D 4.1. SWOT Analysis of Responsibilization Strategies

21 December 2022

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Project start date: 01.09.2021

Duration: 36 months

Date of issue of this report: 31.12.2022

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Boost EuroTeQ Engineering University

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Our European University Network

BoostEuroTeQ

Strengthening institutional transformations for responsible engineering education in Europe

How can technical universities help to create a workforce that **meets the challenges of complex global problems that cut across technology and society?** How can we support the **professional development of future engineers?** How can we **effectively upscale co-creation teaching practices?**

These are some of the questions we aim to address in **BoostEuroTeQ** – a scientific research project funded by EU Horizon 2020. As a complementary project of the Erasmus+ funded EuroTeQ Engineering University our goal is to encourage institutional change towards **responsible research and innovation. The multidisciplinary project brings together engineering education, philosophy, ethics, and science and technology studies.**

Over the course of three years (2021-2024) we will work on two main dimensions

Boost EuroTeQ

Enabling individuals

Supporting the lifelong learning journey of European professionals by conceptualising new professional profiles

- Analyse the developmental needs of the engineers of the future
- Develop a strategy for the upskilling of professional engineers at universities
- Create tailor-made training programms in close collaboration with institutional and industry partners
- Conceptualise training for Learning Professionals with the aim to qualify them as specialists in the scientific upskilling of engineers

Societal transformation

Augmenting the transformative potential of universities in society by investigating co-creation practices and developing context-sensitive strategies for their reflexive institutionalization

- Create a EuroTeQ Co-Creation Manifesto on institutional strategies that will enhance the evolution of responsibility practices at technical universities
- Support the development of learning networks to increase co-creation practices in each community
- Conduct stakeholder engagement events on responsibilisation instruments at EuroTeQ partner universities
- Investigate the benefits and challenges as well as identify potential indicators for successful co-creation teaching at universities
- Develop a roadmap for the upscaling of co-creation teaching practices

1. PREAMBLE

“BoostEuroTeQ: strengthening institutional transformations for responsible engineering education in Europe” explores innovations in engineering education brought into the Erasmus+ funded “EuroTeQ: European University” alliance. Its main objective is to contribute and strengthen EuroTeQ actions by carrying out rigorous empirical work in the areas of lifelong learning and responsible co-creative engagement between technical universities and society.

The EuroTeQ Engineering University builds on the belief that societal developments of recent years call for strong university alliances to make the knowledge square of education, research, innovation and service to society a reality and its impact a benefit to Europe and beyond. As six leading Universities of Science and Technology, spread across Europe, situated in innovation eco-systems and with great collaboration experience, the partners in this consortium have the ambition to introduce a paradigm shift in the engineering education of the future, striving for responsible value co-creation in technology. “EuroTeQ Engineering University” has a twofold meaning: To provide excellent education to our future engineers and to engineer the University of the Future, thus becoming a role model for the European Higher Education Area and beyond.

As highly renowned European Universities of Science and Technology, we share the conviction that for effectively shaping value creation processes in technology, we need an approach that involves all of society as an active partner, including all relevant stakeholders in the process (developers, producers, and utilisers) alongside civil society and policy-makers. Yet, each of us lives in different societal structures and traditions. Therefore, value creation processes are shaped and perceived differently across different countries, requiring a situated approach to understanding and utilizing the science-society interface. We share the conviction that Europe with its European values in general bears successful societies, but we are interested in understanding the differences, unique features and best practices across the continent. The relative comparability of our Partner Universities is an advantage when analysing and assessing the learnings of each activity within the EuroTeQ Engineering University. It will also help to understand the benefits of international and transcultural collaboration for each of the involved societies. By collaborating with this set of Partner Universities, we expect findings that will be transferable to other university networks across Europe and beyond, and that will ultimately promote a deeper understanding between the different national societies and societal layers alike.

BoostEuroTeQ strengthens the EuroTeQ alliance by carrying our research and interventions on two main pillars. On the first pillar, it develops the concept and profile of learning professionals – the mediators between technical universities and professional engineers, on the side of universities (WP2) – and a strategy to upskill professional engineers (WP3). On the second pillar, the project develops a **strategy for reflexive institutionalization of co-creative and responsible teaching and research practice**. It does so by investigating the responsibiliization strategies of technical universities (WP4), the co-creative communities they help develop (WP5), and by building on those, designing a strategy to boost co-creation in teaching (WP6). WPs 1, 7 and 8 contribute to achieve these research goals and enhance their impact by conducting rigorous project management and communication and dissemination activities, while also strengthening the links with the EuroTeQ alliance. **The purpose of this deliverable is to present a SWOT analysis of responsibilization strategies at the EuroTeQ universities.**

2. EXECUTIVE SUMMARY

Work packages 4-6 focus on the development of a **strategy for reflexive institutionalization of responsible and co-creative teaching and research practice at the EuroTeQ universities.** The three work packages follow a shared research strategy divided in three phases. On the first phase, we carry out empirical research to get a grasp of the current status of responsibility practices and their links to co-creation efforts. On the second phase, we carry out interventions oriented to strengthen these activities but also to build stronger ties to the main Erasmus+ EuroTeQ alliance and its different components and work packages. On the third phase, we carry out a policy analysis and connect it to our efforts to design policies that should lead towards the reflexive institutionalization of responsible co-creation in teaching and research across the six EuroTeQ universities. These include, for example, a "Co-creation manifesto" and a "Co-creation teaching roadmap".

This deliverable presents a rigorous and context sensitive **Analysis of Strengths, Weaknesses, Opportunities and Threats of Responsibilization Strategies at the EuroTeQ Universities**. This work builds on previous efforts reported internally in Milestones 4.1 (Project guideline) and 4.2 (Database on responsibility practices and experiences at EuroTeQ Universities) and sets the grounds for work on the intervention phase of the project. In a later stage, this SWOT analysis will guide our efforts in the development of policy recommendations and exploitation outputs.

Description of work

Between September 2021 and December 2022, we conducted empirical research at the six[1] EuroTeQ universities intending to get a grasp of the initiatives that contribute to enhance their sense of responsibility alongside ongoing efforts to transform engineering education. These general efforts were carried out in close coordination between work packages 4, 5, and 6, as we intended to identify connections between initiatives aiming at increasing reflection on responsibility in research and innovation, innovative activities such as the EuroTeQ Collider, and other co-creative teaching offers. We also paid attention to novel "collaborative spaces" across the universities. Following from these efforts, we then demarcated between cases that fitted better the analytical focus of WP4 (responsibilization strategies) and WP5 (co-creation communities).

The SWOT analysis we present here was complemented with situational analysis and constructionist grounded theory involving multiple qualitative research methods, as we describe in more detail below. Collectively, we conducted about 20 interviews and engaged in a similar number of informal conversations, observations, and site visits to university venues hosting a wide range of initiatives that deserved our attention. The SWOT analysis focuses in particular in four dimensions that resulted critical for the development of a strong strategy of reflexive institutionalization of responsible co-creation across the EuroTeQ universities. These include initiatives to 1) addressing sustainable transitions, 2) incorporating social sciences and humanities (SSH) in technical universities, 3) fostering multi and interdisciplinary research, particularly across SSH and STEM disciplines, and 4) engaging with society.

[1] Research focusing on L'X is more limited since there are no staff members of this institution involved in WP4-6, who could gather the information required for this SWOT analysis. The missing information will be collected after the submission of this deliverable. It is worthwhile noting, however, that L'X counts with university structures and initiatives that will provide relevant information about the four themes examined in this SWOT: addressing sustainable transitions, integrating social sciences and humanities, fostering interdisciplinarity, and engaging with society.

