CO-CREATION.

A Roadmap Towards Socially

Responsible Engineering Education.

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1. Summary

EuroTeQ universities express a clear goal in their mission statements: to be more socially responsible and contribute to sustainable development.

However, the connection between mission and practical implementation is often unclear. What is missing are resources on how to "do" responsibility in the classroom.

We collected data from teachers, students, teaching units, managers and stakeholders across the EuroTeQ universities to learn about challenges and opportunities for better co-creation practices.

This roadmap provides practical steps to bring social responsibility into engineering classrooms, enabling more inclusive engineering and technology development processes.

2. Abbreviations

- CBL: Challenge Based Learning
- CTU: Czech Technical University
- DTU: Danish Technical University
- EuroTeQ: EuroTeQ Alliance
- TalTech: Tallinn Technical University
- TU/E: Eindhoven Technical University
- TUM: Technical University of Munich

3. Who gains from this report?

3.1. Teachers & course designers:

- Practical steps on how co-creation could complement current teaching activities toward more societal responsibility
- Specific roles and responsibilities of the teacher - and which tasks to outsource

3.2. Innovation (space) managers

- Detailed information on recruiting stakeholders, including critical points for external communication
- Information on necessary resources and infrastructure

3.3. Research managers & administrators:

- Insights into necessary institutional framework and resources needed to support and incentivize co-creation teaching

3.4. Pedagogical units

- Clarity on a pedagogical framework, learning goals, and evaluation
- Insights into required up-skilling strategies for teachers

3.5. Policy makers

- Framework to strengthen technical universities' responsible role in society
- Proposal for excellent research & science focused on societal impact

4. Introduction

We are starting this roadmap by introducing the basics of co-creation. Why do we need co-creation? What does it mean for engineering universities? We look at how co-creation could be an answer to the existing missions of EuroTeQ universities and what steps our research team took to find meaningful pathways for this roadmap.

4.1. The problem

Technical universities are transforming. After controversies such as the VW diesel scandal, transport safety issues, or gender biases in facial recognition, engineering universities have been aiming to transform themselves with **a renewed spirit for societal responsibility and sustainability** (Martin et al., 2023). Part of the goal is to maintain trustworthy societal institutions (Geschwind et al., 2019). External pressure has recently grown, asking universities to produce societally responsible solutions through contact with external partners to maintain legitimacy (Pulkkinen & Hautamäki, 2019). Since many of the significant challenges of the 21st century, such as the climate crisis or the digital transformation, are “wicked” problems (Lönngren, 2017), the **need to involve diverse actors beyond academia** becomes progressively urgent.

This complexity requires **new tools and methods.** Quantitative methods are vital in technical universities as they put numbers on resource flows, expenses, and emissions. Yet, central figures within the engineering discipline call for more inclusion of the social sciences. For instance, Timothy Gutowski (2018) from MIT, remarked "**Where are the people?**" in large-scale quantitative modeling approaches. Life cycle assessment (LCA), for instance, is a popular tool to measure resource flows, but it would run short of adequately respecting human behavior,

preferences, and needs in its models. As such, quantitative approaches can produce unrealistic claims of future tech development at scale and can therefore lack an in-depth understanding of context (Taylor et al., 2013).

For example, focusing solely on quantifying material flows falls short when addressing waste management improvements. The intricate processes of collection, reuse, separation, recycling, preservation, financing, and maintaining the collection system involve **human participation in each step**. Consequently, these activities impact people's relationship to waste and influence their behavior in everyday practices (Ranzanto and Moretto 2018). Recognizing these interconnected aspects becomes more feasible through collaborative efforts between engineers and society.

In fact, engineering students are increasingly being requested to master the skills necessary for such **"bridge-building" with civil society**, organizations, and industry. This is evident from the high demand for communication and collaboration skills in engineering. Within the EuroTeQ ecosystem, collaboration partners have voiced a strong need for engineering students to improve **communication and dialogue** (EuroTeQ Engineering University 2022). Improving engineers' interpersonal skills for a more nuanced understanding of socially inclusive tech development are part of the more collaborative relationship between technical universities and society. By adopting this approach, universities can ensure future engineers will tackle real-life problems in a **systemic, holistic, and inclusive way.**

4.2. Our take on co-creation

As a result, members of the public are increasingly becoming **co-creators of tomorrow's technical solutions**. Such new approaches need to be strategically included in engineering education, as it is here where our future technical leaders are raised.

We define co-creation in line with Müller et al. (2021). Corresponding to the focus of the SCALINGS roadmap for innovation, participation & co-creation, we focus on the

second part of the definition, its opportunity for making processes more inclusive and responsible.

“The term “co-creation” broadly denotes the collaboration of **diverse actors**, such as **companies, universities, policymakers and members of the public**, in innovation processes. Co-creation is often understood as a way of sparking new ideas for innovation processes and making innovations more user-friendly and hence more successful in the market. However, at the same time, co-creation is also heralded as an opportunity for making innovation processes more **socially inclusive and responsible** because it allows innovators to integrate **diverse actors** into the innovation process”

- Müller et al. 2021, p.2

This roadmap shows **seven steps to make implementing social responsibility through co-creation with society more feasible in teaching**. Responsibility here not only includes the social but also the environmental sphere. We, therefore, see co-creation explicitly as an opportunity for sustainable development (Trencher et al. 2014).

