DIVERSITY AND INCLUSION IN ENGINEERING

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While engineers have an immersive and important impact on technological, business and societal development via their research and innovation, they are often diversity-blind. Engineers overlooking potential end-users with diverse backgrounds affected by their research and innovation processes and outcomes are the rule rather than the exception. In engineering, more often than not, men build a world for men (C.C. Perez, 2019).

The problem, however, goes well beyond differences in sex and gender. As a case in point, Seaborn, Barbareschi, and Chandra (2023, p. 1) found "… evidence of limited, obscured, and possible misrepresentation in participant sampling and reporting along key axes of diversity: sex and gender, race and ethnicity, age, sexuality and family configuration, disability, body type, ideology, and domain expertise" in human-robot interactions.

In this short book chapter, we reflect on opportunities and challenges in making engineering projects more responsible by overcoming their diversity-blindness, even beyond sex and gender. We achieve this by providing information on the relatively sparse theoretical background in this matter and on our empirical data and methodology. Based on this, we highlight the opportunities and challenges of leveraging human diversity for technological and business success and discuss whether diverse teams contribute to this. We conclude the paper by discussing our findings in the light of their technological and business impact.

THEORETICAL BACKGROUND

While national governments and the European Commission have made genuine efforts to address the diversity-blindness in engineering, the focus of their initiatives has been limited to sex and gender, and their general uptake has been disappointing.

Funding agencies in various countries and the European Union have requested the sex- and gender-responsiveness of scientific research and innovation (Hunt et al., 2022; European Commission, 2020). Despite the incentives provided in the European Commission's Horizon 2020 funding programme, engineers did not systematically apply a sex- and gender-inclusive approach to their projects (Cheveigné et al., 2017).

There is some literature suggesting that engineers can make their research and innovation outcomes sex and gender-responsive by modifying their research and innovation processes or by diversifying their teams. To adapt their research and innovation processes, engineers considering the diversity of human beings must critically reflect on and likely modify their research questions and methods, as well as their reporting of results and innovation activities (Nielsen et al., 2018; Werker, 2021). Engineers could use existing examples (Tannenbaum et al., 2019) and adapt existing guidelines for gendered research and innovation (Nielsen et al., 2018) to consider diversity beyond sex and gender in their research and innovation processes.

The social categories beyond sex and gender are age, race, disability, sexual orientation, social class and others (Rice et al., 2019).

Moreover, intersectionality, i.e. people being under-privileged because of a combination of social categories as mentioned before (Rice et al., 2019), might also play a role in research and innovation processes.

To alter their teams, engineers can use diverse team members with various values, perspectives and ideas. Nielsen et al. (2018), suggest a positive relationship between diversity in research teams and more inclusive research and innovation outcomes. Yet, to our knowledge, there is no empirical evidence supporting this positive relationship.

DATA & METHODOLOGY

The data we analyse stems from the eighteen ATTRACT Phase 2 research projects funded by the European Commission's Horizon Europe funding scheme. The ATTRACT project has been taking place in two phases, i.e. the already finished ATTRACT Phase 1 and ATTRACT Phase 2, running until August 2024.

The aim of ATTRACT was to identify and develop breakthrough detection and imaging technologies. Therefore, it spans basic research, applied research and market innovation, thereby aiming at both technological and business success. In ATTRACT Phase 1, 170 project teams received €100,000 each to develop a proof of concept for their technology (ATTRACT, 2023a). In ATTRACT Phase 2, eighteen research projects, often emerging from a few ATTRACT 1 projects, received €1,000,000 in funding to convert their proof of concepts into market-ready prototypes while also seeking private funding and industry collaborations to launch their prototypes into the market (ATTRACT, 2023b).

We rely on two types of data, i.e. semi-structured interviews and a survey. For the first type of data, we carried out the semi-structured interviews via MS Teams in three steps. In the first step, we interviewed all project leaders and eleven team members of five teams in early 2023. We followed up with the team leaders of these five teams in autumn 2023 in a second step. In the final third, we conducted interviews with the team leaders of the remaining thirteen research projects in the winter of 2023 and 2024. For the second type of data, we carried out a survey in June 2024, which was mainly completed by team leaders.