Main findings

	INTERNAL/CURRENT		EXTERNAL/POTENTIAL	
	STRENGTHS	**WEAKNESSES**	**OPPORTUNITIES**	**THREATS**
ADDRESSING SUSTAINABLE TRANSITIONS	All EuroTeQ partners have recently launched strategies. Specialist research centers on sustainability topics. World leaders in diverse renewable technologies.	Strategies are in early stages, under-staffed and under-funded. Many strategies and statements, little implementation. Mostly tech-driven solutions.	Students are very committed to sustainability. They lead many initiatives. Collaborations in other national university networks. Universities can learn from each other	University actions could be constrained by strategic partners from unsustainable sectors. Technology-driven solutions overshadow other possible responses. Overemphasis on marketable "green" solutions.
INCORPORATING SOCIAL SCIENCES AND HUMANITIES IN TECHNICAL UNIVERSITIES	All EuroTeQ partners have SSH departments. Diverse experiences training engineers or SSH specialists. SSH expertise in diverse technical domains (e.g. mobility, energy, robotics, AI). Student projects make it possible to bring together SSH and STEM students.	Challenges to scale-up. Shortage of specialists and specializing students. Lack of clarity between SSH and other "soft skills" offers. Economics and entrepreneurship receive most attention. Assumption that other universities can provide SSH expertise when needed.	Crises such as the pandemic highlight the relevance of SSH to address apparently technical problems. SSH scholars and departments are internationally renown. Great opportunities by increasing collaboration in specific technical domains. Opportunities sharing courses and advanced students. Opportunities to examine similar sociotechnical issues across the 6 EuroTeQ locations.	Narrow view of SSH value as merely helping tech transfer and economic impact. Highly mobile and ephemerous staff as obstacles to continuity of research lines. Vulnerability to institutional re-structurations. Under-appreciation of SSH are a challenge to attract prestigious researchers.

	INTERNAL/CURRENT		EXTERNAL/POTENTIAL	
	STRENGTHS	**WEAKNESSES**	**OPPORTUNITIES**	**THREATS**
FOSTERING MULTI AND INTERDISCIPLINARY RESEARCH (ESPECIALLY SSH-STEM)	Multi and disciplinary departments in all universities. Pioneer academic programs and courses that bring together multiple disciplines.	Not too many examples of interdisciplinary projects across SSH and STEM disciplines. Not many explicit incentives and organizational mechanisms to foster interdisciplinary work. Interdisciplinary mode that predominates is “service-subordination” of SSH to STEM. Assumption that SSH help to “fix society”.	EU and other research funders increasingly encourage interdisciplinary collaboration between SSH and STEM. Many opportunities of mutual learning about organizational structures to facilitate interdisciplinary research. Much to learn from successful experiences across all EuroTeQ universities.	Contradictions between expectations for interdisciplinary growth but lack of incentives for scholars. Lack of recognition that interdisciplinarity takes time. SSH-STEM collaborations depend on individual people rather than institutional structures. Highly volatile and vulnerable.
ENGAGING WITH SOCIETY	Different formats of enegagement with society in all universities Engagement at different scales, local, regional, global	Diversity of engagement and meanings of engagement can turn into ambiguity. Industrial and governmental elites become main targets of “engagement with society”, rather than more diverse communities. Vague definitions of what or who is “society” – in strategies. Roles given to societal actors may be too restrictive.	EuroTeQ could push for collaborative forms of engagement across universities, with a focus on specific technical domains. These can help to foster a sense of Europeanness. Increase impact by focusing on specific sectors of society, also across universities. Reflect on inclusion/exclusion dynamics across different forms of engagement and work to address them.	Engagement as tick box exercise rather than genuine effort to democratize knowledge, technology and innovation. Narrow focus on priviledged sectors of society. Society has little or no decision-making power. Unreflexive engagement with disadvantaged populations.

3. METHODOLOGICAL OVERVIEW

The identification and analysis of “responsibilization strategies” in technical universities is not a straightforward task. The term “responsibilization strategies” in itself is open for multiple interpretations and it can refer to different and even conflicting understandings of university practices. A basic and modest understanding refers to the steps taken at a collective level – being this a research group, institute, initiative, faculty, or the university as a whole – to openly and explicitly engage with the reflexive assessment of the outcomes and implications of research, teaching, and other university practices such as innovation, public engagement, and science communication. Responsibilization strategies can refer to the adoption of codes of conduct in research practice, to research that explicitly intends to address the societal, ethical, and environmental impacts of technological developments and implementations, engagement with society – in particular with non-expert and vulnerable populations – , and teaching ethics, philosophy, and social sciences to science and engineering students. In recent years, the European Commission has supported the adoption of principles from the Responsible Research and Innovation (RRI) Framework and some universities have followed suit (de Saille, 2015; Doezema et al., 2019; Owen et al., 2021), either to align their language to it or to implement actions in that direction.

The analysis of strengths, weaknesses, opportunities and threats (SWOT analysis) is a tool mostly used in strategic management to produce basic overview information about organizational and project-based work. It is broadly used in corporate, marketing and consulting practice but also in academia. According to Helms and Nixon (2010) SWOT analysis started to be used in the late sixties. Although finding an original source and first proponents has been problematic, some authors attribute it to scholars from Stanford and Harvard universities. SWOT analysis has been used to examine single and multiple organizations and even multi-country analyses focused on a broad range of topics (Helms & Nixon, 2010).

Despite its extensive use, SWOT analysis has received multiple criticisms. For example, that it has no theoretical basis, that it mostly relies on “folk wisdom” of organizational actors, and that participants can easily confuse and allocate organizational features in the wrong category. For example, they may take threats as opportunities and miss that “strengths that are not maintained may become weaknesses [and] opportunities not taken, but adopted by competitors, may become threats” (Helms and Nixon, 2010, p.235). SWOT analysis also has been described as an oversimplified and vague process that leads to shallow and misleading results. Moreover, Helms and Nixon observe that it does not lead automatically to actual strategies.

Most of the problems have to do with uses of SWOT analysis that end up in non-prioritized and short lists of bullet points. However, Helms and Nixon and several other authors observe that its shortcomings can be addressed by complementing it with other analytical tools and methods. They observe the use of complementary analytical tools common in strategic management such as scenario analysis, “Multiple Criteria Decision Support (MCDS)”, and “Telescopic Observations Framework”. Moreover, they note that SWOT analysis can also be improved by combining it with “desk research, literature review, expert interviews and workshops, scenario planning, and needs analysis” (p.240). In this study, we take advantage of the simplicity and easy-to-grasp nature of SWOT analysis, but combine it and strengthen it with the use of multiple qualitative research methods. These include desk research and document analysis, ethnographic, participant and non-participant observation, qualitative interviews, and open conversations with stakeholders.

There are different ways of elaborating SWOT analyses. The analysis can focus in key criteria from which strengths, weaknesses, opportunities and weaknesses are examined, or it can instead collect strengths, weaknesses, opportunities and threats in a more open and unstructured way. In this study, we followed the first strategy, since the focus on key criteria makes it possible to examine the current situation at different universities in a more meaningful way, also lending itself to comparative analysis. Additionally, there can be discrepancies regarding what counts as “opportunities” and “threats”. There are studies that consider these “external” elements over which an organization have no control, and other studies take them to be potential or future variables. We keep open to both interpretations.

In this study, we examined several practices that provide evidence of implicit and explicit responsibilization strategies in the EuroTeQ universities. We followed an iterative qualitative research approach taking insights from situational analysis and constructionist grounded theory (Charmaz, 2006; Clarke, 2005, 2009). What this means is that we started by creating multiple but interrelated “situational maps” that allow us to understand the interrelations between different elements and components of the EuroTeQ universities: when these were brought in, what else was happening in that local and historical context, and how words such as “responsibility” and “co-creation” re-shape and re-arrange what was there before.

