that it would be possible to cover the content of the course despite this interruption.

The initial workshop was conducted via Zoom during the pandemic, which did not change the workshop's flavour or quality. It can easily be adapted to either an in-class or online format. The following sections describe the course format with the approximate duration of the activity given in the heading.

2.1 Control Engineering Workplace (30min)

The first part of the workshop consists of a brief talk by a control engineer to make the workshop specific to control engineering and to bridge the gap between the course and the working environment. There are several options to do this: by (i) inviting a guest lecturer from industry, by (ii) using a pre-recorded video, or by (iii) talking about different applications of control engineering.

Guest lecture: Ideally, the guest lecture is carried out by a control engineer from a diverse background after the principle that 'seeing is believing', see Section 2.4. One of the reasons for inviting a guest lecture is to link the topic of diversity and inclusion to the course content of control engineering. However, we felt that a guest lecture from any background would be beneficial as long as the guest lecturer is aware of the workshop's aim, promotes diversity and inclusion in their work environment, and is able to add to the discussion.

Pre-recorded guest lecture: Alternatively, a pre-recorded guest lecture can be used. We have recorded such a lecture, which is available from the university website. This sample lecture covers the process industry in particular, and gives an example of a cold rolling mill process, see Fig. 1, given by the principal author of this paper.

General applications of control: Another alternative is to look at the different applications of control and present work environments in these application areas. An overview of applications is given in Fig. 2, which could be used as a starting point of the presentations. The attractive characteristic of control engineering is that it can be applied to many applications and is relevant wherever dynamic systems can be measured and acted upon.

2.2 Activity: Who are we? (10min+5min)

After this presentation, we continued with a warm-up session for the students that also served to get to know each other. This was particularly important during online teaching in the pandemic because the students felt isolated studying at home. In the warm-up session, the students were put into groups of 3-4. This worked well in Zoom with breakout rooms as well as in the classroom. The students were asked to find three things they all had in common. Some topics were suggested to speed up the process: whether they have siblings and how many, whether they have a pet, play a musical instrument, grew up in a big town, have the same primary language, or play a sport.

After the students had time to find commonalities, they were asked to present the most interesting common trait they had seen. After this, we asked the students why they thought we did the exercise with them. (The purpose of this exercise is to make students aware of their commonalities and differences. It is essential to understand that this is not a one-dimensional problem male/female or homosexual/ heterosexual. Instead, every person brings different characteristics that make him or her unique.)

2.3 Activity: Bias Self-Test (Implicit) (10min+5min)

The next activity for the student is a self-test everyone can take online[2]. In the classroom, students used their mobile phones to conduct the test. 10 minutes were allocated followed by a short break. In the Zoom meeting, the students turned their cameras off and combined the test with a short break. According to its main authors, the IAT is a general-purpose procedure for measuring the strengths of automatic associations between concepts' (Greenwald, 2000). Since its start in 1998, the implicit association test (IAT) has received tremendous attention from the social psychology research community. More than 10 million tests have been taken at www.implicit.harvard.edu. Although there is some controversy about the interpretation of the results, the test is a powerful tool to draw light onto implicit associations we all are victims of. There are many different categories of implicit

[1] https://cloud.haw-hamburg.de/index.php/s/hlK7jHmc9W81mfu
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[2] https://implicit.harvard.edu/implicit/takeatest.html

