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EXAMPLES OF ENABLERS FOR CURRICULUM AGILITY

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ABSTRACT

Within six institutions, Chalmer's University of Technology, Delft University of Technology, Eindhoven University of Technology, NTNU, Queen's University Belfast, and Umeå University, activities of self-mapping Curriculum Agility have taken place, facilitated by the co-creators of this work. In this paper, they reflect on enablers of Curriculum Agility that they identified during the self-mapping process at their respective institutions. By putting a spotlight on enablers, ways to overcome obstacles are exemplified, when the ambition is to proactively futureproof an engineering curriculum. These enablers help in four curriculum innovation areas, which each have their own challenges: (1) Continuously adjusting learning content in courses, creating a need for a teaching and learning system with more dynamic learning goals and on-the-go, reciprocal expertise development. (2) Implementing or refining flexible education pedagogy and didactics to tailor to and being inclusive of the diverse student populations entering university. (3) Working with a responsive organisation and a continuously-change-facilitating management, where engagement and ownership of educational innovation is shared, and innovation space is constructively created where desired and needed. (4) Continuously developing all academic staff involved in engineering education innovation, for informed decision-making and shared understanding of the pedagogic and (inter- and trans-) disciplinary innovations needed to keep the engineering programme relevant and of high quality. This paper highlights positive examples of Curriculum Agility, and how its characteristics and principles can be implemented in a variety of university contexts with different organisational structures.

KEYWORDS

Curriculum Agility, Transformative Curriculum Change, Futureproof Engineering Education, Change Management, Standards: 1-12, Optional standards: 1-4

INTRODUCTION

The concept of Curriculum Agility (Brink et al., 2024a) emerged from the need for educational systems to be more responsive to rapid changes in society and technology, and widening student population characteristics. The student population has become more diverse due to successful inclusion efforts and lifelong learning developments, creating a need for curricula that can be tailored and adapted promptly to meet a diverse range of individual needs. Technology is present to enable this. Online resources, digital classrooms, and AI-driven adaptive learning systems encourage a shift towards dynamic, customizable learning experiences. With the rise of technology and globalization, the skills and knowledge that are relevant for students to learn quickly become outdated and are in need of continuous adjustment (Kamp, 2016). Employers seek individuals who can adapt, think critically, and innovate (Malmqvist et al., 2022), and society needs graduates who are able to work on global sustainability challenges (Hanstedt, 2023), which are both complex and uncertain. Existing curricula need to be adaptable to prepare students for this increasingly unpredictable world, resulting in numerous concepts of 21st century skills for digital literacy, sustainability, and social transformation (Kopnina, 2020) (Hoggan, 2016). That the changes deemed necessary are ever developing is evident in the sub-themes of this conference, which includes ethics, emotions, and transdisciplinary approaches.

In an era of constant demands for updates to engineering curricula, guidance is sought to make curricula more agile. This concept of Curriculum Agility has been developed between 2018 and 2023 in a series of focus group sessions with engineering education practitioners and experts. Throughout these co-creational and iterative sessions, Curriculum Agility was defined an on-going innovative framework for establishing a responsively organised education, with dynamic learning contents and flexible pedagogy and didactics, and with all involved staff continuously developing competency to deal with the necessary transitions. Figure 1 highlights these four core characteristics of Curriculum Agility and ten principles that directly influence such responsive curriculum change processes (Brink et al., 2024a).

When course content is more dynamic it can be responsive to relevant developments in a timely manner. Pedagogy and didactics that are flexible and tailor-made help the learning experiences of an ever more varying student body. When the organisation and management are co-creators in curriculum development, their informed involvement in desirable changes grows with their responsiveness. In that sense, staff development is pivotal in educational innovation not only for teaching staff, but for all who are involved in the design, decision making, and operation of the engineering curricula.