In the early stages, the WP4 leads asked the other members of the WP4-6 team to write down and share a summary of the main responsibility-related cases and events that had taken place in their universities in the last ten to twenty years. The team members were also asked to include cases that could represent engagement with societal actors and co-creation. Then, in a meeting one month later, all cases were presented and discussed, and the team members were asked one more time to refine their lists by adding other cases that were not considered beforehand, but which resonated with the experiences in other universities. From all the identified cases, a number of them were selected to conduct more in-depth study, shifting from desk and online research to interviews with diverse stakeholders. The selected cases have been and will be part of different comparative studies, therefore these had to be relatively similar to those existing in the other EuroTeQ universities. By focusing on specific and similar areas, it is also possible to limit the study to a more manageable size. Since universities are organizations that bring together thousands of individuals and host hundreds of projects, and empirical study can only pay attention to a very limited number of cases, narrowing down the umbrella of empirical possibilities is warranted. Such a narrowing down was inspired by what grounded theory analysis calls “theoretical sampling” (Charmaz, 2006): “seeking and collecting pertinent data to elaborate and refine categories in your emerging theory” (p. 96). In a later stage, equivalent cases will provide opportunities for more comparable interventions while also allow us to bring together people that can establish a rich discussion on shared topics of interest.

The project partners identified as main areas related to responsibilization strategies a number of cases focused on:

1) Official strategies and workplace and research ethics statements
2) Sustainability
3) Social sciences and humanities
4) AI, robotics and smart systems
5) Mobility
6) Light and energy

Once projects in these areas were clustered, the team partners noted that there were large differences between them to produce meaningful analysis. Moreover, although these seemed to be areas of analytical opportunity, these are still many sites, at least for examining during the first year of the project and for the elaboration of this SWOT analysis. For that reason, the cases were re-clustered once again only paying attention to those that could be more effectively examined for the SWOT analysis. The outcome of this new re-clustering was the decision to look only at the areas:

i) Addressing sustainable transitions;
ii) Incorporating social sciences and humanities in technical universities.

In addition, we considered worthwhile paying attention to dimensions related but not limited to specific technical domains. Other areas of further reflection included:

iii) Fostering multi- and inter-disciplinary collaboration, particularly across social sciences and humanities (SSH) and science, technology, engineering and medicine disciplines (STEM); and
iv) Engaging with society.

Once these four areas of general relevance for the SWOT analysis were defined, WP4-6 team members were asked to re-examine and refine their data t by focusing on more specific analytical questions that were later distributed. In addition, team members were asked to conduct interviews with at least two stakeholders involved in social sciences and humanities departments, and sustainability initiatives and projects. Finally, the WP4-6 team also conducted document analysis of extant university strategies. The obtained information was shared and discussed to inform the elaboration of the SWOT analysis. This discussion also focused on the formulation of strategies for reflexive institutionalization of responsible co-creation at all the EuroTeQ universities.

4. SWOT ANALYSIS – LITERATURE REVIEW OF THEMES

The four dimensions we examine in this SWOT analysis (addressing sustainable transitions; incorporating social sciences and humanities; fostering multi and interdisciplinary collaboration; engaging with society) have received substantial attention in the academic literature and research, education and innovation policy. Often there are overlaps between two or more of these dimensions. For example, there are efforts to address sustainable transitions that explicitly look for engagement with citizens, and which involve social science and humanities scholars to come up with novel and creative formats of engagement (Chilvers et al., 2018; Stirling, 2008). However, when these efforts are restricted by previous commitments to facilitate the adoption of some winning technologies, the roles that SSH scholars and citizens can adopt are already too constraining (Barry et al., 2008; Calvert & Martin, 2009). As a consequence, these participants are likely to abandon those initiatives. These complicated situations illustrate the need to examine how exactly those different dimensions are brought together, by whom, and for the benefit of what particular stakeholders (Chilvers et al., 2018; Estalella & Sanchez-Criado, 2018). This study benefits from the literature on interdisciplinarity and other forms of cross-disciplinary interactions that has grown in the last three decades (Barry & Born, 2013; Gibbons et al., 1994; Klein, 2010; Nowotny et al., 2001; Salter & Hearn, 1996). In particular, it engages with Barry's (Barry et al., 2008, 2008) differentiation between contrasting modes of interdisciplinarity. These include integration-synthesis, service-subordination, agonism-antagonism.

The presence of SSH studies of science and technology in higher education institutions and technical universities in particular has also increased in the last decades (Klein, 2010; Pritchard & Baillie, 2006; Stroeken & De Vries, 1995). The growth and institutionalization of fields such as STS, environmental humanities, health humanities, transition management, and philosophy and history of science and technology illustrate this trend.

The topic of sustainability and sustainable transitions has been explored from many different disciplines. An early study by Irwin (1995), writing from an STS perspective, suggests that forms of expertise and contextual knowledge held by citizens are essential for sustainable development ideas to thrive. In this way, citizen participation has been closely linked to sustainability in the literature. Felt et al., (2016), however, observe that there are tensions between involving citizens in sustainability efforts and classical academic outputs. Other studies observe the relevance of attending not only technical solutions that are implemented in spaces or niches that are protected from the market, but also their interrelation with broader sociotechnical regimes and landscapes, in specific geographical contexts, and with particular power relations (Lawhon & Murphy, 2012; Smith et al., 2010). In a recent book, however, Bihouix (2020) challenges the idea that innovative technologies will lead the sustainable transition because they depend on non-renewable resources. He argues instead that the future is “low-tech”.

Different trends of academic literature have examined the engagement of science and society and the particular role that universities play to create and maintain these interactions. In policy, but also in the academic literature, the “third mission” of universities has become an area of increasing analytical attention. The “third mission” is referred to as universities’ “contribution to society”. Accordingly, universities “are becoming engines that contribute to the social, economic and cultural development of the regions in which they operate, by transferring knowledge and technologies to industry and to society at large” (Compagnucci & Spigarelli, 2020, p. 1). However, in their systematic literature review, Compagnucci and Spigarelli observe that “third mission” is an ambiguous and nebulous concept. It involves actions of technology transfer, creation of spin-offs, forming an entrepreneurial spirit, and broader societal and cultural contributions, which seem to be less often pursued and explored. Compagnucci and Spigarelli recognize that the meaning of the “third mission” is context sensitive, depending on “i) the configuration of the activities carried out in a given university; (ii) the degree of its territorial embeddedness; [and] (iii) the institutional frameworks in which the university operates” (p.4). Additionally, other authors observe that the meaning of the “third mission” is affected by “the kind of community involved, local, regional, national, or international” (Compagnucci & Spigarelli, 2020, p. 4).

The literature also notes that besides economic impacts through technology transfer and entrepreneurship, other connotations of the third mission refer to “providing education to audiences beyond traditional students and contributing to public debates and cultural activities” (p.4). Compagnucci and Spigarelli observe that there is less attention paid to specific university strategies in the area of the “third mission”, an area in which this SWOT analysis can contribute. Moreover, they posit that it is difficult to create indicators to measure the performance and impact of third mission activities because these activities “consist of intangible assets” which are difficult to quantify (Compagnucci & Spigarelli, 2020, p.15). Another aspect is the lack of attention in the literature to the role and impact of SSH disciplines in third mission activities. Warning against the assumption that one model fits all regarding third mission activities that universities should deliver, Compagnucci and Spigarelli suggest that “a university may tailor institutional approaches to fit its own identity, culture, and specific ecosystem” (p.16). In addition, university strategies should pay attention to “(i) the interdependencies between the three missions… (ii) the local embeddedness of the university, (iii) the heterogeneity of third mission activities; (iv) the role of the SSHs in the potential development of the third mission” (p.16).

The third mission can also refer to “promote sustainability … and social justice orientation, particularly with reference to race, class, and gender” (p.18). In their study, Compagnucci and Spigarelli leave one of the final and smallest sections to “the function of co-creation for sustainability”, underscoring with it the fact that the meaning of the third mission is still open for debate. One of the most relevant publications pointing to co-creation for sustainability, and even framing it as a fourth mission rather than a third one, is by Trencher et al. (Trencher et al., 2014). They argue:

> In contrast to the narrow economic scope of the third mission… the function of co-creation for sustainability is far better equipped to bring about the sustainable transformation of a specific geographical area or societal sub-system. Essentially, this is due to a fundamental difference in focus: that of *contributing* to economic development versus that of actually *creating* societal transformations in pursuit of realizing sustainable development (p.7, italics in original).