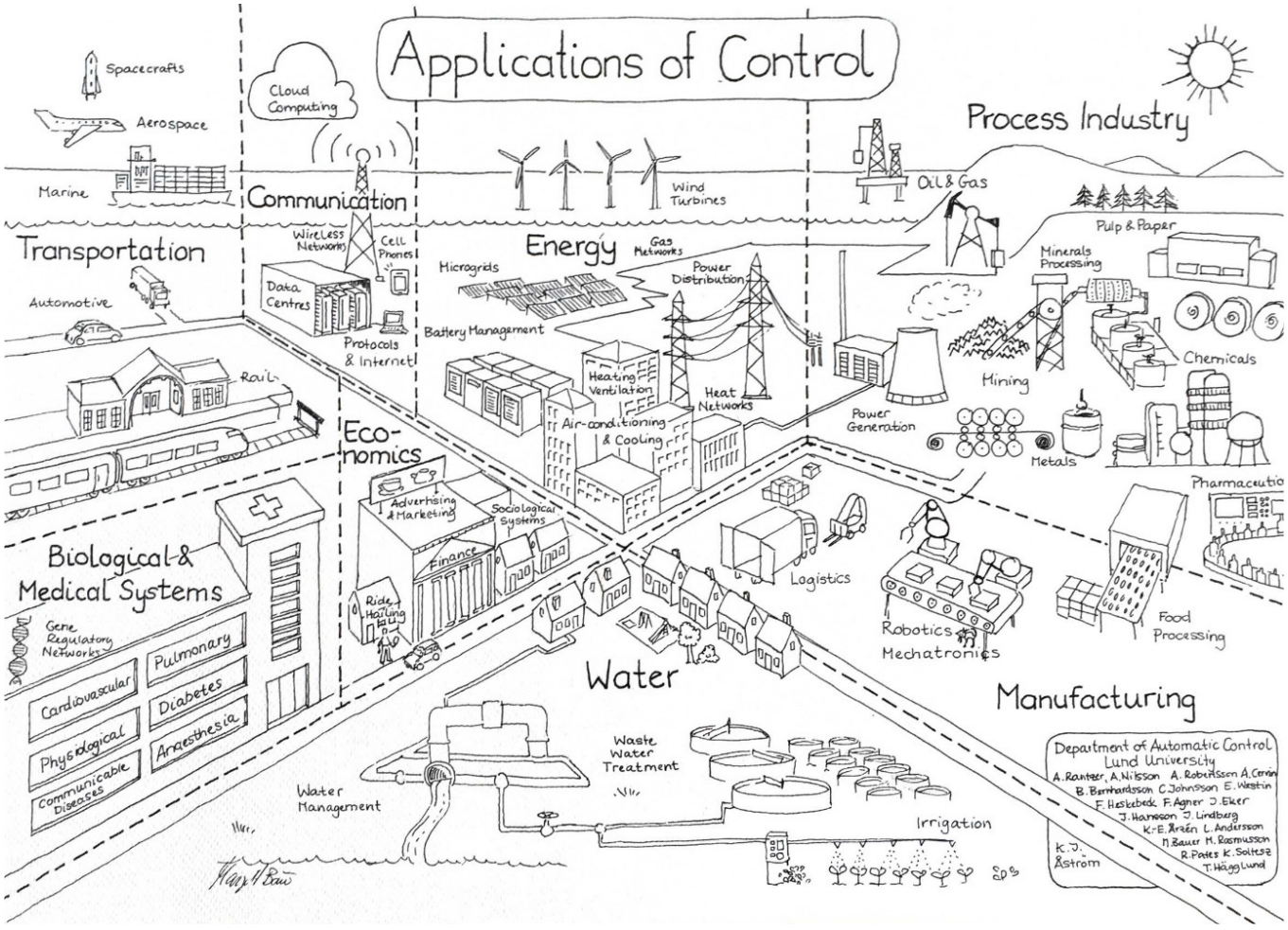

Fig. 2. Applications of control. https://cloud.haw-hamburg.de/index.php/s/3mVws2l1iTvC8fc. Password: ACE2022

association. The test has been used in similar settings as well as in the engineering context (Farrell & Minerick, 2018).

Here, we asked the students to follow the Gender-Career-IAT. The test presents the test taker with male and female names which the test taker match with career (career, corporation, salary, office, professional, management and business) or family associated words (wedding, marriage, parents, relatives, family, home, children). The test measures the speed in matching male and female names with either career or family terms.