The ten principles of Curriculum Agility emphasise dialogue in a proactive approach for all stakeholders involved in curriculum development, change, and innovation. Note that they are not one dimensional and do not have a single solution or absolute measure defining them. They accommodate the local values and context, making Curriculum Agility more inclusive and relevant in a worldwide engineering education setting. They cover education, organisation and overarching themes. When discussing curriculum change on programme level in both local institutional contexts and broader academic cultures, numerous barriers were mentioned. These barriers made it challenging to increase flexibility and responsiveness, even when the need was recognized within the participating higher education institutions. The barriers were the grounds for the principles.

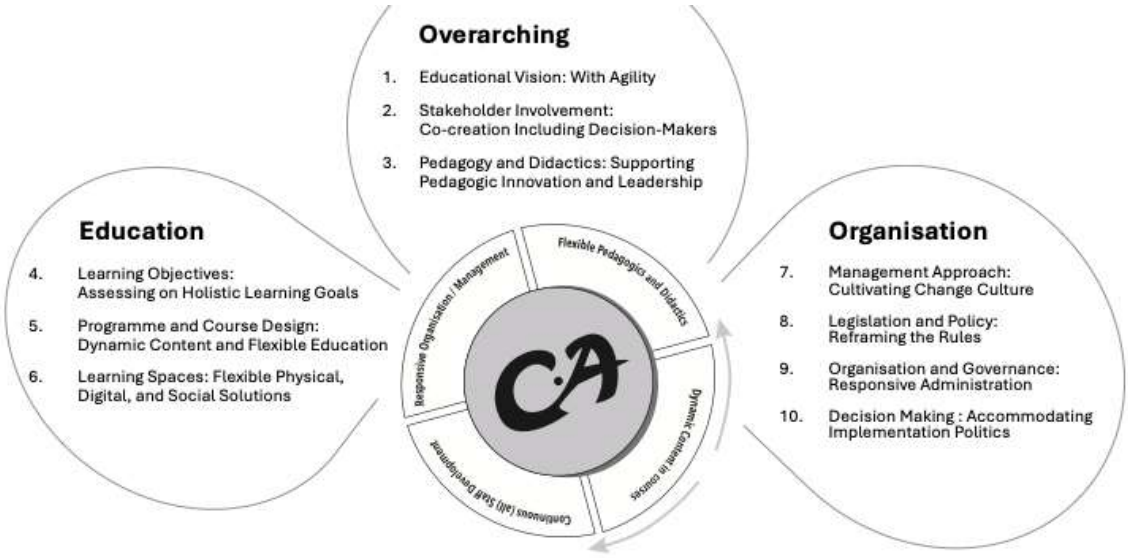

Figure 1: Curriculum Agility and its principles (Brink et. al., 2024a)

Besides the barriers, good examples were also part of identifying the principles. Higher education institutions (HEIs) are organized and run differently everywhere, and local, regional, and national differences make some principles easier or more established than others in certain contexts. While mapping their Curriculum Agility, six European universities gained detailed insights into where their institution stood on these relative, pluriverse, qualitative scales of the principles. We discuss the enablers in this paper for inspiration and as a counterweight to all the barriers - sometimes seen as obstacles - that we, as critical-thinking academics, are prone to focus on.

METHOD

For this study, illustrative examples of enablers for Curriculum Agility were collected. Six universities from Sweden, The Netherlands, UK, and Norway, participated in a pilot of mapping Curriculum Agility at their own institutions: Umeå University (UmU), Chalmers University of Technology (Chalmers), Delft University of Technology (TU Delft), Eindhoven University of Technology (TU/e), Queens University Belfast (QUB), and NTNU University of Technology (NTNU) at different institutional levels (Brink et al., 2024b). The mapping process comprised of five steps: informing, probing, envisioning, strategizing and prioritizing. A protocol with information, worksheets, and tips on each step was offered to the mapping facilitators, co-authors of this paper. The facilitators had different positions within their organisation: head of school, head of education, director of educational services, academic developer, head of programme, and strategic consultant. Based on their first-hand experiences during the mapping, each facilitator reflected on what enablers had been identified by the participants.