Here, we employ a mixed-methods approach, sharing insights from both types of data. Leech and Onwuegbuzie (2007) provide a typology using three criteria: (1) emphasis on approaches, (2) time orientation, and (3) level of mixing.

Regarding (1), qualitative and quantitative data have roughly equal status in our reflection.

Regarding (2), to learn from the interviews, we carried them out sequentially with the survey.

Regarding (3), our level of mixing is relatively high as we follow up on questions about diversity in research and teams in the semi-structured interviews, with related and adapted questions about the same topics in the survey provided us with more comparable data.

Secondly, based on what we learned during the interviews, we adapted the questions in between steps and developed the questions for the survey based on our learnings in the interviews, thereby entering the interviews by using flexible data collection methods that allow us to take advantage of emerging topics and concepts as suggested by Eisenhardt, 1989.

Below, you will find a reflection on our descriptive results from the survey, along with some insights from the interviews. While we intentionally use results from the within-case analysis of the interviews, we also conduct a comprehensive cross-case analysis and report findings from individual cases. Cross-case analysis presents the challenge that the emerging theory is often parsimonious, as it

excludes all aspects not replicated across multiple cases (Eisenhardt and Graebner, 2007). Here, however, we are looking for opportunities and challenges of diversity in research and in teams in engineering.

In this context, singular results are also of interest, as they help us identify openings for business and technological opportunities.

REFLECTION

Due to the requirements of ATTRACT Phase 2, we find universities, research organisations and firms engaged in project teams collaborating on an international level. At the same time, the diversity of project team leaders and members is rather low. All research team leaders have a background in either engineering or natural sciences, sometimes combined with a business or entrepreneurial background.

Most of the team members we interviewed are researchers and innovators. One of the team leaders is a woman. The female team members typically work on the business or legal aspects of the projects.

None of the project teams had considered the diversity of human beings in their research and innovation processes when we first interviewed them. Yet the interviews worked as a sort of intervention. In particular, the project leaders were very interested in the question of diversity in research and innovation processes. In ATTRACT Phase 2, project leaders were expected to develop prototypes and secure funding for their market introduction. They were therefore seeking business opportunities for the technological solutions they were developing.

Two out of the five project leaders we interviewed in the first round incorporated our suggestions on how to consider the diversity of human beings into their plans. In the second round of interviews, six months later, they reported concrete prototype changes, such as a surgical device also available for the smaller hands of female surgeons and an optical solution providing visibility for colour-blind men.

Initially, the diversity of team members did not play a role at all in considering the diversity of human beings in the research and innovation processes, most likely because the majority of the engineers carrying out research and innovation had a somewhat similar background regarding gender, age and educational background. In the case of the surgical device, the project leader enlisted female surgeons to help him develop a prototype suitable for smaller female hands, which would also likely be useful for men with smaller hands.

In the survey conducted after all interviews were completed, we found that ten out of eighteen research teams considered the diversity of human beings. Often, they considered various types of diversity. In Figure 1, you can see the distribution of the kinds of diversity considered, with age, gender, and educational background leading.

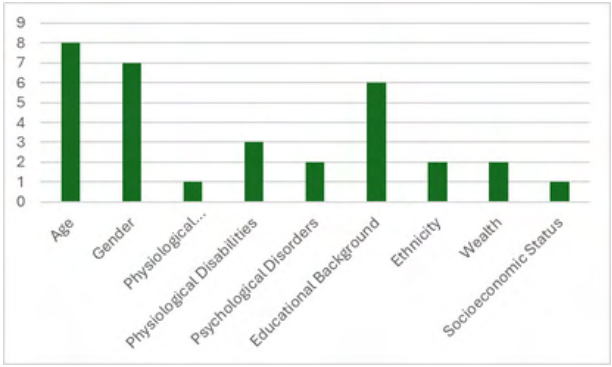

Figure 1. Types of diversity considered

In the survey, it also became clear that the phase in which the diversity of human beings was considered was rather late in the process, i.e. mainly in the development phase (see Figure 2).