There are plenty of **reasons** to look at co-creation practices in engineering education.

Research suggests the following potential benefits:

- Bridging between disciplines and expertise
- Inclusive technology development processes
- Empowerment of local stakeholders
- Democratizing expertise
- Enhanced partnership network
- Increased service quality
- More efficiency over the lifespan of a product
- Sustainable development through partnerships
- Deepening in-demand engineering skills

Source: Brandsen, Steen, and Verschuere 2018, Smallman and Patel 2018, Trencher et al. 2014, EuroTeQ Engineering University 2022.

The idea of co-creation relates to early discussions on public participation in tech development starting in the 1960s. However, the term “co-creation” was initially merely used in a business context (Prahalad and Ramaswamy 2000). Companies began to see **customers not as passive recipients of products but as active participants** in product development.

Over the years, co-creation has become more normative, reaching beyond using peoples’ insights for increasing company revenue alone. The term co-creation entered the policy arena and has, over the last decade, become an essential criterion of **“good innovation” in EU frameworks** (Meister Broekema et al., 2021). The implicit goal has frequently been to use co-creation to pre-empt the outburst of “irrational publics” against new technologies (Ruess et al., 2023).

It has thus often served as a strategy to avert techno-political controversies that have historically arisen in the realms of nuclear, waste, and food management, particularly with issues like BSE or GMOs.

However, there are many problems with this approach. A significant issue is that co-creation is often merely **seen as a way to “fix” technology development processes** (Frahm et al., 2022). Instead of a more open, transformative dialogue, the simple goal in such a view is to ensure the neatless uptake and dissemination of novel technologies. Such attempts have often served to advocate for and strengthen policymakers' preconceived ideas of technological outcomes **rather than improving dialogue for more democratic purposes** (Ruess et al., 2023).

Scholars working within Science and Technology Studies (STS) and Responsible Research and Innovation have stayed particularly critical of such a view on co-creation. They argue for a **shift from seeing the public as deficient** in the “right”

way of knowing and instead **argue for deeper dialogue with them** (Irwin, 2014; Stilgoe et al., 2013).

In addition, designers working with inclusion, Universal, and Systemic Design (e.g., Drew, 2021; Design Justice Network), as well as scholars within critical disability studies and feminist design (e.g., Bennett & Rosner, 2019; Friis & Sanchez, 2021, Carreras & Winthereik 2023) have been wary of similar concerns, and make a strong proposal for **designing for justice and accessibility.**

Their concerns applied to a co-creation context can be translated as follows:

- How can we increase public participation in science & technology processes?
- Whose perspectives are included and excluded in co-creation processes?
- How can we open up processes for diverse perspectives and experiences?
- Who benefits, and how can we create a win-win situation for all participants?
- How can we ensure the process matters as much as the outcome?

The recommendations found in this report result from aligning field observations towards such concerns around inclusive participation.

4.3. Where are our universities going?

Indeed, pleads for a more responsible relationship between tech development and society are not solely discussed in academic literature. As the following page shows, the EuroTeQ universities' missions show that they all **strive to become more socially and environmentally responsible institutions**. Yet, there are a lot of different paths our universities take.

Eindhoven University of Technology

- Advancing knowledge in science & technology for the benefit of humanity
- Tackling challenges of a sustainable world, the technology revolution, and the impact of technology on society

- Furthering collaborations with industry and civil society

Source: TU/E strategy 2030

Czech Technical University

- Attention to the societal dimension, promoting diversity and participation of different groups, and engaging in the mitigation of social disparities
- Excellence in education, science, technology, innovation and application that contributes to the
- betterment of society

Source: CTU Strategic plan 2021 +

Tallinn University of Technology

- Encouraging academics to interact with the general public
- Aiming for smart solutions for a climate neutral digital society

Source: TalTech strategic plan 2021-2025

Technical University of Munich

- Human-centered engineering
- Shaping the future with talent, excellence and responsibility
- Integrating the humanities and social sciences
- Taking political, ethical, and economic aspects into account

Source: TUM Agenda 2030

École Polytechnique

- Supporting Innovation, scientific excellence, and serving society
- Grounded in science and conscience, sustainable development & social responsibility

Source: I’X Our missions

Technical University of Denmark

- Towards Technology for people
- Serving the benefit of society
- Sustainability through green tech & education

Source: DTU strategy 2020-2025

4.4. How did we proceed?

The data in this report derives from qualitative research across the EuroTeQ universities, mainly conducted by the author herself and supported by data and feedback from BoostEuroteQ colleagues, university staff, external stakeholders, and students. Most data was gathered between early 2022 and end of 2023, with the last three events taking place in 2024.

A Grounded Theory approach inspired the seven steps for co-creation teaching (Corbin & Strauss, 2008). Following an inductive approach, the coded data allowed us to see overarching categories. Those categories were then scrutinized from the perspective of inclusive and responsible co-creation, as described earlier. In addition, we added organizational ideas to help manage classes efficiently.