Data analysis

Each facilitator wrote a narrative describing their identified strengths and enablers. The facilitators' observations were discussed and categorized into three categories during four online focus group meetings with the other facilitators, as can be seen in the result section.

RESULTS

The results are presented in three parts. First, we describe enablers categorized under the characteristics Flexible Pedagogy and Didactics and Dynamic Contents of Courses, next the responsive organisation, and lastly the continuous staff development.

Flexible Pedagogy and Didactics & Dynamic Contents of Courses

Several of the facilitators observed enablers that made their HEIs advance towards flexible pedagogy and didactics, and facilitating courses to offer dynamic contents to their students.

The TU/e Vision on Education guides the university's future direction, focusing on (1) preparing engineers to tackle major societal, technical, and scientific challenges and (2) providing high-quality, adaptable education for a rapidly changing world. This vision enhances TU/e's resilience to global changes, shaping it into a learning organization that fosters diverse T- and π-shaped engineers with knowledge in different disciplines and interdisciplinary expertise. Developed collaboratively with staff and students, the vision embraces continuous learning, reflection, and development. University-wide initiatives, curriculum innovations, and bottom-up projects explore and implement educational advancements tailored to TU/e, such as Challenge-Based Learning (CBL), digitalization, and flexibility. Key elements include interactive, small-scale campus learning enriched by digital tools, strong industry and research collaborations, and team-teaching approaches. Research and education are deeply connected with sustainability (Sustainable Development Goals), playing a central role.

A vision that embeds agility enables curriculum flexibility, and TU/e exemplifies how such a vision drives meaningful change. Diverse stakeholders—teachers, policymakers, and educational experts—have contributed, with the broader university community engaged through dialogue sessions. Several aspects of the vision have been translated into university-wide programs that support faculties and educators in creating more flexible, dynamic study programs.

At NTNU, the project Technology Education of the Future was established in August 2019. A framework for NTNU's educational portfolio in technology was developed to ensure that NTNU's portfolio of technology and engineering programs is well aligned with technology development, societal challenges, and industry needs for a future beyond 2025. In the final report (Øien and Bodsberg, 2022) Curriculum Agility was recognised as a necessary feature for the educational portfolio and that its principles were fully compatible with the recommendations put forward in the project Technology Education of the Future. The only aspect of the three principles not explicitly addressed in the university policy documents were that agility is not explicitly incorporated in the vision. Work on the future strategy is presently on-going, and agility is likely to be addressed in the work.

An important enabler for flexible and dynamic education at Chalmers is their Tracks initiative. Tracks courses are not tied to any specific department, school, or programme but are open to all students, ranging from second-year BSc students to those at the MSc and PhD levels, as well as for professionals. Courses are proposed through open calls, encouraging contributions from faculty and external collaborators. To qualify, courses must address pressing societal challenges and/or cutting-edge research, attract students from multiple programs, feature diverse teaching teams, integrate interdisciplinary projects where students with varied backgrounds collaborate, and actively involve external stakeholders.

Tracks courses bring together students from various programs and levels, as well as professionals, fostering a collaborative environment where they learn both together and from

one another. To maintain relevance, each approved course is offered only three times. Through Tracks, dynamic learning contents are realised by swiftly integrating emerging technologies, materials, and concepts into its education, responding effectively to the needs of industry and society. New courses can be developed and implemented in as little as three months, complementing the more structured, program-based educational framework.

Chalmers Fuse, an innovation lab with a flexible and dynamic learning environment focused on design, build, test, and experiential learning, is an important part of the Tracks initiative. It enables cross-disciplinary collaboration by bringing together participants from diverse programs, fields, and sectors to learn, innovate, conduct research, and test new ideas. While it primarily hosts Tracks courses, Chalmers Fuse also supports other educational activities, projects, start-ups, and events in collaboration with industry and society.