The aim of this test in the workshop context is to make the participants aware of biases that we all carry with us. It is possible to answer without any bias, but the test taker will automatically wonder how his colleagues respond. The test was very revealing and powerful to some students, highlighting a sensitive area that is usually not addressed.

2.4 Research on Equality (10min)

As control engineers, we are no experts in gender studies. However, some recent publications are accessible to the layperson. The arguably most popular book on the topic is 'Lean in' (Sandberg, 2013). While the anecdotes and advice in this publication are controversial, it has been criticised for downplaying the effects of gender bias.

We found that the publications of behavioural economist Iris Bohnet provide an excellent introduction to the area, and we take the majority of the advice included in this workshop from her book (Bohnet, 2016). Passages from her book were used in the presentation and are hyphenated here.

Women are not encouraged to speak up: What is not commonly known is that women speak less in meetings. This is independent of whether there are fewer women present in the meeting or not. Two studies reveal this:

"In a study at Yale University, male executives who spoke up were rewarded with higher ratings of competence compared with their peers. In contrast, both male and female evaluators punished women for speaking up and gave female executives who spoke more than their peers substantially lower ratings."

In short, it is not advisable for women to speak up frequently as they most likely will be punished by both men and women for it. The second citation reads as follows:

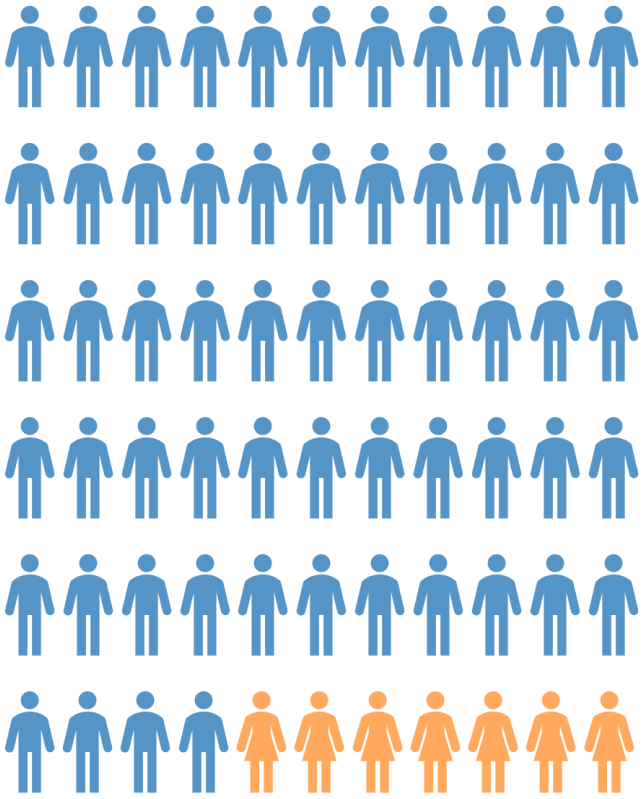

Fig. 3. Representing the fraction of women in corporate boards, exclusive. Adapted from Bohnet (2016).

"In the Swedish parliament, the Riksdag, female members of parliament give significantly fewer speeches than their male colleagues, despite the fact that over 40 percent of the MPs are women."

So even in an environment with nearly equal representation, women still feel less inclined to speak than men.

Women are taking fewer risks. While there are certainly exceptions, women on average, are more conservative risk-takers than men. This is important to know when designing, for example, exam questions. Multiple choice questions favour risk-taking and therefore can be easily biased against women. As a direct consequence of risk adversity, women put their names less often forward in promotions and for higher ranking positions. Worse still, women are also less likely to be asked to run for office and are more likely to decline than men if asked.

Teacher expectation and self-fulfilling prophecy: There is an important study on teacher expectations (Brophy, 1986). In an experiment, a class of pupils was divided into two groups. Each group was allocated to a teacher at the beginning of the year. The teachers were told that they had either received the top students or the bottom students of the year. At the end of year, the students allocated to the top class performed considerably better than the students allocated to the bottom class. What the teachers did not know was that the pupils were allocated randomly.