The following steps were taken:

- Course selection based on finding co-creation like criteria across EuroTeQ ECTS courses
- Online & offline participant observation in 11 classes
- Single & group interviews with 31 students
- 8 interviews with teachers & course organisers
- Interviews with 9 teaching & learning professionals
- Report on “indicators for co-creation teaching”

- 2 Workshops with teaching & learning professionals
- Feedback Boost EuroTeQ research team WP4-6
- Feedback from external stakeholders
- Roundtable discussion across teaching & learning units, university management and course designers

5. The starting point

A quote from a EuroTeQ engineering student: “Usually, as an engineer, you reach a wall, and you try to break it. But if only I could find more ways to go around the wall, instead of just tearing it down… I hope that my problem solving and people handling abilities would improve for the future.”

5.1. The role of engineers and technology

Co-creation relies on a specific understanding of the role of the engineer in society. We propose the following conceptual starting points.

- **Engineers are more than technical experts.**

They are bridge builders for a better society who need to be able to listen, package, and communicate knowledge (Boomsma 2021; EuroTeQ Engineering University 2022).

- **Technical solutions work best when considered in context, rather than in isolation**.

They are embedded within socio-technical systems. Engineers need to be familiar with the socio-political context and the relationship between actors (Hersh 2015; Greenhalgh et al. 2016).

- **Technology development needs to center human experience beyond “users”**.

Solutions improve in quality and efficiency once we see people as collaborators, everyday-life experts, or citizens (Brandsen, Steen, and Verschuere 2018).

- **Engineers need to focus on processes**, **not only on products**.

Products often receive most attention in engineering education. Yet, we need to foreground the processes of technology development when co-creating products as they determine how inclusive and responsible a product will be, and how it will interact with larger systems of power (Greenhalgh et al. 2016).

5.2. Requirements for co-creation in engineering courses

Co-creation in the classroom requires an applied context. Completely theoretical courses are therefore not suitable. These three parameters are minimum requirements for successful co-creation in education (adapted from Voll, 2023):

- Collaboration in a real-life context
    - “Real-life” case
    - Complex problem framing
    - Engagement with different forms of expertise

  Time & space for proximity-seeking activities (site visits, interviews, observation, …)
- Holistic student experience
    - Student ownership and emotional experience
    - Space for dialogue
    - Working through different value-systems
- Pedagogical setup for multi-layered learning experience
    - Teacher as “scaffolder” of learning journey
    - Mixture of theoretical and hands-on sessions
    - Methods for exploration and reflection
    - Learning goals reflecting more than technical knowledge
    - Multi-layered evaluation

5.3. Crossroads: CBL, Design Thinking, Co-creation

During our fieldwork, we realized that one might quickly become confused with the diversity of concepts describing a more active, participatory learning approach. Questions were asked about the relationship between co-creation, Challenge-based learning (CBL), and Design thinking. The following pages show a summary and a detailed table of similarities and differences (Table 1).

How is co-creation different?

In short, **CBL** emphasizes student learning. The pedagogical concept emerged in response to the perceived necessity for engineering students to acquire contextual skills relevant to addressing challenges in the modern engineering workplace. The focus so far has primarily been on the individual student and their learning outcome rather than large-scale societal transformation. However, there are increasing attempts to focus on "societal impact."

Design Thinking highlights human experience, underscoring user preferences and adaptability. The "humans-first" approach guides where design thinking takes its point of departure. A user-centric perspective opens up for diverse voices; risks and consequences are analyzed for the individual user, less so for society at large.

As presented in this roadmap, **co-creation** differs as it is intricately linked to the call for increased participatory engagement between the public, science, and technology. There is no "go-to" method for co-creation; all potential methods are scrutinized under the criteria of enhancing inclusivity and amplifying marginalized communities' voices. Qualitative methods play a significant role in this.

Similar to Design thinking, co-creation strongly emphasizes iteration and collaboration to identify and address people's everyday life issues. Its uniqueness lies in the commitment to mutual responsibility and reciprocity, characterized by viewing stakeholders not merely as consumers or users, but as partners, collaborators, and experts in everyday life.

Table 1. Overview of participatory approaches across universities studied.

	CBL	DESIGN THINKING	CO-CREATION
OCURRENCE	Primarily TU/E, growing at CTU, DTU, TalTech.	Primarily DTU, to a lesser extend TalTech.	Primarily DTU and TUM.
HISTORY	Pedagogical concept in higher education. Increasingly used after 2001.	Departing from “Design school” that tries to target and intervene in “root” behavioural causes of contemporary problems.	Initially from the business world, concept more widely spread in policy context since the 2010s.
GOAL	T-shaped engineer, student learning & student benefit. Experiential or inquiry learning for a global mindset.	Systemic view on design by integrating perspectives from user standpoints. Human-centered design.	Public participation, democratizing science & technology. Inclusion, responsible tech-development, and systemic view on socio-technical change.
TOPICS	Globally important (sustainability, war).	Diverse, from big to small. Increasing initiatives around design for social justice and sustainability.	Both global and local. Focus on social and environmental sustainability, social justice, and democracy.
MULTI-DISCIPLINARITY	Aims for multidisciplinarity but currently focused on STEM field (engineering, computation).	Designers as bridge-builders between different disciplines and (business) contexts. Little, though growing, attention to STEM field.	Aims to bridge social and technical disciplines, includes social science methods.
PROCESS DIMENSION	Receives attention, however little critical reflection on benefits and drawbacks of methods.	Focus on iterativeness and human-centeredness. Double Diamond (divergent & convergent phases) as guiding with strong focus on finding the “right” problem. Partly seen as a method in itself.	Not uniform, but strong reflection on benefits and drawbacks of participatory methods and on the risk of “scaling up” co-creation since this might disrespect local contexts.
EXTERNAL STAKEHOLDERS	Primarily industry, growing inclusion of cultural domain. Reflection on stakeholder’s role in society beyond affiliation (“industry”, “culture”) largely missing. Little information on input, perception and evaluation of collaboration.	High degree of influence and attention to user needs. “People first approach”. Risks analysed for users, not broader stakeholders or society at large. Validation process with stakeholder is present, but often rushed. In the classroom setting, the validation process can be truncated.	Previously business, now focus on civil society & (digital) public services. Diverse roles of society: as partners, collaborators, (everyday life) experts, rather than users or consumers only. Attention to reciprocity, including marginalized voices, and reflecting on societal role of stakeholders.