Aligning with the Bologna model (BSc + MSc), an enabler for agility is Chalmers' 3+2 programme structure. Unlike traditional five-year engineering programmes in Sweden, this format allows students to choose from a variety of master's programmes after the third year. It also enables faster implementation of curricular changes, as major updates can be delivered much faster, compared to a five-year programme cycle.

Additionally, Chalmers is revising its master's-level offer, with existing programmes being replaced with broader, more interdisciplinary platforms. These new master's programmes begin with a common core, followed by specialized and replaceable tracks that provide depth and professional skills. This modular approach allows for quicker creation or discontinuation of specializations, enhancing responsiveness to industry, research, and individual needs. The curriculum development is collaborative, involving faculty, students, and external stakeholders, and often spans multiple departments, fostering interdisciplinary learning, research, and innovation.

Many TU Delft degree programs, 3-year bachelor's and 2-year master's, have a fixed core curriculum with separate tracks that students can choose. The learning objectives and learning content of courses are relatively fixed. The dynamics of course content vary considerably between faculties and degree programs. The most recent degree programs and the forthcoming new degree programs have much more dynamic content and pedagogies than Delft's traditional degree programs. Larger curriculum renewals (1x per 5-10 years) are the moments to fundamentally reconsider programme and course content. This process is usually led by the degree programme leader and/or the Faculty's Director of Education.

These are opportunities that could enable a more agile curriculum at TU Delft. Individual degree programme leaders align the pedagogical philosophy and approach of their programme with their Faculty's Director of Education. Degree programme leaders and their Faculty Director of Education talk to their Faculty Board of Studies (both student and teacher representatives), their Board of Examiners (teachers), and their Faculty Student Council about pedagogical policies and practices. Academic freedom is important to teachers, course coordinators, and degree programme leaders, giving them agency to decide their didactic approach in their class, course, and/or degree programme within the context and conditions of the education vision of the School/Faculty, degree program, or course. This means that individual teachers and course coordinators in Delft are given ample room and support to develop their pedagogy and didactics within courses, usually in close collaboration with their course teaching team of lecturers, professors, and teaching assistants. Educational advisors, blended learning developers, and the Media Centre, are available to support the execution, development, or innovation of teaching practices. Course coordinators align their learning and

teaching activities and assessment strategies with the degree programme leader, to keep each other accountable.

UmU offers two compulsory faculty-wide courses in all engineering programmes: the Design-Build-Test Project and Sustainability for Engineers. Students of different engineering disciplines meet each other and work over the borders of their own discipline. In a relatively direct way these courses can be tweaked, adjusted, and offer dynamic learning content by changing projects and clients. Programmes have several designated moments where students are free to choose electives, giving them flexibility to specialize as desired.

Responsive Organisation and Management

As the participating institutions have different organisational structures, resulting in different perspectives on responsiveness, the self-mapping processes showed a variety of enablers.

At QUB, a 2030 strategy was developed to enhance education and research, with input from staff, students, and external stakeholders. Part of the education and skills strand of this strategy is centred on a course management framework, which included a project to improve the approval processes for curriculum and course changes. This project sought to implement a risk-based, enhancement-focused approach to these approval processes that ensured agility while complying with Competition and Markets Authority (CMA) guidance. The project concentrated on staff engagement and sectoral benchmarking to identify barriers and enablers to change in the existing processes. This included reviewing definitions and classifications of changes, change authorities and responsibilities, communication processes, operational procedures and documentation, and CMA guidance. Engagement workshops were held with representatives from all schools, faculties, and relevant directorates within the university, as well as local educational partners. Their aim was to fully understand these barriers and enablers to curriculum and course approval and adjustment, and develop more agile, compliant approval processes. This subsequently led to revised processes, which were endorsed by the university. The activities included mapping current curriculum and course approval processes, reviewing CMA compliance, and current processes and forms, establishing criteria for major changes and delegation to committees, and identifying ways to increase agility and addressing constraints.