As a warning note, however, Trencher et al. observe that it may not be possible for all universities, in all geographical regions, adopt this fourth mission. They explain that “the promotion or expansion of co-creative activities for sustainability would almost certainly encounter tensions with the incumbent values and practices of the third mission regime which… is formulated almost entirely in economic terms” (p.9). Moreover, the differences between this fourth mission of co-creation for sustainability shows that the “entrepreneurial university’ does not constitute the final chapter in the evolution of the modern university” (p.18). If a back-up for such an argument is required, they conclude that “global and local manifestations of diverse sustainability challenges such as climate change, food, water and energy security, ecological decline and decaying socio-economic conditions are threatening the relevance of pursuing economic development alone” (p.20).

The following section provides a detailed description of the findings of our SWOT analysis.

5. SWOT ANALYSIS - RESULTS

This section presents the strengths, weaknesses, opportunities and threats of each theme examined for this analysis. The idea is not to compare between different EuroTeQ universities but rather to keep eyes open for generalities that emerge through a cross-examination of all the universities. The purpose is to come up with a general strategy of reflexive institutionalization, not six independent ones.

5.1 Addressing sustainable transitions

Strengths

The most relevant strength is that most universities have launched ambitious sustainability strategies almost simultaneously within the last two years. TUM celebrated in October its first ever Sustainability Day, where the sustainability strategy was presented, but also there were activities, discussion panels, presentations and research showcases in all faculties and campuses. Similarly, DTU has held a Green Week and a Green Challenge since 2010.

Some university strategies count with diversified lines of action to implement these strategies. These include for example, particular objectives on research, governance, education, and operations (TUe),

and innovation and entrepreneurship, and communications added on top (TUM). At TUe the line in governance is fundamental for the implementation of sustainability in a more reflexive way by connecting it to questions regarding what forms of partnerships with industry should and shouldn't be developed. It also encompasses the ethical issues that sustainable implementations may involve. Others (CTU) are divided in spatial efficiency and flexibility, social responsibility, synergy and cooperation, environmentally friendliness and sustainability, future-oriented planning, and image of an attractive and innovative institution. Moreover, TUe addresses the dimension on sustainable research through the notion of "transformative research", currently promoted in Dutch universities. This means research that is oriented to re-imagine research systems in order to transform them. Transformative research involves multi, inter and transdisciplinarity, collaboration with stakeholders, action research and valorization.

Yet, besides the similar and almost simultaneous temporalities in which the EuroTeQ universities have launched their sustainability strategies, there are substantial differences in how these were developed and how they are internally perceived. In some universities, the strategy is meant to be the result of a well-coordinated participatory effort, while in others there seem to be big contrasts between bottom-up initiatives and unofficial meetings, and top-down strategies. In some universities, the top-down strategies often lack the institutional know-how to persuade different research groups to get involved. As a result, some universities have many actions which are disconnected from each other and that have only recently gone through centralized coordination efforts. The diversity of experiences and modes of creating strategies is a strength because it offers a broad range of possibilities that can be adopted and from which all universities can learn.

In most of the EuroTeQ universities there are specialist research centers and even whole campuses focused specifically on sustainability. To name only a few, CTU has the University Center for Energy Efficient Buildings, the Centre of Vehicles for Sustainable Mobility, and the Centre for Advanced Photovoltaics. TUM has the Campus Straubing for Biotechnology and Sustainability, the Center of Energy Efficient and Sustainable Design and Building, and the MCube project and cluster, which aims at co-creating and testing sustainable mobility concepts for the Munich metropolitan region, and will be active for the next 8 years. TUe, in turn, has Brainport Smart District, which combines cutting-edge smart technologies and participatory design aimed at experimenting with smart city concepts in the real living environments. Finally, it is worthwhile to include the Novo Nordisk Center for Biosustainbility and some still ongoing projects of the initiative EnergyLab Nordhavn in DTU.

As a strength, some of the EuroTeQ universities are world leaders in particular renewable technologies, for example DTU in wind energy. Other universities are very strong in other renewable energy technologies and mobility.

Although not connected in all cases to strategies at the university level, student-led initiatives and organizations are a strength that most EuroTeQ universities count with, and which represent opportunities worthwhile considering.

Weaknesses

One of the most concerning weaknesses is that there are many strategies and statements for sustainability, but these by far outnumber actual implementations. Moreover, all strategies are still young, little known, and lacking resources. For instance, most universities have little budgets and a

small number of people actively working full time on developing and implementing the sustainability strategies.

Although strategies exist, these were created not necessarily out of genuine interest but intending to increase the universities' positions in national and international rankings.

Some of the EuroTeQ universities have made efforts to identify, catalogue and sometimes quantify the amount of courses that explicitly involve content on sustainability. At TUe, there is a database collected by the Go Green Office that links extant courses to specific Sustainable Development Goals. These databases reveal that currently it is still a small percentage of courses which relate to sustainability. But the shortage is relatively common across universities, even in technology universities in countries as progressive as the Netherlands. At least in TUe, the hope is that Challenge Based Learning could contribute to address this shortage.

Since technical universities are often conceived as places that train engineers to develop novel technologies, one of the weaknesses is that solutions to sustainability problems seem to be technology oriented, and other approaches such as de-growth, responsible stagnation (de Saille & Medvecky, 2016), and related governmental and social solutions seem to play secondary role at the most.

Opportunities

Even though university-wide strategies are in the early stages, one opportunity is that some of the EuroTeQ universities participate in local and national initiatives. For example, CTU is part of a network of 20 Czech universities seeking best ways to adopt and contribute to the Sustainable Development Goals. Participating in these networks offers opportunities to understand better the national context of sustainable transitions and a chance to act in a context-sensitive way. These opportunities represent ways in which the EuroTeQ universities can receive support and advice, but also the possibility for EuroTeQ universities to become a leading force to inspire and provide direction to other higher education organizations.

One of the most valuable opportunities is to take advantage of the new generations of sustainability-enthusiastic and proactive students. The students of EuroTeQ universitis are a very committed group of stakeholders who are very interested in sustainable transitions. At TUe, DTU, and TUM there are many student-led initiatives on sustainability. There are different forms of student initiatives that deserve attention. There are those that exist internationally and across universities, for example Enactus, 180 Degrees and the Eco-teams of Formula Student, and those that originally started at the EuroTeQ universities. One example is the TUM-based Plant a Seed, which intends to transform campus spaces into urban gardening pits, encouraging students to get involved, learn and share knowledge and experience.

A key opportunity is for all EuroTeQ universities to discuss their current efforts and limitations, and explore together what is the role that these universities should play in sustainable transitions. These should include highlighting distinct cases that are technologically and research-wise strong, but also strong with regards to their engagement to teaching and their involvement of diverse sectors of society. Examples are wind energy in Denmark, mobility justice in Germany, automated infrastructure inspection in CTU, and smart cities in Tallinn and Eindhoven.

Threats

Among the threats, the EuroTeQ universities do not make explicit mention of the active roles that other sectors of society can play in their sustainability strategies. This is a concerning threat because it reproduces the assumed boundaries between university and society and between experts and lay people. If the universities want to be role models in the promotion of sustainable change, they should be more explicit about what these role models are, whom they involve, who they benefit, and who loses.

Another threat is that the universities have different understandings about what sustainability strategies are for and at what level they should operate. Some universities have a holistic view and actions, but others understand sustainability mostly as something that campuses should physically do, for example aiming to create “climate neutral campus”, rather than a shift in perspective on research and teaching. While the contrasting ways of understanding and implementing sustainability strategies could offer opportunities for mutual learning, it also can create misunderstandings, lack of cross-university engagement, and loss of interest.