6. Pathways

In the following sections we detail seven important steps for responsible engineering education:

6.1. Inviting

The first step deals with **inviting connections that allow for diverse perspectives.** We observed that many cooperation partners at EuroTeQ universities are medium- to large-scale companies. Such connections to business can yield valuable work experience for students, giving them insight into work structures and current market development. A potential risk we see is "responsibility-washing," where corporations that primarily rely on environmentally or socially unsustainable businesses portray themselves in a more "clean" and collaborative fashion than responding to their everyday practice. Here, it is essential to **discuss a company's overall business model critically** in the classroom. Large companies often come with **narrowly defined problems and solutions** that need to fit current customers and markets.

An issue we notice is that students, due to the power dynamic, end up unquestionably making the company's problem formulation their own without engaging in more innovative approaches outside the status quo. This limits the transformative potential of co-creation, as people's needs come after commercial pathways (Engage2020 Consortium 2015).

We encourage a diversity of partners, including the **public sector** (e.g. waste management, digital agencies), **NGOs** (e.g. disability organizations, environmental groups, organizations for homeless people), or **cultural actors** (e.g. artists, sport clubs, museums). Those actors are invited to collaborate on a challenge that matters to them.

A diversity of actors ensures that people are seen through equally diverse lenses, as **concerned, engaged, creative citizens, rather than product users alone**. As part of becoming a responsible university that takes a plethora of societal needs,

particularly those of marginalized voices, seriously, inviting diverse collaboration partners is an important though often forgotten step. At the same time we need to be aware that some partners are more eager or available than others. Understanding how to lower barriers for participation for hesitant or low-resource groups is therefore important.

To collaborate or not to collaborate?

Eindhoven University decided to listen to student concerns: A group of students raised concerns about the university's strong collaborations with unsustainable companies. TU/E staff now develops a criteria list defining with whom TU/E will collaborate in the future, and which partners are not considered sustainable partners.

- Decide on a boundary spanner. A person or division (e.g. Innovation or Outreach unit) is needed that takes care of the process. This person or unit will coordinate the interaction between university and external partner.
- Take stock of existing collaboration partners. Is there a tendency towards one industry or sector? Each country has their own tradition with local partners. Consider potential blind spots.
- Invite new partners in. Consider diverse channels. To increase diversity, collaboration partners could be publicly invited to apply for collaboration (e.g. SoMe, university fairs). An idea could be a workshop with the external partners where the collaboration framework is presented.
- Lower the obstacles for participation. Consider that resources to participate are unequally distributed. Make sure to lower obstacles for low-resource organizations by having a clear "onboarding" process in place.
- Manage expectations. The external partner should know about estimated time investment for introducing their case, providing feedback, and the need to provide basic data about their challenge. Some external partners have high expectations on student performance; the boundary spanner should introduce the pedagogical framework and learning goals to find a shared vision. Mention that the stakeholder also needs to be open to onboard on a learning journey.

- Pinpoint benefits of collaboration, such as receiving innovative ideas, interacting with a new target group (students), raising awareness for a topic, supporting educational development, opening doors for potential future interns. Also point to limits, as students should not work as company consultants.
- Keep a database for overview. Ideally, this database will be known and accessible for course designers and outreach partners across campus. It could contain a brief description of how the collaboration went.

6.2. Framing

Since co-creation aims to bridge different forms of expertise and invite different disciplines to interact, **finding a suitable problem formulation is crucial.** A problem formulation that is too narrowly defined risks excluding students and the transformative potential of co-creation. With the complexity of today's problems, it is more necessary than ever to question the established approach to defining problems. On the other hand, a too-broad formulation risks that students don’t know where to start. A suitable problem formulation allows all students to contribute with their disciplinary knowledge.

It also allows to collect new data and collaborate with groups of people previously disregarded in answering the question. The external partner and university staff (e.g., course designer) must first frame an initial problem formulation for students to start with.

Later in the co-creation process, students must be active and find people who relate to and have knowledge on the problem. Students thereby, step by step, narrow down the initial problem through investigating the case.

A challenge with this is that many engineering students are used to being given a concrete problem to calculate the right solution. The diversity and uncertainty of solutions inherent to wicked problems can be challenging for engineers (Lönngren, 2017). Co-creation courses differ in that they offer the possibility to zoom out and investigate the issue from a variety of perspectives. While this is out of the comfort

zone of many students, it seems students can yield beneficial insights, as the quote on the next page shows.