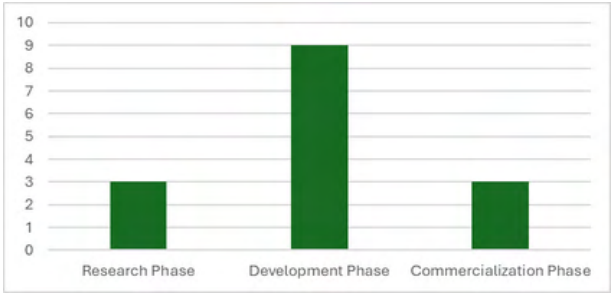

Figure 2. Phase of diversity considered

While project leaders saw the business opportunities of taking diversity of human beings on board, they also had to deal with severe challenges:

Entrepreneurially experienced leaders had to convince their younger, academically oriented co-

lleagues and their business partners of the business value of inclusive engineering. While this approach seemed to work well with the project members, business partners turned out to be a significant challenge: Several project leaders reported that, although in principle, their industry partners were very interested, they wanted to see the prototype before investing more money. However, building the prototype is expensive. Finding partners who are willing to fund prototypes up-front is a serious challenge for the project leaders.

CONCLUSIONS

While none of the eighteen project teams had considered the diversity of human beings in their research before our interviews, ten did so afterwards (see Figure 3). Team diversity did not initially play a role, but it was addressed in the context of more inclusive developments.

The ATTRACT Phase 2 research projects had a particular history and set-up. We conducted our data collection and analysis while they were developing their prototypes and seeking funding.

Our findings suggest that diversity-blindness in engineering does not occur because of a lack of willingness but rather a lack of knowledge of how to approach diversity in their research and teams.

To overcome diversity-blindness in engineering, several things had to come together: Firstly, the project leaders needed information about how to consider the diversity of human beings in research and innovation processes. Without originally intending to, we did so with our interviews. Secondly, they needed entrepreneurial experienced leadership to convince team members and partners of the business value of their technological developments.

This points at another important role for entrepreneurial leadership on top of the already shown roles in these breakthrough technologies (Feenstra, Hopp, Pruschak and Werker, 2024). Lastly, they needed time and money to build prototypes adhering to the needs of diverse human beings when relevant. In overcoming diversity-blindness in engineering, project leaders would not only open new markets but also provide more inclusive engineering solutions for human beings otherwise underserved.

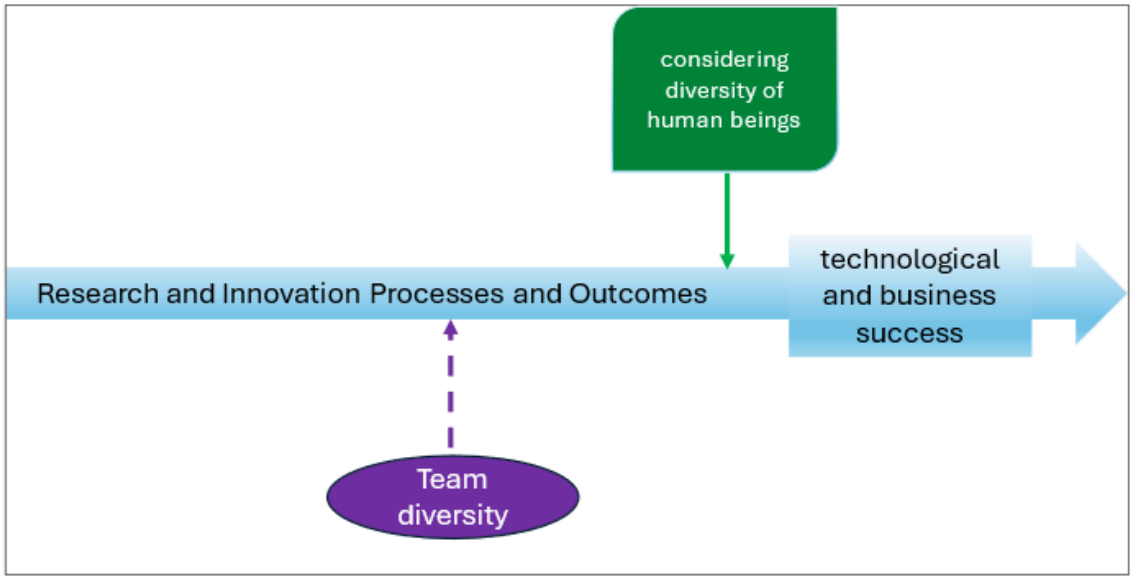

Figure 3. Diversity in research and innovation and in teams as driver of technological and business success