Although it is an advantage to have overlapping partners in the EuroTeQ and the EuroTech alliances, having lines of action on sustainability that exclude the EuroTeQ partners that are not EuroTech partners is a threat, since it can jeopardize the sense of collaboration and cooperation that the alliances intend to represent.

In some of the universities, the research groups demarcate clearly between the technologies that they aim to use to contribute to sustainable development and those that get the most attention and which guide where the funding is going. The tension between autonomy and originality of single universities on the one hand, and collective missions should be handled carefully so that it does not become a threat.

The most serious threat is that most of the EuroTeQ universities and their actions on sustainability are often hindered by their strategic partners: strong industrial actors that represent the incumbency of widely established sociotechnical systems. Technical universities face the major challenge of learning to deal with the fact that they have helped to establish and maintain systems that are now see as a threat to environmental and human welfare. It is important that the universities learn to engage reflexively with the non-innocent roles they have historically performed.

Finally, one external threat is represented by current economic crises and the war in Ukraine. These might undermine the importance and urgency of sustainable transitions.

5.2 Incorporating social sciences and humanities in technical universities

Strengths

One of the main strengths of the EuroTeQ univerisities is that they all have established organizational units dedicated to bring skills and knowledge from the social sciences and humanities to enrich the education of their engineers. In most if not all of the EuroTeQ universities, it is common understanding that the social sciences and humanities are required to address real-life problems and global challenges. The level of support, however, has varied, and while in some universities the social sciences have been present for many decades, their growth has been relatively stagnated. By contrast in other universities the newcomer disciplines have experienced increasing support and steady growth.

The presence of social sciences and humanities is crucial for the responsibilization of engineers because these are the fields of knowledge that are the most capable to observe and reflect upon different forms of impacts of science and technology in society. Social scientists and humanities scholars have the role of offering to engineering students other sets of literature and modes of thinking unavailable to engineers. The text of the TUM Excellence Strategy 2030 states: “Stakeholders in technical sciences also increasingly recognize that connections to the humanities and social sciences must be indispensably anchored in the education of future engineers and scientists” (p.15). TUM has hosted historians and sociologists at the Faculty of Medicine since 1972. Then, a professor of history of technology was appointed in 2003. In 2004, the TUM launched the Carl Von Linde Academy with support from the Linde Foundation (Linde Stiftung) and the Bavarian State Ministry for Science, Research and the Arts. Its purpose was "to house the Humanities, Cultural and Social Studies" (CvL webpage). Some years later, with support from the German Science Foundation and its Excellence Initiative, in 2012 it planned the launch of the Munich Center for Technology in Society, finally established between 2014-2015. In 2021 the MCTS became the TUM Department of Science, Technology and Society, and is among the three largest departments of science and technology studies (STS) in Europe. Besides STS, the TUM School of Social Sciences and Technology houses a Department of Governance and a Department of Education, and a large School of Management that is independent of the School of Social Sciences and Technology. TUM has the ambition to make courses on social sciences of technology and Responsible Research and Innovation (RRI) available for all their students in the coming years. Thus, in about 8 years, TUM experienced a rapid growth in its social sciences and humanities’ workforce.

The other EuroTeQ universities are not behind. DTU appointed the first Professor of Responsible Technology, Maja Horst, in 2019. Her division now offers courses to a large number of engineering students across programs. Yet, there were social scientists involved in wind energy research and developments and also economics and management divisions since much earlier. TUe has housed STS but also philosophers of technology since the 1990s (Stroeken & De Vries, 1995). Their relevance for the whole student population increased with the establishment of the Bachelor College in 2012, through which students can combine courses and tailor their education according to their own interests, aiming towards a holistic education. At CTU, different engineering faculties have established their own units (called departments) of social sciences, offering students courses on history, sociology, economics management, but mostly languages. TalTech has hosted a Department of Economics since 1940, and a department of social sciences and humanities was established after during the 1990s. Its main focus was training a new elite for the public sector. In 2017, both departments merged.

In particular, the strategy documents highlight key notions that suggest a shift towards responsibilization of the EuroTeQ universities. TUM and DTU use the notions of Human-Centered Engineering (TUM), Technology for the People (DTU). Both notions highlight the relevance of social sciences and humanities for engineering. One equivalent vision that highlights attempts of responsibilization is TalTech’s goal to contribute to a “climate neutral digital society”.

Despite these similarities, the approaches of integrating social sciences and humanities in the EuroTeQ universities are different. While DTU, CTU and TUe are dedicated almost exclusively in forming engineers, and they offer few study programs in management and economics, TalTech and TUM also offer full study programs in diverse social science disciplines. The most relevant for considering responsiblization strategies include the MA in STS, Responsibility in Engineering, Science and Technology (RESET), both at the TUM-STS Department, and Politics and Technology, at the Department of Governance. The different approaches – whether forming social scientists oriented to technology, or engineers with social sciences and humanities’ understanding –, offer different

advantages and disadvantages. An advantage of forming fully trained social scientists is that they can become excellent research assistants and eventually PhD researchers to contribute to projects in other disciplines. A disadvantage is that most of the staff have to cater for their own programs rather than establishing formal teaching collaborations with as many other faculties as possible. An advantage of only giving social sciences and humanities courses to engineers is that smaller departments are required. A disadvantage is that there is no chance to form future social science specialists who could engage with other departments. For the engineering students, the disadvantage is that they don't learn to talk with people with distant disciplinary formations, but only with other peer engineers.

One main strength is that once they are taken all together, the EuroTeQ universities cover a broad range of social scientific and humanities' expertise focused on specific technical domains. These include, for example, energy economics (CTU, TUM, DTU), wind and publics (DTU), mobility (TUM, TUe), smart cities (TalTech, TUM partly), genome editing of cattle (TUM), robotics (TUM), AI law and governance (TUM).

Weaknesses

In most of the EuroTeQ universities, the majority of degrees on offer are in engineering. There is a limited role in forming technology and engineering-oriented social scientists and humanities professionals. The weakness this involves is that the shortage of social science and humanities' students results in very limited experience of engineering students to discuss with students with other concerns, skills and trajectories. For the lecturers, the lack of social sciences and humanities students implies that they have limited chances to develop advanced courses using cutting-edge theories and methodologies. Moreover, there is little potential to scale up the amount of in-house formed social scientists and humanities scholars. TUM has currently the capacity to form a few dozen social scientists that could play a role in other universities.

Another weakness is that the expectations and assumptions about what social sciences and humanities are for differ across all EuroTeQ universities. Interests for integrating social sciences and humanities in individual EuroTeQ universities go from attempts to revolutionize the concept of the engineer (e.g. Human-Centered Engineer; Technology for the people) in some, to no mention of social sciences and humanities in the university strategy, in others. The same applies to responsibility and ethics in general and Responsible Research and Innovation (RRI), which do not figure in strategies' objectives, missions or milestones.

In general, STEM disciplines are still seen as more prestigious than the social sciences and humanities within the universities. Moreover, there's a lack of appreciation of how social sciences and humanities enrich research, university life, and students' skills. Furthermore, in some universities there is an unclear focus of the relevance of social sciences and humanities, bringing together management and entrepreneurship skills, language training, and other rather invisible functions. Social sciences and humanities seen as instrumental to solve social problems, fix laws, policies, business models of technology transfer, and convince people to accept novel technologies.

Social scientists and humanities' scholars are highly outnumbered by engineers and natural scientists in all the EuroTeQ universities, which makes it challenging to involve social scientists in more areas. Even when engineering departments and PI's are interested in getting social scientists and humanities' scholars involved, the existing social sciences and humanities' staff have no more capacity to respond

to their calls. If the social scientists and humanities' departments don't form specialists, there is no capacity to scale up their collaborations with other departments in a sustainable way.