A similar phenomenon can be observed for women.

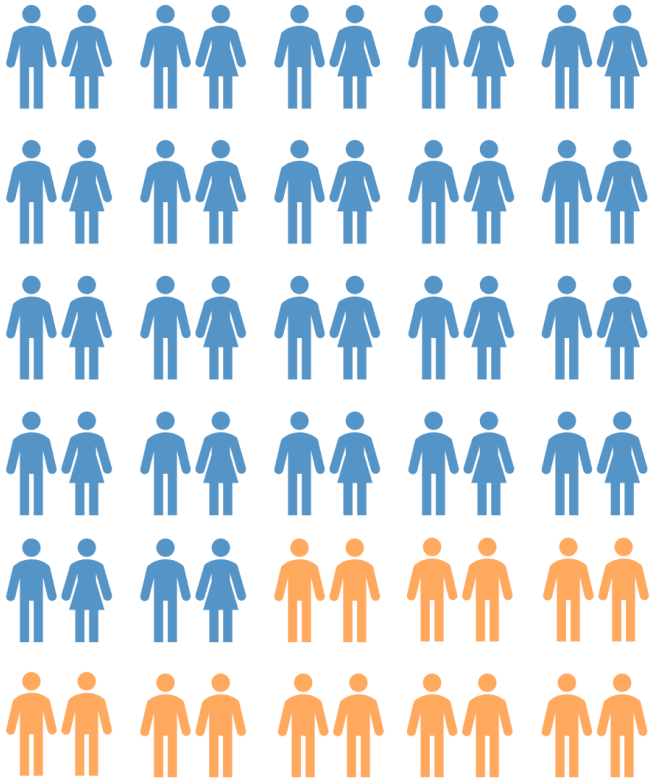

Fig. 4. Representing the fraction of women in corporate boards, inclusive. Adapted from Bohnet (2016).

"Women who were told that a math test was particularly difficult for women performed worse than men. When the test was presented as equally difficult for both men and women the gender gap in performance disappeared."

Negotiating your salary: One crucial step when embarking on your career is negotiating your salary. Before negotiating your salary, it is important to know the following:

"People around the world responsible for personnel decisions feel women who ask for better compensation violate gender norms."

This seems to be an impossible situation. Fortunately, there is a proposed solution, discussed in the following.

After describing the current situation in the workplace, the focus should be veered to tools that people can use to overcome challenges.

Addressing the problem of negotiating salary: There are two ways to solve this conundrum. Firstly, one could ask a colleague to negotiate the salary on your behalf. This requires a trustful relationship with the involved parties. Secondly, one could take this evidence in the form of the publications by I. Bohnet to the negotiating table and explain that it is difficult to negotiate the salary because of the Catch 22 situation. It is good advice to mention the elephant in the room.

Measure the percentage of women in your organisation: The very first step for any organisation is to measure the number

of women at all levels. It may not be the best idea to ask about the number of women