On completion, QUB's project to approve curriculum and course changes was reviewed and mapped against the ten principles of Curriculum Agility. It has promoted a more dynamic and responsive approach to curriculum change, thus ensuring the university can adapt to societal and technological shifts. Its engagement with staff, students, and external stakeholders has established new processes to ensure that future curriculum transformation can meet the evolving needs of all parties involved. The project emphasis was on flexible and enhancement-focused curriculum approval processes that allow for the integration of holistic and adaptable learning outcomes. By definition, the project has fostered a culture of change and innovation through proactive engagement and improvement of existing curriculum development processes. By adhering to CMA guidance whilst pursuing greater agility, the project has demonstrated how to navigate and innovate within existing regulatory frameworks. The inclusion of representatives from all university sectors has ensured that the administrative structure supports and maintains curriculum changes effectively. Thus, the project has succeeded in streamlining curriculum approval processes and making them more transparent agile and efficient.

Looking into aspects that can be seen as enablers for establishing Curriculum Agility, at NTNU there are several factors that can be argued to be useful. First among these is the work done

in the project Technology Education of the Future. The reports from the project recommend the establishment of a vision for the STEM-educations at NTNU and of holistic competence goals for the study programmes and also provides a large number of concrete recommendations to be implemented at different levels of the organization, with clear recommendations on who should be the responsible actors. Second, the project process has been a benchmark study in co-creation where stakeholders, both external and internal, have actively collaborated in the project. The result is that the project recommendations are broadly anchored among staff and departments at NTNU, which provides a template for going forward. In other words, faculty staff from deans, through pro-deans for education, heads of study programmes, department heads, and teaching staff are not only reasonably well-informed about the project but also about the desired development work.

At TU/e, innovations, especially at the curriculum level, are part of a co-creation process involving programme directors, bachelor and master deans, and other stakeholders. Following the establishment of the education vision, initiatives are underway to implement various elements of the vision, such as Challenge-Based Learning and Personal & Professional Development, into the engineering programs' curricula. The implementation of these innovations occurs at multiple levels. On policy development, by creating directives and guidelines that cover regulations on bachelor curriculum and innovative educational elements, to integrate, for instance, CBL in the curricula. The process of developing the directives is a co-creation process in which Program Directors and dean Bachelor College in the Bachelor Curriculum Committee agree on the guidelines. These guidelines are also discussed with co-determination and consultation university bodies before being definitively approved. Each department has established a curriculum committee. The Program Directors also discuss the bachelor guidelines with their own Curriculum Committees in their own faculties. These committees consist of programme directors, teachers, teacher support staff, and, to some extent, students. They collaborate on integrating innovations and redesigning the curriculum. Education staff (e.g. staff responsible for the support and implementation of education) are also involved and consulted.

At Chalmers, programme advisory boards are engaged in ongoing processes of programme and course development. These advisory boards consist of representatives from industry and society, students and teachers, and thereby providing both indirect and direct stakeholder input on how programmes should develop. Besides offering flexibility to students, the 3+2 bachelor-masters model at Chalmers results in increased organisational flexibility and shorter response times, as changes can be made on both levels independently. Efforts are ongoing to make the master's level more flexible organisationally, with minors and specializations that can be added or changed without having to start new programmes.

TU Delft has many hierarchical levels and sub-units that are responsible for leading, organizing, and managing education, and the decision-making and governance processes vary per Faculty. On the one hand, this makes the decision-making process complicated, less transparent, and relatively slow, therefore less agile. On the other hand, many stakeholders already play a role in the curriculum development. Directors of Education, Degree programme leaders and their course coordinators, Education managers such as the director (central) and heads (local) of ESA, and the Boards (Board of Studies, Board of Examiners, Student Council) all meet separately and together regularly. In addition, responsibility is given to students and student bodies in decision-making, such as in curriculum renewal processes. Study associations and the formal Student Councils (Central and Faculty level) are well-organised and are seen as pivotal partners in developing, organizing, managing, or advising on the education.