Students learn to approach an engineering problem from different angles: “What I have learned as a software developer, is that you get a problem, and you solve it. You don’t look at different perspectives of that problem. But by taking this course, I have learned that you can zoom out of the problem, and have different angles. It is like a bird’s view. This course actually teaches engineers to look at the problem, not only as a problem, but there might be something else that could be the underlying cause of that problem.” Quote from a Student in computer science after participating in an explorative course format.

Example: low and high co-creation potential

Low co-creation potential:

How can the battery performance of e-cars be optimized by 20%?

- Narrow disciplinary boundaries
- Requires high level of specialized knowledge
- Limited solution space with little space for interaction with non-technical experts

High co-creation potential:

How can sustainable transportation become more accessible by 2030?

- Open disciplinary input (renewable energies, behavioral sciences, transportation, business, ...)
- Invites interaction of traditionally neglected actors (e.g. people with physical limitations, rural residents, the elderly)
- Broad solution space

6.3. Locating

Locating here relates to the practical set-up of co-creation courses, including the physical and digital space, as well as material and tools.

Co-creation doesn't need a "fancy" location. Any combination of lecture hall and group working spaces is suitable. However, most universities connect to innovative spaces where co-creation activities could occur for additional benefits. At the EuroTeQ universities, we particularly see **DTU Skylab, TU/E's Innovation Space, TalTech's Mektory, and Munich Urban Colab as promising spaces.**

On the one hand, those places offer enough space for student teams to work undisturbed in groups. On the other hand, they provide material resources that come in handy when experimenting.

Students can use printers, Lego, or post-ITs to make the collaboration experience more playful. Sometimes, co-creation courses also go as far as to develop and test prototypes, and access to machinery and tools makes it easy to test out simple ideas.

Some collaborative spaces also include a bigger lecture hall, so that a course can swiftly move between theoretical input in plenary and practical sessions. Both in Skylab and Innovation Space, the places to meet for lunch or coffee are designed to be central parts of the building, and students can continue talking more informally. Since co-creation courses are often very interactive, time to get to know each other during a break can be a comfortable add-on.

Even though it cannot be covered in depth here, there are guides for how to design inclusive and accessible classroom (more resources can be found at the end).

The place where interaction with the external partner takes place, should generally be **aligned with their needs**. For instance, people with cognitive processing challenges might prefer collaborating asynchronously with students through digital platforms, rather than being part of larger workshops. To adapt to a hybrid format,

many digital methods can be used for co-creation activities. A frequently used tool is miro where participants can work together digitally in real time.

If partners want to meet in person, **the place should be convenient and stimulating and/or allow students to gain insights into the contextual nature of the issue**. For instance, when working on accessible transportation, students could follow the partner through their day, or visit a trainstation for participant observation. If the partner is a wheelchair user or has another physical disability, students need to make sure the meeting location is accessible for them.

Innovative Spaces: best practice for co-creation

Advertise opportunity to host collaborative events across campus.

Introduce teachers to the setup & functioning of the space.

Broaden ways to attract a diverse student body (e.g. DTU introduced “Food Lab” besides more traditional welding machines, to attract more female students).

Provide Low- and High-tech tools (e.g. whiteboards, Post-ITs, tongs, 3D printers)

Offer lecture hall and groupwork spaces

Allow external stakeholders to be welcomed in a meeting place

Host a space for non-work related activities (e.g. cafe)

Figure 1. Picture of two students who are in front of a writeable wall at a groupwork space at DTU SkyLab. One of them is touching a PostIt on the Wall. There are some words written on the wall.

Figure 2. Students sitting on hexagon shaped tables together, watching towards a person with a microphone who stands at the front. There are other students standing at the front of the classroom, indicating they have been taking part in a group presentation.

Students need to **experience** co-creation: “The most important thing is that it's a **hands-on learning experience**. They have to try it. Giving **lectures** about co-creation isn't the same thing (...). Intertwine it with them actually being able to **plan and facilitate workshops** because **learning from experience** usually brings much more into the brain.” Quote from a Teacher working with co-creative methods.

6.4. Teaching

In many aspects, co-creative teaching differs from the status quo we currently see in the majority of EuroTeQ classes. That’s not always easy and needs preparation and support throughout the process. Teaching co-creation courses can be fun, but at the same time, it often requires new tools and skills for the teacher. To begin with, it means more resources and work hours. It’s also important to accept that co-creation and interactive formats, in general, are not every teacher’s thing. If anything, we

know from our analysis that **teachers need sufficient training, institutional support, and assistance** in preparing and conducting co-creation courses.

Indeed, co-creation might seem more relevant within some study lines than in others. However, all study programs that directly and indirectly deal with planning and designing engineering systems (transport systems, energy systems, waste systems, cyber systems, …) will in some way need to **deal with human behavior and diversity** and are therefore suitable to include co-creation.

A good starting point in class therefore is to explain to students how co-creation for responsible engineering complements their education and what they can expect to learn in the course.

Teachers can use various frameworks to guide co-creation, while some core principles remain. We often saw the classic Double Diamond ("Discover, Define, Develop, Deliver") used in explorative course formats. Another approach from Software Development is the Agile framework ("Plan, design, develop, test, deploy, review, launch").