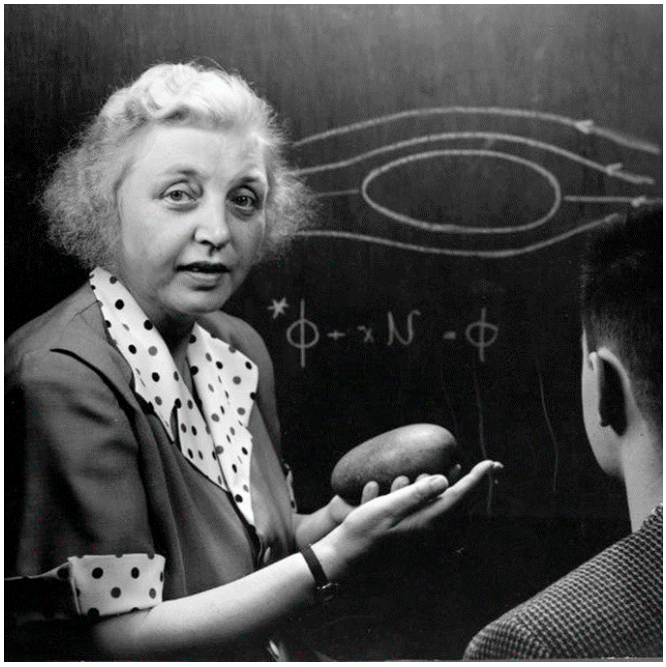

Fig. 5. Irmgard Flügge-Lotz (1903-1974)[3].

working in the environment in your job interview, but it should be noted generally. It is also important how the percentage is represented. Fig. 3 and Fig. 4 have been adapted from the book by Bohnet. Fig. 3 is the general way of depicting the percentage of women. Many organisations use this kind of representation because it is the most obvious one. However, it pitches the women against the men. It also makes men feel threatened by diversity programs that actively promote women only. Fig. 4 is a much better way of presenting diversity. The men are matched with the women to show that parity is the final goal. There is room for everyone.

Diversify portraits on the wall. Another recommendation by Bohnet is to ensure that the future workplace has diverse portraits on the wall. This refers to historical figures or former heads in the organisation whose portraits are sometimes displayed in the corridors.

Increase the fraction of counter-stereotypical people in positions of leadership. Seeing is believing is a simple sentence from the book as it raises the issue of lack of diversity in leadership roles. The principal author can confirm from her own experience when she started work in a very stimulating corporate research environment with around 120 researchers and scientists. At the time, the organisational chart of the research centre was placed in the entrance hall and showed pictures of all colleagues. The centre manager, the department heads, as well as all the group leaders at the time were all male. So were all colleagues. The only two female colleagues were the department secretaries and one other female. It takes extra effort to see yourself in a role when no role models exist. Fortunately, in 2016, the first female group manager was appointed who has gone on to become research centre manager. Women in this environment, however, are still in the overwhelming minority.

Find role models: In control engineering, it can be easy to think that there are and only have been men who have made the major developments. We are all familiar with Nyquist, Nichols, Kalman, Bode, and so on. It can easily lead to the conclusion that there were no women involved. But just like women such as Marie Curie or Lise Meitner, who have been deliberately overlooked in receiving, for example, the Nobel Prize in chemistry and physics, the same applies to women in control engineering. One great example is Irmgard Flügge-Lotz, see Fig. 5, who described the mathematical foundation of the on/off controller (Flügge-Lotz, 1953, reprinted in 2015 by Princeton University Press). For the classroom, and the control course, her picture and work can be included.

More examples of women in control engineering are described in an article by McClamroch and Pasik-Duncan (2002). There is work underway at Lund University to identify further women who have made their mark in control engineering, the female historical influencers.

Include men: Diversity and inclusions or equality schemes can easily lead to a hostile environment. After all, there are only so many managerial positions to be filled, and if these are given preferably to women, the idea can backfire. The goal is to make the organisation inclusive, which most likely everyone wants. We all want to feel valued and heard.

There is one other good piece of advice given by Bohnet: Be aware that fathers of daughters are more likely to care about gender equality.

2.5 Discussion (15min)

The discussion is probably the most essential part of the workshop where everyone can contribute and voice their opinion. The discussion should be open and moderated by the lecturer. Fortunately, there are no structures amongst students, and they are most likely freer in the discussion than they would be in a work setting.

3. CONCLUSIONS

The students filled in a short feedback form at the end of the session asking about the experience. The feedback was positive (the sample was too small for a full statistical analysis).

The authors believe that it is important to include such a workshop in the student syllabus, linked to a discipline and in particular to control engineering. The purpose of the workshop is to make students aware of the topic before they enter the workforce and give them tools to question and improve the future work environment for both men and women.

[3] https://en.wikipedia.org/wiki/Irmgard_Flügge-Lotz

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