Continuous Development of (All) Academic Staff

At UmU, the development of innovative pedagogic competencies among its academic staff is supported through a variety of staff development courses and workshops, both for new and experienced academic staff. In these, participants from different disciplines and teaching cultures meet and get inspired by each other, from engineering to humanities, to medical and social sciences. These efforts are driven by UmU's Centre for Educational Development (UPL), as well as by specialized activities within its faculties. In a practice as you preach way, UPL's courses and workshops are designed to be flexible and personalized and always varied in learning activities to be inclusive to the different teaching traditions and values in the different departments. Pedagogic leadership and scholarship of teaching are fostered, aimed at student- and learning-centred approaches. Pedagogical innovation is valued, and next to academic developers' support in curriculum innovation processes, central funding is available for innovative initiatives and explorations by academic staff on a yearly basis. In addition, teaching excellence is rewarded through promotions and a meriting system with financial benefits. Management signals the importance of such pedagogic quality development by awarding the merited and distinguished teachers alongside those receiving research awards.

The TU/e vision on education embraces the concept of a learning organization by emphasizing the support of academics and teachers in their teaching roles and providing opportunities to develop their knowledge and skills, contributing to the Continuous Professional Development (CPD) of teachers. Pedagogic innovation goes hand-in-hand with supporting teaching staff and their professional growth. To facilitate the professional development of TU/e teaching staff beyond the compulsory University Teaching Qualification (UTQ), which covers the basics of educational competencies (designing, teaching, assessment, organisation of education, and professionalization), TU/e offers CPD pathways. These pathways are flexible and optional for those seeking further professionalization, career ambitions and/or in need to upgrade their educational knowledge and skills regarding new challenges in pedagogy and/or tools, i.e. Challenge-based learning, AI, etc.

The TU/e has stated a Reward & Recognition Policy to acknowledge education career development at the same level as research output. In addition, the TU/e Academy for Learning and Teaching (ALT) serves as a platform for dissemination of innovations and provides support for teaching staff to carry out innovations and equip them with the necessary skills. For senior academic staff, such as Program Directors or teachers with curriculum development responsibilities, an Education Leadership Program is available. This programme equips senior staff with substantial knowledge of educational theories and leadership skills, enabling them to lead redesigning of the curriculum, educational innovations and reforms.

TU Delft's central department of Teaching and Learning Services is responsible for Delft's institutional staff development programme, but the Teaching Academy (TA) is the community that runs the physical hub for all university teachers to meet, share, inspire, exchange, and learn from each other. The TA hosts the institutional Education Fellowship programme and the yearly TU Delft Education Day, where good teaching practices, educational innovations, and education research are presented and discussed. Other subunits and programs such as the Extension School (online education), the 4TU Centre for Engineering Education, the Delft-Rotterdam Convergence program, Delft's AI program, and many more also offer teaching staff opportunities for staff development. In the last years, Delft hired tens of new Academic Career Trackers (Assistant Professor level) with an emphasis on teaching and learning in their track,

in line with the Dutch university policies on diversifying academic career paths. This brings new momentum to advance TUD's teaching culture.

One of NTNU's outcomes of the project Technology Education of the Future was the further development and support of a centre for Science & Engineering Education Development (SEED). From 2023 onwards SEED has run seminars for faculty education committees, heads of study programmes, and participated in programme development work. The work has arguably had a considerable and immediate impact in establishing a change mindset among the management. The centre has chosen as a supporting strategy to negotiate invites to already existing meeting arenas where middle management staff is informed about the details of implementing the recommendations from the project Technology Education of the Future. At the meetings analytical tools to use in their development work have been presented and tested. The meeting places have been regular meetings, such as faculty educational committees, educational days, and department meetings that already are scheduled. The fact that the meetings are already schedules means that they are not seen as an extra burden in a busy calendar, and the outcomes of the meetings have been very well received. Another aspect worth mentioning as an enabling factor is the programme for recognition of pedagogical merits. Teachers that can show that they meet a set of four criteria for high quality teaching are rewarded with a raise in salary and a lump sum to be used for further education development at their discretion.