Another weakness is the "takeover" of social sciences and humanities' areas of expertise by STEM staff. Sometimes engineering researchers address social sciences and humanities' questions without looking for further involvement and engagement with of social sciences and humanities' departments. This results in impoverished research and missed opportunities to engage and enrich the intellectual spirit that universities should advocate for.

In some universities, the academic units of social sciences and humanities' are attached to engineering faculties and lack common structures. This implies that they have little autonomy to establish shared, merge funding and intellectual resources, and establish common goals. Put otherwise, they are fully subordinated to specific engineering disciplines.

In some of the EuroTeQ universities, moreover, there's an assumption that other local universities will provide the of social sciences and humanities' skills when these are needed. This is problematic because it is not guaranteed that other universities will have within their ranks the staff that the technical universities require.

Finally, some social sciences and humanities are less regarded than others, and the interest is mostly on management and economics and entrepreneurial skills. In one of the EuroTeQ universities, in 2017 compulsory philosophy courses were replaced by courses on entrepreneurship. Issues like the Facebook-Cambridge Analytica scandal, Dieselgate, and the frauds by FTX cryptocurrency and blood testing startup Theranos' provide hints of why a richer political, social, moral and ethical formation are warranted amid the allure for entrepreneurship.

Opportunities

The involvement of social sciences and humanities in engineering projects is gaining popularity within and outside the EuroTeQ universities. Challenges such as climate change, the pandemic, crises of misinformation and techno-scientific controversies make it clear that their role and the skills they bring to universities are crucial for the engineers and engineering of the future.

In some of the EuroTeQ universities, the social sciences and humanities' departments are some of the most highly ranked within the individual university, and they are also highly regarded by the broader technology-oriented social sciences and humanities' academic community. The presence of social sciences and humanities in all EuroTeQ universities could easily become more visible because there is already a lot that has been achieved. A great opportunity lies in making more advertising of past and recent achievements. Moreover, funding opportunities encouraging the involvement of social sciences and humanities in technology research projects has increased in recent years. The EuroTeQ alliance as a whole could target novel funding opportunities but also serve as a role model for research and innovation policy.

In some EuroTeQ universities, TUM for example, there is the institutional willingness to make courses on social sciences, humanities and Responsible Research and Innovation (RRI) available to all students. To achieve this goal, TUM can build on the teaching strategies of other universities. DTU and Eindhoven have more experience offering social sciences and humanities inputs to very large classrooms. Going further, they all can benefit from all the experiences accumulated.

As noted earlier, there are not many students specializing in technology-related social sciences and humanities across the EuroTeQ universities. In order to address this shortage, one opportunity is that one of the partner universities with many of these students share advanced postgraduate students to the other universities for diverse activities. For example, these students could complement teams of Challenge Based Learning courses such as the Collider. These students could also participate as research assistants in projects of other universities.

University alliances make it possible to form a critical mass of social sciences and humanities, even if they are in the minority in individual universities. A great opportunity lies on making the most of understanding novel technological developments, or sociotechnical challenges across borders. There could be greater interconnections between diverse specialists working on the "human aspects" of engineering both within and across EuroTeQ universities. For every technological domain examined, there could be socially robust knowledge gathered across the six cities or countries where the EuroTeQ universities are based.

Threats

Social sciences and humanities face a number of threats across the EuroTeQ universities, some of which are more pressing in some of them rather than others. The first threat is the tokenistic inclusion of social sciences and humanities in strategy documents and research and teaching portfolio. This threat can be mostly noted when there is flashy advertising of these fields of knowledge but there is no truly and genuine appreciation of the multiple ways in which these (can) contribute to the intellectual life of the university. Across the EuroTeQ universities we note a dominant assumption that social sciences and humanities can help to "fix" society, policies, regulation and culture to make it more welcoming to novel technologies. In addition, there is a predominance of economics, management and entrepreneurship as the social sciences and humanities' disciplines that are the more relevant for a technical university. We note that economic growth narratives cast a shadow over other forms of appreciating these disciplines.

Furthermore, there is the assumption that the social sciences and humanities in some of these universities are of lower quality because their publications and journals have lower impact factors. In fact, the publication and citation practices in the social sciences and humanities differ dramatically from those of engineering and scientific disciplines.

The lack of appreciation of social sciences and humanities also involves the misconception that engineering students and professionals who shifted to those other disciplines did so because they weren't good enough and had no chance to make a future in such a competitive environment.

Finally, this lack of appreciation is apparent when social science and humanities' courses are part of a broader "menu" of so-called "soft skills" from which students can choose (or not) in order to spice up their education a little.

The second major threat is that social sciences and humanities' departments within the EuroTeQ universities (and other) are vulnerable to institutional re-structurations. These may encourage strategic actors to shrink departments, eliminate programs, or shift some "soft-skills" offer for others. A currently concerning example for some of our interviewees was the re-design of the Bachelor's College in TUe,

which makes the relevance of the philosophy-oriented courses uncertain. Similar concerns have been lived in the other EuroTeQ universities.

Third, a more general threat social sciences and humanities' staff face is the precarious situation produced by short-term contracts and the international competition which makes it appealing for staff to move in search of better and more stable opportunities. Due to the high mobility of staff, universities can rapidly lose areas of technology-oriented social scientific expertise that they might have been cultivating for some time from the bottom-up. Networks between social sciences and humanities scholars' and STEM departments disappear as people move, and these are not merely taken up by new coming staff. Moreover, for many social sciences and humanities' scholars, working in a technical university that lacks prestigious social sciences and humanities' departments and research-support structures might not be too appealing as a career prospect (Rabinow & Bennett, 2012; Tsai-hsuan Ju & Zehr, 2022; Viseu, 2015).

The most concerning threat is that engineering staff and students, and strategic actors of the university, remain in the assumption that societal concerns and the domain of social sciences and humanities is not what they should be concerned about, as if it was enough that other professionals and organizations took care of them. If these technical universities wish to become role model institutions, they cannot delegate their responsibility. They should become more aware of the limitations of their traditional disciplines and technical knowledge and recognize that these are not enough to address the most pressing local and global challenges.

5.3 Fostering multi and interdisciplinary research (especially across SSH-STEM)

Before presenting the results, it is relevant to underscore how interdisciplinarity relates to responsibility. One clear case is through the involvement of social scientists and humanities theories and methods to facilitate reflexivity on questions of societal aspects of research and innovation. However, a much more profound link is that interdisciplinarity makes scholars more aware of the limitations of their own disciplines, which could result in further dialogue and openness. Furthermore, it is through interdisciplinary engagements that engineers learn to communicate with other professions and communities of practice, and most importantly, to appreciate their value.

Strengths

There is the widespread assumption across the EuroTeQ universities and beyond, that interdisciplinary research is beneficial for addressing real world challenges. Most of the EuroTeQ universities have organizational units that bring together different departments and faculties for the purpose of strengthening their capacities on interdisciplinary research. Reinforcing these organizational units or existing independently, the EuroTeQ universities also host several projects that involve and bring together multiple disciplines. Although the majority of these projects and organizational units bring together mostly engineering and scientific disciplines, collaboration with social sciences and humanities has increased.

Interesting examples of interdisciplinary units include the FinEst Smart City Center of Excellence (TalTech), "Integrative Research Centers" such as the Munich Center for Technology and Society

(MCTS, now Department of Science, Technology and Society) and the Munich Institute of Machine Intelligence (MIRMI) (TUM), and the University Center for Energy Efficient Buildings (CTU). For instance, at TUM the MCTS started having joint tenure-track assistant professorships across departments. Initially there were assistant professors affiliated to both the MCTS and to the School of Management, School of Life Sciences, School of Architecture, and School of Governance. TUM also counts with the Institute of Ethics of AI, which has received financial support from the private sector. The funds received are used to fund projects of interdisciplinary nature that bring together PI's from two different disciplines, either from TUM or external.

For academic programs, CTU and the University of Texas in El Paso's have a joint Master's program on Smart Cities. One of the highlights at TUM is the Master in Responsibility in Engineering, Science and Technology (RESET) at TUM, which offers advanced but applied social scientific skills for engineering and science graduates.

