

# Teaching Gender in Engineering: Path-creation for Gender-Sensitive Innovation

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## Abstract

*Neglecting characteristics and requirements of women resulted in a number of products that were less safe for females than for men, including airbags, safety belts, and medical personal protective equipment. Efforts to develop gender-inclusive products need to go beyond aesthetic design features and require engineers to reflect consequences of technical product development that targets properties of male bodies only. Rather than a single course on applied ethics and gender issues, we demonstrate how a more inclusive perspective for reflecting how to define application profiles can be implemented in several courses in engineering education programmes. We present how to build on standard concepts and tools in product and service development, drawing attention to the requirements of females to enable gender-sensitive innovation including an adequate pricing strategy. While integrating inclusive innovation or gender-sensitive innovation in the learning outcomes of modules may results in stronger integration in a curriculum, there are also benefits in implementing a gender-perspective immediately.*

**Keywords:** *Engineering education; gender equality, gender-sensitive innovation; gender-sensitive pricing; product development; UNSDG.*

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## 1. Introduction

Research in gender studies has shown that neglecting women<sup>1</sup> with their characteristics and requirements in innovation may result in products and services that discriminate them (Marçal,

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<sup>1</sup> Throughout this content, the terms 'woman' and 'female' are used in an inclusive manner to encompass all individuals whose bodies and needs align with characteristics and requirements that are distinguishable to 'male' bodies. We recognize and respect the diversity of gender identities, and our use of these terms is not intended to exclude or marginalize any person based on their gender identity or expression. The use of these terms is intended to be inclusive rather than exclusive. If you have specific concerns or questions regarding the language used, please feel free to reach

2022). The examples range from airbags and safety belts in cars, medical devices, personal protective equipment, to athletic shoes. Some of these products even caused physical harm to women, which are roughly fifty percent of our society. Moreover, improving the products to accommodate characteristics of women afterwards requires additional innovation resources. Accordingly, it can be also framed as an economic and sustainability problem, when engineers and designers neglect crucial requirements of their product design in the first place, and have to invest additional resources to improve it afterwards.

We do claim that including a gender-perspective in product development may result in more robust, equitable, and safer innovation and contributes to gender equality (UNSDG 5). Consequently, to create awareness amongst engineers, the importance of gender-sensitive application profiles should be taught in higher education curricula. Instead of an extra course on gender-sensitive innovation, it can be implemented in several modules that involve product development, without having to change the learning objectives and go through official administrative changes of the courses. However, implementing gender-sensitive and inclusive innovation in the learning objectives may encompass that it depends not on individual instructors, whether students learn to reflect on this.

In the following, we present a brief introduction to the issue of gender-sensitive innovation in the theoretical background. Then a case study illustrates how it is implemented in an engineering module. The discussion section provides some advantages and disadvantages of this approach in comparison to implementing gender-sensitivity in the learning objectives.

## **2. Theoretical Background**

Thinking through gender-sensitive innovation, it is helpful to distinguish aesthetic requirements from technical features. Looking merely at aesthetics, our world is full of products and services targeting women to increase their appeal, and in some instances justify a higher price. However, an athlete training shoe in pink or pastel colors does not mean necessarily that the sole is designed to absorb and cushion a female runner. Hence, in this section we present a brief introduction to gender-sensitive innovation and gender marketing, to illustrate the differences.

### **2.1. Gender-sensitive innovation**

While products and services are design with aesthetic features targeting women, they are not necessarily developed to specifics of female requirements. Issues associated with product development that neglects requirements specific to women can impact their health and safety. Airbags and safety belts initially have been tested and certified with dummies simulating the

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out, as we are committed to fostering an environment that values and acknowledges the rich spectrum of human experiences.

properties of male-bodies (Linder & Svedberg, 2019). Accordingly, this led to airbags deploying with excessive force for smaller and lighter individuals, including women. The forceful deployment of airbags caused injuries, such as bruises and abrasions but also more severe outcomes, such as broken bones and internal injuries. Early designs of seat belts were not optimized for pregnant women. The positioning and tightness of the lap belt could result in discomfort or even harm to the fetus in the event of a collision. Consequently, pregnant women were at risk of injury due to the improper fit of seat belts, and in some cases, they chose not to wear seat belts at all, further increasing the risk of injury in the event of a crash (Linder et al., 2018). Personal protective equipment is also a product field that discriminates women. Although female workers achieved some attention for this topic, e.g. through work unions and some of the businesses providing personal protective equipment improved their products (e.g. Johnson and Johnson Foundation, 2021), a recent report amongst Canadian women shows that about 58% of women are still complain about wrong fit and even 28% do not wear equipment because of discomfort and ill fit (Gowan Consulting, 2023). These results emphasize the health risk for women when personal protective equipment such as safety harnesses, protective shoes and overalls, are still designed for men with “scale-down” versions for women that lack proper fit.