Engineering students are often mainly familiar with the stages of developing and delivering a product. To foster co-creation for responsibility, **we emphasize exploring the problem from multiple viewpoints and reevaluating first assumptions over just concentrating on the final product.** The Double Diamond and Agile framework can be used for co-creation with these focal points in mind.

When entering this explorative field, teachers should have **knowledge of the people and cultures** that they cooperate with. For instance, when working together with a fem tech company on app-based cykletracking, it is important to have done prior research on how potential users refer to themselves; not everyone who menstruates refers to themselves as a woman, and people who identify as a woman do not automatically menstruate. Teachers should bring those nuances into their lectures and also allocate time in the course schedule for students to conduct desk research before doing fieldwork.

The teaching team therefore **juggles multiple roles, acting as coaches, experts, moderators, and science advisors.** During a class debate, the teacher guides the conversation to ensure that arguments are balanced, constructive, and inclusive of all perspectives. This teaches students how to engage in respectful discourse and models how diverse opinions can coexist and enrich understanding. In coaching a group session, a teacher or assistant actively listens and asks open-ended questions, steering students toward self-discovery and collaborative problem-solving. They provide feedback and strategies tailored to the group's dynamics, **empowering students to set and achieve collective goals.**

Example: defining learning objectives. Inspired by a co-creation course at DTU, combined with own ideas.

A student who has met the objectives of the course will be able to:

- **Justify** which problem focus is legitimate and relevant to pursue based on different expertise and perspectives.
- **Analyze** how a technology interacts with and might impact other social, political, environmental, economic and technical systems.
- **Evaluate** the advantages and disadvantages of involving different expertise at specific times in the development processes.
- **Identify** how the development process can be made more inclusive.
- **Combine** and **evaluate** co-creation methods.

Example: setup of a co-creation course at DTU

- Weekly changing format
    - Alternating between academic lecture and workshop/ experimental session
- Uses Double Diamond
    - Focus on discovering of problem formulation together with external partner
    - Time for reviewing the problem statement
- Students choose methods from DTU’s Playbook for Universal Design

- Supervision and feedback through teaching assistants and teacher
    - Staff is experienced in theory and practice of co-creation methods

What do teachers need for co-creation teaching?

Each university has its way of developing teaching. Since co-creation teaching differs from the traditional lecture format, the following shows some of the possible “ingredients” - some might be more relevant than others in your context. The support from educational staff is crucial, as they have time to think about and develop frameworks.

- **Communication skills** (e.g., facilitation, conflict resolution, supervision)
- **Knowledge of co-creation tools, methods & principles** (e.g. workshop formats, interviews, digital tools, knowledge of co-creation history & dilemmas)
- **Organizational support** (e.g. teaching assistants, coaches, training in interdisciplinarity and inclusivity)
- **Infrastructural means** (e.g. material resources, facilities)
- **Performance management tools** (e.g. integration in learning objectives, evaluation tools)
- **Incentives** (e.g. opportunity to learn new skills, increased network, internal recognition)

Recommendation

Useful guides introducing participatory methods such as **Interviews - participant observation - camera journaling - community mapping - participatory games - multicriteria mapping - desk research** can be found at the end of the document.

Teachers also need awareness of their **target group:**

“The diversity of students is striking. For some engineers, the appreciation of human beings is a big step. For others it is not. **Architecture starts from humans,**

whereas data science starts from 0s and 1s. This makes a huge difference!" Quote from a Teacher involved in bridging humanities and engineering sciences.

6.5. Interacting

Interaction happens primarily between three different parties: Teaching staff, students and external partner(s). Here, we want to particularly focus on the interaction between students and between students and stakeholders.

When students had to choose their own team, the situation has often been described as "awkward". An opportunity to avoid this is to have a structure in place, which places students in groups based on their discipline, interest, motivation, gender and/or personality trait. While this process is more time-intensive, it increases chances that student groups are **diverse and interdisciplinary**.

The students can be asked to **choose a specific role in the group**. A student experienced in facilitation can act as the facilitator in the group. The facilitator role oversees the progress, keeps time, and guides the discussion to other methods when the team is stuck.

Co-creation, though, is more than "group work". Another important part of co-creation is the dialogue with external stakeholders. A major question here is how to interact for mutual benefit. This ethical consideration is especially important when dealing with socially vulnerable people, and partners or organizations with limited resources. Often, collaborators dedicate their free time, ideas and knowledge to a project and should not be "exploited".

Example: The EuroTeQ Collider course

Our universities are at different starting points when it comes to student interaction. In some universities, groupwork has been called suspicious because it seems like "cheating". In such cases, explorative formats such as the EuroTeQ Collider can

bring a first flavour of what collaborative learning could look like. On the other hand, group work is already well established in other EuroTeQ universities.

The EuroTeQ Collider is an initiative of the EuroTeQ universities. Within the course, students solve a real-world problem through **critical thinking, creativity and collaboration**. In some universities, it is an extracurricular activity, while it is part of a curriculum in others.

The topic is linked to a relevant global challenge, such as “Leaving no Waste behind” or “Enhance connections for sustainable futures.”