Multiple student project-oriented courses and the "project weeks" at TUM intend to bring together students and researchers from STEM and SSH study programs. There are ambitious cross-departmental student project-based courses that bring together students from 3-4 departments, and also professors and PhDs and postdocs get involved as mentors. For example, "euMOVE: European Mobility Venture" brings together students from the MCTS, the School of Management, and the chairs of automotive technology, architecture, and urban development and transport planning to send them to investigate innovative mobility projects in other European cities. In DTU, an interesting course that encourages interdisciplinary work is the mandatory "Innovation in Engineering" and "Facilitating Innovation in Multidisciplinary Teams".

Interdisciplinary courses are a good way of creating synergies between different researchers but also between different departments. They allow exploring how different bodies of knowledge can be combined but also the institutional and organizational challenges of doing so.

Weaknesses

One of the limitations is that most interdisciplinary and cross-departmental research occurs mainly between different engineering disciplines, and participation of social sciences and humanities is limited. Almost none of the university strategies specify make what type of interdisciplinary work they wish to support or to see increasing.

Some of the EuroTeQ universities have rather hands-off policies and strategies, and there are no specific structures to foster multi- and interdisciplinary work. Moreover, there are not yet many cross-departmental academic study programs.

Although interdisciplinary work between STEM and social sciences and humanities has increased, it is still the case that it very few professors genuinely value the collaboration with social sciences and humanities' scholars. There have been cases when professors try to exclude previously social sciences and humanities' researchers despite previous agreements. In those cases, re-negotiation between PI's are necessary to keep "field sites" open to the social science PhD researchers as originally agreed.

At TUM, the Excellence Strategy 2030 recognizes that the social sciences and humanities are "still insufficiently integrated into teaching and research in the engineering sciences" (p.15). However, the university has not done much to encourage professors to be more open to interact with PhDs and

postdocs from the social sciences and humanities when they approach them. STEM professors have neither been encouraged to welcome courses that bring together their own staff and staff from social sciences and humanities departments.

When research priorities established centrally at a university focus merely on individual faculties, there are no big incentives in place to move away from traditional disciplinary silos. Even when funding opportunities facilitate cross-faculty and interdisciplinary collaborations, usually these vanish as soon as the funding period is over.

As noted in the previous section, social sciences and humanities are many times considered subordinated to larger goals of scientific and engineering projects, where their role is to “fix” society, policy, regulation, etc. In other cases, social sciences are praised only when they highlight economic impact of technological developments (see Barry and Born (2013) for a critical analysis of interdisciplinarity in the mode of service-subordination, rather than integration- synthesis or agonism-antagonism).

Opportunities

Despite the weaknesses, there is much that EuroTeQ universities can learn from each other and the organizational structures they have put in place in order to facilitate and encourage interdisciplinary research. This is the more relevant in the case of interdisciplinary research across social sciences and humanities and STEM disciplines. Key actors should be encouraged to learn the trajectories of these organizational structures and how these have been established. Key areas of collaboration include social studies of energy, mobility, robotics and AI, smart cities, and gene editing.

One possibility would be to bring together people from different EuroTeQ universities working on the same technical domain to listen how other universities have benefited from collaborating with social scientists and humanities’ scholars. These discussions should also expose the challenges and frustrations that are part of this type of interdisciplinary work. These opportunities could also extend to sharing experiences on implementing interdisciplinary courses and academic programs, and keeping them alive.

The EuroTeQ universities should also share what incentives they have put in place to encourage interdisciplinary research, and to reflexively identify the elements that constrain it in their particular national contexts.

Finally, there is a lot to gain from doing further advertisement of extant and previous successful experiences. All universities have achievements that are worthwhile highlighting. These should contribute to establish a culture of appreciation of social scientific-STEM collaborations. These contributions should not be restricted to highlighting economic value or market opportunities.

Threats

Interdisciplinary research faces a number of threats that are not limited to specific EuroTeQ universities. The first is the possible contradiction between expecting interdisciplinary research, courses, programs, and centers to appear, while at the same time there are scholars’ career evaluation mechanisms that punish interdisciplinary research. For example, if the universities or individual faculties and departments

prioritize publications in high impact journals, these usually tend to exclude interdisciplinary research outputs (for a broader discussion see (Rafols et al., 2012)).

One of the largest threats to multi- and inter-disciplinary research is that alliances between departments tend to depend on individual people. For example, if a postdoc or a junior group leader pushed hard for the three or four years for establishing contacts while he or she was hired in a university, these contacts may disappear when they move to a new position in a different university. Put otherwise, alliances between staff from different disciplines are personal rather than transcending to become organizationally structured. The EuroTeQ universities have the challenge to find the right balance between allowing and enabling the formation of interdisciplinary formations, and create not too imposing top-down strategies.

Another significant threat to interdisciplinary work is that it is not recognized that it takes time. Even setting up interdisciplinary courses is more challenging and time consuming than standard disciplinary courses. In an academic culture that increasingly prioritizes shorter term contracts and projects, more has to be done to encourage those activities that demand extraordinary efforts and offer little rewards.

As noted earlier, it is a threat to the growth of rich interdisciplinary collaborations across STEM disciplines and social sciences and humanities when STEM researches do work that might superficially resemble social scientific and humanistic input. While these ad hoc approaches “get the job done” they undermine the value of stronger interactions across disciplines.

The largest threat is the structural display of under-appreciation. It has been the case that during professorial appointments of social sciences and humanities’ scholars the chair of the committee is a natural scientist or an engineer with no interest, openness or understanding of these disciplines. In these situations, the universities are an obstacle to the goals they themselves try to achieve. Moreover, natural scientists or engineers in the committee tend to give preference to scientists or engineers who applied for the post, even though “society” or social scientific/humanities theoretical input do not figure much on their research. Even when internationally renowned candidates participate in these recruitment processes, the attitudes of the chairs and other committee members disappoint them and discourage them to take the posts. This environment of lack of intellectual appreciation for social sciences and humanities is one of the largest threats faced at EuroTeQ universities.

5.4 Engaging with society

Strengths

All EuroTeQ universities’ strategies underline that their *raison d’etre* is the bettering society. They have good examples of projects that involve citizens in different ways to play different roles in research. The Covid-19 pandemic highlighted the role that technical universities can play to engage with the wider society and contributing to address rapidly emerging challenges. During the pandemic, the EuroTeQ universities made information campaigns for the public, carried out research on impacts of the pandemic, and worked on designing technical solutions, from masks to artificial ventilators. Other examples abound, for example, engaging with society to explore issues around wind energy (DTU), with art curators using drones to inspect decaying historical monuments and infrastructure (CTU), and exploring mobility justice in deprived communities (TUM).

The EuroTeQ universities involve citizens in different ways. In TalTech, for example, citizens participate in pilot projects that make it possible to transform research findings into spinoffs. TUM offers multiple

opportunities for the general public to develop their entrepreneurial skills. In those universities with a larger amount of social scientists and in particular STS researchers, studies have paid particular attention designing inclusive recruitment strategies for testing subjects in robotics research, perceptions of vertical farms, farmers' expectations and attitudes towards gene editing in livestock agriculture, and public servants' experience on European robotics innovation policy. The EuroTeQ universities also provide advice to government and local industry.

There may be different understandings of who counts as "the society" that the EuroTeQ universities aim to serve and engage with. TUM, for example, has campuses and liaison offices and partnerships in London, San Francisco, Brazil, Ghana, Singapore and different locations in Germany, even outside the state of Bavaria. In other words, its society is global to some extent. Inside Munich, TUM has established "bridge professorships" (about 50) between TUM and other research organizations and industry.

More traditional, ways of engaging with society include the participation of university staff in science and art festivals, for example CTU's participation in the Signal Festival in Prague, or the Street Fest in TUM. CTU also offers public lectures such as "Physics Thursdays" at the Faculty of Electrical Engineering.