This technology gap is attributed amongst other reasons to the fewer proportion of women that work in research and development, and in higher managerial positions, deciding on innovation (Rüst, 2020). This claim is substantiated by findings, that the focus on women increases with increase in female workforce. A recent study amongst European businesses found that women in management boards correlate positively to inclusive innovation that target the needs of people who live in poverty (del Mar Fuentes-Fuentes et al., 2023) – with the majority of them being female as the wealth distribution amongst people who live in poverty effects women more than men (Nieuwenhuis et al., 2018).

## **2.2. The female beauty tax as part of gender marketing**

Browsing the offers at online shops, drug stores, shopping malls or inner city districts in Germany, the country seems to offer more products and services to women than to men. Hence, this richness may distract from the issue that we require gender-sensitive innovation.

Marketing strategists discovered gender as a source of additional income and invented gender-based pricing, targeting women with higher prices, often for products and services that are associated to their beauty such as cosmetics, clothing, haircuts, and dry-cleaning of clothes. This price markup is also referred to as the “female beauty tax”, “hidden tax”, “gender tax” and “pink tax” (Dueterhaus et a., 2011; Liston-Heyes & Neokleous, 2000; Shenbagavalli et al., 2023). For example, hair loss fighting foam on the U.S. market was 40% more expensive for women, despite the same active ingredients and volume, also clothing alteration as a service of retail stores are offered in some areas for free to men as part of the sales package, while women have to pay for this (Jacobsen, 2018, 243). This gender tax is discriminatory, as the cumulative costs

of products and services add up (Duesterhaus et al., 2011). Especially when considering the gender pay-gap and wealth disparities (Meriküll et al. 2021), the amount of money that women have to spend for equivalent products and services appears double unfair.

### **3. Examples of Introducing Gender-Sensitive Innovation in Engineering Education**

Offering individual courses on gender studies often results in self-selection of students, who are already interested in the subject. Consequently, in order to contribute to gender equality, study programs should aim to introduce gender-sensitive innovation tools in the standard curricula. The following case study on how we teach it in an engineering study program (B. Sc. and M. Sc.) may provide inspiration for implementing it at low threshold, without having to go through formal adjustments of learning objectives and skills. Our course evaluation has shown that by introducing a gender perspective on requirements and pricing, students become more sensitized to gender equity issues and that it increases their motivation to participate. They may spread their knowledge at their future workplaces contributing to gender-sensitive innovation.

#### **3.1 Innovation tools that facilitate gender –specific requirements**

The following two suggestions can be implemented in any engineering modules that cover e.g., product development, quality control, standards and testing, material selection, even basic math such as statistics and physics to sensitize students for technology gender gaps:

In a first step, reflecting market-pull and technology-push mechanisms in innovation, students may comprehend that even with inventions that are based on new technologies – a successful market diffusion is only possible when it meets market requirements. We use smart-textile applications as example and analyze why some are successful and others fail. Then, introducing examples such as personal protective equipment and test dummies for vehicles, we discuss health risks when innovation is not fit for purpose.

We usually use two sessions to reflect on innovation and market diffusion, as well as gender-sensitive innovation to overcome gender technology gaps in the beginning of a product development project module that runs over three months. The students – depending on the complexity of the development – may work in groups or sub-groups to then define a need and develop a suitable product that addresses this need. In general, all groups – but at minimum two groups – are eager to experiment and contribute to solutions that address needs that would improve the life of women. We found tools from design thinking, such as defining a persona and a user journey map are especially helpful to analyze the requirements. This includes researching the daily lives and specifics of women. To list a few that came up during the courses, this includes menstrual cycles, pregnancy and menopause, temperature differences in limbs, and the higher share of care-work (encompassing e.g., caring for children, parents, and any sick

family member, cleaning, cooking, grocery shopping), higher vulnerability when moving after sunset or on their own during cities and the country side, including using public transport, and in many instances a higher pressure and/or desire for beauty encompassing clothing, recovery, cosmetics, leisure sports, and healthy diets.

To provide a few examples, the product development resulted in a round-shaped shelter tent for refugee camps as a recreational space for women, considering also the psychological effects of colors and shapes and the insulation effects of different materials. Another development was a single-person tent integrated in a backpack that was designed for average German female body shape and requirements to go hiking. A coat was developed with distance measuring sensors in the back, that is connected to a vibration mechanism in the sleeve and a switch in the sleeve that allows to turn on flashing LEDs in the back to signal more distance to passengers who walk up too close and do not respect the comfort zone of the wearer.

With a first market research on what is available, what can they built on, we derive already at gender differences that are acknowledged in products, but also at gender marketing. This leads to the next example: gender-sensitive pricing.