The categories offered are a track on “nature”, “technology”, and “people”. The Collider thereby opens up to diverse pathways for socio-technical change for more sustainable futures, **considering technical, but also social innovation.**

There is no one-size-fits all solution to how fair benefit sharing looks like; an important milestone is to **communicate expectations and potential outcomes both initially and continuously during the project**. The orange box provides suggestions for fair collaboration with community partners. These collaborations emphasize the reciprocal nature of partnerships, focusing on objectives like community welfare, educational enrichment, and societal impact.

Reciprocity looks different when cooperating with large corporations. As mentioned in a previous BoostEuroTeQ report (Voll, 2023), there is a risk students are merely seen as “free labor” doing corporate work. Companies can likewise give back to students. As an example, a company who collaborated in an innovation course at DTU has offered additional coaching for students, if their final idea had the potential to be continued after the course finished.

Questions to consider for a **win-win** situation in community collaborations:

- How would the interaction be sustainable for the partner? Which **economic, social, or material exchanges** are possible?

- What is their **imagined role** in the project? Are they consultants, experts, or someone who shall be “fixed”? Which role do they want to play?
- What happens **after the project** has finished? What about sharing data, accreditation and intellectual property?

Our 6 principes for systemic design

Interaction needs to be guided by ethical standards. These six principles have been suggested for systemic design and represent a way to frame responsibility in interactions within and outside the classroom.

1. People and planet centered
- Focus on the shared benefits of outcomes for humans and the environment
- Based on respect for symbiotic relationships
2. Zooming in and out
- Between personal problem to systemic structures
- From the present to the future
3. Testing and growing ideas
- Making things to test their effects
- Including constant feedback to grow the product/service
4. Inclusive and welcoming difference
- Creating safe, shared spaces and language
- Bring in multiple and marginalized perspectives
5. Collaborating and connecting
- Seeking relationships to other projects, actors, developers
- Connecting the project to a wider movement of change
6. Circular and regenerative
- Focus on existing assets (social and physical)
- Value what is there before adding the “new”

Principles adapted from Drew, Cat (2021)

6.6. Evaluating

Evaluation in this context encompasses the assessment of students and more open-ended evaluations during the co-creation process.

First, we explore grading. Multiple-choice questions don't fit the context because they may fail to assess critical thinking, problem-solving, and creativity, essential for handling intricate and nuanced challenges. Since co-creation activities are not linear but iterative, reflective, and explorative by nature, **assessments need to mirror this complexity.** Yet, how universities assess, and grade depends on local tradition, options, and course flexibility. We, therefore, present various opportunities to assess students in co-creation courses.

Grading of the individual student and/or the whole group is possible. On the process dimension, this could be done by asking students to answer questions about specific criteria such as the inclusivity of their co-creation process.

The teacher can then assess, how well the students integrated academic literature or how well they addressed inclusivity in practice to improve the co-creation process. On the product dimension, students can be evaluated on a tangible outcome, for instance, a poster presentation or a short video clip.

Ultimately, the uniqueness of co-creation lies in the opportunity to co-evaluate as part of the co-creation processs. Here, co-evaluation with the external partner is **an opportunity for connection and deeper understanding** of each other's preferences.

6.7. Embedding

As part of this, both students and external partner engage in ongoing evaluations, providing feedback, assessing progress, and jointly determining the project's success based on academic and real-world criteria. For example, a student group

working on improving digital healthcare for patients with chronic pain might initially think of "ease of use" or "aesthetics" as relevant criteria for a new digital health platform. In dialogue with chronic pain patients, however, the students discover that "reducing screentime" is the most desired digital healthcare improvement. Students need to gather enough valid data. Upon finishing, they can collectively decide, which criteria to prioritize. Ideally, such exercises are used as part of the co-creation learning process. Outcomes will be discussed with a teacher or coach so that students can reflect upon different positions. This is important because **there is a risk that students unquestionably take the opinion** of the co-creation partners as final.

Teachers can guide their questions to help students reflect on the validity and scope of collected input and point to other relevant experiments or literature. For instance, Richard Sclove (1997) offers design criteria for democratic technologies that can serve as additional inspiration for students to build responsible technologies.

While including the external stakeholder in a final presentation is beneficial, we still think the teacher should do the final grading by relating outcomes to learning goals. External partners are though welcome to join the final presentation, ask additional questions, and to participate in an evaluation of the course as a whole. Again, **informing them about the course's learning goals can be a good idea**.

Description of different forms of evaluation:

- Collective exercise in co-evaluation, possibly involving both qualitative and quantitative parameters (e.g. criteria ranking & evaluation interview). Benefit: students expand their perspective through the co-evaluation process with external stakeholder. Co-evaluation progress needs to be discussed critically with the teaching team, which provides feedback and guidance (e.g. academic literature, group feedback).
- Student assessment can be both on individual and/or group basis and include the process and/or product dimension. **Process dimension**: students are assessed on their answer to process questions, e.g., Are there barriers to

participate in your project? How will you ensure the participation of disadvantaged groups? Benefit: Allows students to reflect on positionality and inclusivity. **Product dimension:** e.g. audio/visual outcome, or co-creation playbook including methodological reflections Benefit: students are often motivated by tangible outcomes; yet, too much focus on product dimension risks taking the focus of the problem framing phase.