Different EuroTeQ universities have been able to accumulate experiences on open science and co-creation, as recently supported by the European Commission. To name a few examples, TUe has invested large efforts establishing the smart and sustainable "Brainport District", the smartest district in the Netherlands, and its Institute of Lighting Innovation involves societal actors to explore together new possibilities of public lighting. CTU is involved in the EU project SPARCS, which aims at engaging with citizens to establish communities of secure, clean and efficient energy.

Summing up, the strengths that all EuroTeQ universities combined are the diversity of formats and scales in which they engage with society, and the nature of the challenges they address, either specific of particular communities, or response to emergencies.

Weaknesses

One of the weaknesses is that engagement with society is understood in multiple and contradictory ways. These include benefiting society without their direct involvement, with their direct involvement (i.e. the closest to responsible forms of co-creation), merely science communication and popularization of research results, or by fostering entrepreneurial skills. Although it is a strength in itself to have so many different possibilities for engagement, this variation turns into a weakness if it falls into ambiguity rather than to encourage a well-planned diversification of engagement activities. Even at the level of strategy documents, these neither specify what are the sectors of society that deserve the more attention nor through what measures these can be involved. Although CTU's strategy is the only one that mentions the universities intentions to support "disadvantaged groups", it does not explain who these are. One consequence is that economic, industrial and governmental elites tend to predominate as the sectors of society that technical universities aim to serve. In addition, technology transfer is seen as the main form of engagement rather than other, more democratic, deliberative and participatory approaches.

Even in cases where co-creation is the goal, the roles assigned to societal actors are too restrictive. TUe's project in partnership with Eindhoven municipality intended to co-create a novel lighting infrastructure with citizens, but their role was reduced to select between narrowly defined options, all in the benefit of the technology providing company (Lipp et al., 2022). In this case, most of citizens saw little value in their involvement and decided to abandon the initiative.

Some universities have some engagement with society, but they are weak in comparison with other neighboring universities. This is rather odd against the backdrop of the presence and impact of engineering outputs in most of aspects of contemporary life.

Societies have a larger role to play in the development and use of technology than only facilitating innovation and being consumers. When the role of technical universities is seen mostly as developing innovation, other roles of citizens in science and technology become invisible. As a consequence, the technical universities' responsibilities towards citizens become narrowly understood.

Opportunities

Bringing together the experiences and lessons learned from all EuroTeQ universities regarding their forms of engaging with society opens up several opportunities. To put it more concretely, if two or more EuroTeQ universities have made efforts to engage citizens on, for example, discussions about energy futures, similarities and differences between these efforts can be examined. Additionally, for every engagement activity, there could be references to related engagements in other EuroTeQ universities. Such an exercise would strengthen not only the university activites but would also foster a sense of Europeanness.

A first step, however, is bringing closer to each other different plans to engage with society from single universities. In particular, efforts on science communication and on co-creation can be made more meaningful to each other. It is understandable that projects have limited time and there is not much opportunity to make connections and anchoring results to other initiatives once these are available. Larger efforts are required for making those transversal connections.

A second opportunity is to define specific engagement initiatives to different sectors of society. Particular groups that deserves attention is "disadvantaged sectors", as the CTU strategy suggests. But who are the disadvantaged sectors that each EuroTeQ university wishes to support? These details require better attention. In addition, the EuroTeQ universities can learn by reflecting on what societal sectors are being left out from certain engagement exercises and what their implications are. Put differently, while some engagement efforts may be more beneficial for some communities, they may be detrimental for others. For example, an event that searches to gain approval for autonomous vehicles may work against campaigns for active cycling.

Crossover between these engagements with society and reflexive learning from them, with the help of social sciences and humanities, represents the best opportunity for institutionalizing responsibility at the EuroTeQ alliance level.

Threats

As the SCALINGS co-creation roadmap states (Mueller et al., 2021), when engagement with society becomes a tick-box exercise it loses its value and potential. The roadmap also suggests that it is problematic and a threat when "participation [is] limited to socially, economically or politically privileged members of society", "when society participates without decision-making power," and when technological solutions to problems are prioritized.

In one of the locations with EuroTeQ universities, our informats argued that there is a lack of resistance to novel technologies that are implemented. It might be a threat that the EuroTeQ universities consider societal actors as apathetic or act as if they were so, and if consequently they decide to invest little efforts in social and public engagement. As a helathier alternative, the EuroTeQ universities could also think in ways of making a more socio-technically engaged citizenship. This would include discussing what is believed in different technological and scientific fields what citizen engagement is for.

It is also a threat if universities engage with poor locations, for example African countries, without making efforts to achieve equal participation, and either empowering the disadvantaged participants. There is a long history of colonial relations that make it an obstacle to establish egalitarian collaborative relations between powerful European engineering universities, and poor and oppressed sectors in Europe and across the world (de Sousa Santos, 2014). It is also deeply problematic if engagement means transforming disadvantaged sectors and communities in the Global South as market opportunities for the Global North.

6. CONCLUSION: STRATEGIES FOR REFLEXIVE INSTITUTIONALIZATION OF CO-CREATION IN EUROTEQ UNIVERSITIES

This deliverable aimed at identifying strengths, weaknesses, opportunities and threats of the EuroTeQ alliance as a whole. Focusing on the four themes that were selected, and examining both official university strategy documents and primary source empirical materials allowed us to identify a large amount of ideas to inform the development of a strategy for reflexive institutionalization of co-creation in EuroTeQ universities.

The four themes selected provide relevant hints for strengthening responsible co-creation. Addressing sustainable transitions is the most urgent challenge, but also the area where the EuroTeQ universities have the most engagements with society and work that crosses the boundaries between multiple disciplines. The social sciences and humanities are the only domain of knowledge production capable of providing a critical understanding of both responsibility and co-creation, but also methods to enhance mutual learning. Interdisciplinarity is a prerequisite for co-creation, and often for responsibility, since it sets the ground for crossing disciplinary and science/society boundaries. Finally, engaging with society is what co-creation is about, yet not all engagements with society would count as co-creation.

To keep this conclusion short, key areas that will strengthen the EuroTeQ alliance by helping the development of responsible co-creation include:

1. Bring together the notions of “Human-Centered Engineering”, “Technology for the People”, and “Climate Neutral Digital Society”. See how they complement each other and how they play different but interrelated roles to encourage responsible co-creation. Most importantly, these notions should translate into specific content in most of academic programs and lines of research. These should highlight the value of making the social sciences and humanities more visible and relevant.

2. The above notions can be used to guide efforts to bring together courses with relevant content, engagements with society and research projects that explicitly contribute to those notions.

3. The notions should guide efforts to share pedagogic experiences to bring social sciences and humanities' content to different faculties, and in different formats. Staff mobility programs and funding should make these efforts possible.

4. In order to address the shortage of advanced students in social sciences and humanities in most of the universities, with the exception of TUM, the notions above should encourage faculties to organize student teamwork oriented to form interdisciplinary groups of students. The EuroTeQ Collider is a good start. Moreover, these students could carry out internships dedicated to examining social, ethical and political dimensions of engineering projects conducted in the partner universities.

5. Sub-alliances around key areas of SSH-STEM research and collaboration should be established, encouraging students and researchers to learn from previous experiences of social science research in robotics and AI, mobility, wind energy, and smart cities – as starting areas. The purpose is to show that many links between SSH-STEM are possible, and that the EuroTeQ universities have already gone a long way in those directions.

6. The efforts above should help to bring values and skills of the social sciences and humanities out of the shadow that emphases on economic impact, "fixing society", and entrepreneurship cast over them.

7. These notions should nevertheless be reflexively adapted in two directions. First, to determine how these contribute to foster European values in general. And second, how European values address particular challenges of the member states. Yet, rather than assuming that European values are already well-defined, the EuroTeQ network could contribute in this area by fostering the notion of Euro-technical values.

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