### **3.2 Market research to land at gender-sensitive pricing instead of gender pricing**

Innovating encompasses building on what is already available. Accordingly, students perform a market research of a given textile product including materials, special features, and pricing. Then as a second step, the students are invited to look “out of the box” at other products that relate to the application field and features, services, marketing, and in particular pricing strategies. They usually work in teams, report their findings, and discuss them in class. Analyzing pricing strategies with engineering students broadens their perception that prices are (or should) be cost-based, to cover manufacturing, development, marketing and logistics. It is a common practice in many sectors that pricing strategies are based on what costumers are willing to pay, instead of a cost-based calculation considering the efforts and required resources (Meehan et al., 2012). Discussing with students that in a portfolio, not all offerings may be cost-effective but some offers are compensated with higher margins of others, and what potential customer segments are able to pay or willing to pay opens the door to reflecting business ethics and what specific customer segments should pay. Accordingly, considering that women in general own, and in particular accumulate less wealth during their work life (Kukk et al., 2023), pricing strategies should be part of gender-sensitive innovation. Hence – this often leads to the discussion whether gender-sensitive pricing in terms of women who as a group own and earn less get special discounts or have to pay less, is fair or discriminating. Here, the teacher may refer to national constitutional laws and consumer protection acts that prohibit discrimination.

Depending on the academic age of the students and their experience with discussions, it can be helpful to propose a role-play with predetermined opinions. Divided into smaller groups, they

get sorted into proponents who defend or opponents who object gender pricing. Both proponents and opponent get ten minutes to prepare their arguments. Afterwards they suggest a pricing strategy and discuss it with their counterpart. This way, they do not need to have an opinion yet, may enhance their skills to reflect opinions and emphasize with other views.

In the courses, we defined gender-sensitive pricing strategies as recognizing and addressing economic disparities between genders, acknowledging that women, on average, may earn and own less than their male counterparts. By offering lower prices for products and services targeting women, businesses can contribute to bridging the economic gap and ensuring accessibility. This approach reflects a commitment to business ethics in terms of social responsibility, recognizing that affordability is a key factor in enabling equal access to goods and services. These strategies emphasize fairness and inclusivity by considering the economic realities faced by women.

On the other hand, female and male students in Germany do not experience significant difference in wealth and income yet. They may find pricing strategies unfair, that facilitate women having to pay less. The aim of the teacher should not be to drive them to pricing strategies that discriminate men, but rather to facilitate the discussion and reflection. Creating the awareness may empower them in their future work life to discuss with the business units fairer pricing strategies.

#### **4. Brief Discussion and Outlook: Introducing a Gender Equality Focus in Standard Engineering Curricula**

Although there is a positive trend in incorporating characteristics of women in application profiles of products, as they are considered to be an important market, and as more and more women enter jobs in the field of science, technology, engineering and mathematics (STEM), this trend is rather slow. According to a recent report of the World Economic Forum, women still remain underrepresented in the STEM workforce with globally about 29% in comparison to almost half across other occupations (World Economic Forum, 2023). Accordingly, introducing a gender focus in engineering courses that e.g. considers comfort and fit for females but also aspects related to women's health, such as menstruation, pregnancy, and menopause, may improve the situation especially for health-critical products and services.

Offering individual courses on gender studies often results in self-selection of students, who are already interested in the subject. Consequently, in order contribute to gender equality, study programs should aim to introduce gender-sensitive innovation tools in the standard curricula. Whereas these ideas can be implemented immediately, without having to formally change the learning objectives and skills of a module, the following overview points out specific advantages of implementing gender-sensitive innovation formally in the study program:

**Table 1. Advantages of formal and informal implementation of gender-sensitive innovation in engineering study programs**

<b>Formal implementation through adjustments of learning outcomes</b>	<b>Informal implementation in existing modules</b>
Can take a year or longer, depending on the required boards that review the changes independent of instructors	Can be implemented immediately
Visibility that UNSDG-5 is implemented in curricula	Depends on willingness of instructor
Inspiration for other engineering programmes at the institution and at other education institutions	Low entrance barrier to start also at education institutions where gender-issues are still viewed with reservation

This teaching approach is based on the assumption that engineering students who got sensibilised for the technology gender gap may engage in their future work life to improve innovations in a gender-sensitive way, including pricing strategies. However, some studies on gender issues show, that it can also lead to a defensive stance, also from female engineering students, as they do not want to associate themselves with victims. Accordingly, the effects and how to balance the issue should be monitored carefully.

This case study reflected on how to implement a focus on female issues in engineering. While the ideas can be implemented instantly in different modules, there are benefits of addressing gender-sensitive innovation as part of learning objectives and skills. Amongst others, as part of the curriculum the topic becomes independent of instructors and universities may demonstrate to potential students and their future employees, that they do take the UNSDGs seriously, addressing social sustainability and gender equality.

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