Our research showed that **new educational formats must be backed up within the institution**, ideally by top management. This is particularly relevant for countries where group work might be regarded as outside the norm, as described in the case of I'X, CTU, and TalTech. In other countries such as Denmark, group work is already normalized in the educational system, where pupils collaborate in groups from an early age. While our universities might, therefore, use different routes for embedding co-creation teaching to safeguard the longevity of co-creation courses, **each institution must own such formats to ensure continuation**. It is the most efficient way to ensure that classrooms, teachers, and pedagogical units will be adequately equipped in the long run.

"Marketing" co-creation to management, including advertising practical pathways and case studies, is particularly relevant here. This roadmap hopefully delivers both arguments and action steps forward.

Various co-creation initiatives and support structures are already underway. The EuroTeQ Collider offers an opportunity to integrate co-creation with high standards across EuroTeQ. At TalTech, "How does it work?" events show teachers new styles of teaching and offer a platform for exchange. At two universities, we already see a lot of co-creation activities happening, and the continuation and deepening of those is encouraged; specifically, DTU's section for Human-centered Innovation and the program Design & Innovation, and TUM's Department of Science, Technology and Society have been heavily engaged with co-creation as a practice and research subject.

More generally speaking, specific groups at university, such as pedagogical units, innovation spaces, or Science, Society and Technology Studies (STS) units, need to take the lead even more in the future. It is here where most expertise about co-creation at technical universities lies. At the same time, amongst those units we observed a wish for co-creation to penetrate also the "hard sciences"; **more case examples and experiments will be helpful to pave the way.**

Extra-curricular activities present a chance to integrate and nurture courses centered on co-creation in parallel to the existing curriculum. For instance, at TUM, the curriculum development moves towards “Plug-In” modules, which students can add to the existing educational curriculum.

Opportunities for embedding co-creation formats at EuroTeQ universities:

- EuroTeQ formats (e.g. Collider, Microcredentials)
- Extra-curricular activities or “PlugIn Modules” (e.g. @ TUM)
- Raising awareness amongst curriculum designers & managers
- Introducing co-creation to teachers through pedagogical workshops & teaching courses
- Co-creating and adapting pedagogical strategy

Microcredentials offer another opportunity; however, during our research, it became clear that microcredentials, very literally speaking, only present a micro-management solution to a topic that needs to be embedded in university strategies more broadly. Such strategies must move beyond buzzwords and could use insights from this report to specify responsible engineering education. Broader **discussions with curriculum designers and management need to follow.** Another way forward is for our universities to join other national or supra-national commitments. In the UK, for instance, the Civic University Network exists as a network of universities committed to deepening the connection to civil society, particularly to marginalized people.

Another part of embedding and valuing new teaching skills is intentionally attracting talent with experience in co-creation activities and skills such as group facilitation.

Another way to frame this is to include knowledge and dedication to the societal impact of research into future job applications for researchers and teachers. If the goal is to consequently allow for more diverse voices in tech-development, the long-term goal should also include onboarding people from marginalised positions in course development. More leadership and political support in this direction would be helpful.

Next steps:

- Establish a database of “best practices” where emerging initiatives will be listed (e.g., which type of “open framing” has been succesful? How was student progress?)
- Continue the sharing of cases and examples across EuroTeQ
- Learning from examples outside of EuroTeQ (more resources can be found at the end)

7. Conclusion

Co-creation emerges as an important tool for shaping the skills of engineering students, offering them valuable insights that extend **beyond traditional STEM knowledge.** The process not only imparts new and highly significant skills to students, but also plays a central role in expanding their mindset, encouraging a more holistic understanding of problem-solving. Despite its undeniable importance, we need to recognise that co-creation is often challenging and unfamiliar, as it is **placed in a paradigm shift within engineering education** that both educators and students must grapple with.

Acknowledging that co-creation teaching is part of a broader societal transformation towards more diversity means we need to focus on deliberate next steps, as small as they might be. We hope this roadmap serves as a practical companion on the journey.

While uncertainties and unanswered questions persist, it is imperative to move beyond theoretical discussions and put these concepts into practice. **Testing and refining** our understanding of co-creation in real-world educational settings will be instrumental in uncovering its full potential and addressing any challenges that may arise.

The journey to embrace co-creation in engineering education is an ongoing process, requiring a **commitment to incremental change, a willingness to experiment and learn from each other.** The ongoing evolution of co-creation carries the exciting promise of nurturing graduates who not only possess technical proficiency but are also equipped with the “human skills” crucial for successfully navigating the complexities of the future.

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9. Further resources

In this section we index relevant sources and projects related to co-creation and responsible technology development.

9.1. **Participatory methods**

- Community places. 2022. “Guide to Engagement Methods.” Belfast: Community places. https://www.communityplaces.info/sites/default/files/Community%20Places%20-%20Guide%20to%20Engagement%20Methods%20%282022%29.pdf.
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9.2. **Pilots, Research Projects and Labs working with inclusion**

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- Disability Justice & Crip culture collaboratory, Carleton University: - https://www.djccc.ca/
- MetaLab and MACH’s AUF collaboration Vienna: https://machs-auf.at
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9.3. **University Networks for collaboration with Civil Society**

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Note: Student and teacher quotes have been slightly adapted to enhance readability.