DISCUSSION AND CONCLUSIONS

This paper provides insights into enablers for Curriculum Agility as defined by Brink et al. (2024a) in Figure 1. The study across six institutions demonstrated how self-mapping Curriculum Agility can identify enablers on the ten principles for Curriculum Agility, which were formulated through a five-year, co-creational process in engineering education, involving practitioners and experts from worldwide CDIO member-institutions. The enablers shared in this paper illustrate practical examples for the higher engineering education community. In the six institutions, enablers were found in professional development and teaching merits reward structures for at least academic teaching staff, but in some cases also already including all academic staff. Enablers were also identified in stakeholder involvement, co-creation of university or department-wide visions and educational development initiatives, and decision-making processes on curriculum innovations. To ensure that agility permeates all levels of the organization, it is essential to integrate these principles into institutional strategies, fostering a culture of innovation and adaptability. The self-mappings also demonstrated that Curriculum Agility is an ongoing journey, inherently requiring continuous effort and adaptation to benefit students, industry, and society by creating more responsive and inclusive educational environments. This continuous process can be facilitated by using the co-creative, multiple-stakeholder CA self-mapping protocol (see also Brink et al, 2024b).

TU/e's emphasis on continuous learning and innovation fosters a co-creative approach to curriculum design, while its professionalization and recognition systems cultivate a culture of change. This implementation of university-wide initiatives, innovative curricula, and bottom-up projects promoted an environment where evidence-based adjustments are made iteratively.

Similarly, NTNU's approach of strongly recommending holistic learning outcomes on programme level and QUB's curriculum management framework showcase robust strategies to enhance agility. These efforts embraced a culture of change and innovation, ensured administrative support for curriculum development, and facilitated sustainable teaching and learning practices. It has helped stimulate a model for an agile and responsive education.

A fundamental aspect of Chalmers' Tracks initiative is the principle of Stakeholder Involvement. Tracks are designed to provide students with opportunities to develop interdisciplinary and cross-disciplinary competencies while pursuing individualized study paths as elective parts of their education. The initiative also aims to shorten the lead times for adapting education to emerging technologies, new materials, and innovative concepts. By combining flexibility, innovation, and collaboration, it has created a transformative educational experience that aligns with the demands of a rapidly changing world.

TU Delft's flexible project-based education exemplifies efforts to incorporate dynamic content and interdisciplinary learning, though challenges remain in ensuring wider student participation and streamlined decision-making processes due to many who are involved. The same goes for UmU's joint Design-Build-Test and sustainability courses that are given in all engineering programmes and where students of the different disciplines meet each other. At TU Delft, although the more traditional engineering degree programs are less dynamic and flexible in programme and course content, there is a lot of flexibility in didactics and pedagogies and within project education, the elective space, and in extracurricular activities. Most of the newer, inter- and transdisciplinary programmes are designed to be more agile.

UmU's meriting system that actively supports scholarship of teaching and learning underlines the importance of not only engaging academic teachers but also managers in staff development initiatives. UPL offers not only pedagogic courses, but also curriculum innovation consultancy directed at involving all programme stakeholders. TU Delft's support staff and pedagogical experts such as E-learning developers and educational advisors stimulate and facilitate the development and implementation of innovative, flexible pedagogies including assessment strategies. TU/e also acknowledges that teacher professionalization and a recognition and reward system that values education and innovation is crucial.

The enablers discussed are not exhaustive, or indicative for the overall curriculum flexibility of each institution. They should rather be seen as examples of how the characteristics and principles of Curriculum Agility can manifest themselves in different institutional structures and educational contexts. The discussed enablers do underscore that achieving greater Curriculum Agility is an enduring, multi-stake process. While they exemplify effective strategies and structural strengths, they also revealed areas to the facilitators where further work is needed to ensure agility at all levels from the perspective within their organisations. It could also be concluded that the differences in enablers were to be seen from within the local contexts rather than be inter-comparable between the participating institutions. But hearing each other's enablers did inspire.

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