CURRICULUM AGILITY AS OPTIONAL CDIO STANDARD

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ABSTRACT

The concept of Curriculum Agility has been co-created in a series of sessions at CDIO meetings and conferences since 2018. Deliverables were a jointly generated definition, characteristics, a set of principles, and a self-mapping process on these principles. Using the Curriculum Agility concept offers guidance for CDIO programs and institutions in increasing the adaptability of their curricula based on the latest insights and developments in their discipline, continuously fulfilling the need of an ever more diverse student population and anticipating sudden societal changes. Curriculum Agility takes a holistic approach to considering conditions for proactive and timely curriculum development, including but not limited to enhancement of faculty competence. Although the success of CDIO implementation depends on this wider set of conditions that can drive, enable, or hinder change, this is currently not addressed in the CDIO standards. This paper proposes Curriculum Agility as an optional standard in the CDIO framework. It is a widely applicable, program-level concept including both educational and organisational aspects that addresses an important need in engineering education, and it is co-created within the CDIO community. Curriculum Agility is currently not sufficiently present or addressed in the existing standards. Therefore, this paper argues that Curriculum Agility as an optional standard and rubric will be a new useful tool in the CDIO toolbox.

KEYWORDS

Curriculum Agility, Optional Standard, Transformative Curriculum Change, Futureproof Engineering Education, Standards: 1-12

INTRODUCTION

Curriculum Agility is a conceptual framework that has emerged from work in the CDIO community. It refers to the ability of engineering programmes to be responsive to changes in industry and society, and in students' characteristics and needs, by proactively and in a timely manner adapting the curriculum's relevant organisational structures, learning outcomes, learning activities, and assessments.

This paper is a proposal to add Curriculum Agility (CA) as a new CDIO optional standard. When Malmqvist et. al. (2017) introduced the additional category of optional standards next to the core standards, it was to create a way for "*a controlled expansion of the CDIO standards, in consideration of the pedagogical developments within and beyond the CDIO community*". Hence, optional standards help make the CDIO framework more flexible, responsive to the various needs of the community, and it enables the community to take advantage of work on new frontiers. In short, optional standards were introduced to enhance the agility of the CDIO framework itself.

Malmqvist et. al. (2020b) presented a process for proposal, review, and acceptance of optional standards. The first step is to present the proposed optional standard at a CDIO conference, with a publication in the conference proceedings. The purpose of this paper is, accordingly, to be subject for general discussion and review in order to reach consensus in the community. Ultimately, it is the CDIO council that formally approves new optional standards.

FULFILLING THE OPTIONAL STANDARD CRITERIA

Optional standards should meet certain criteria, listed by Malmqvist et. al. (2020b). In this section, we will discuss how curriculum agility meets those criteria of importance for engineering education, novelty, program-level, wide applicability, and absence in the current standards, grouped and synthesised into two themes described below.

Addressing an important need in engineering education, not sufficiently addressed in the CDIO Standards, providing inspiration and guidance for CDIO programs and institutions in taking the lead

The CDIO approach is captured in two steering documents. *The CDIO Syllabus* (Malmqvist et al., 2022) is a comprehensive list of topics that can be addressed in engineering education to better prepare for professional practice. The document can be used by educators when customizing their programme learning objectives, or it can be used to analyse programs. *The CDIO Standards* are a set of aligned strategies for educational development, created to support the implementation of the CDIO Syllabus in an engineering programme. The standards *"define the distinguishing features of a CDIO programme, serve as guidelines for educational reform, enable benchmarking with other CDIO programmes and provide a tool for self-evaluation-based continuous improvement*" (Malmqvist et al., 2020a).

With regards to the function of providing guidelines for educational reform, Standard 1 is about deciding to educate graduates for professional practice, hence establishing the need for educational reform. Then, Standards 2–8 and 11–12 specify strategies for curriculum and course development, and evaluation. Interestingly, Standards 9 and 10 are of a somewhat different character, as they address the need for enhancing faculty competence with regards

to the desired changes in what to teach and how to teach. They can be seen as a recognition of conditions that can drive, enable, or hinder change.

However, over decades of experiences of curriculum development, members of the CDIO community have many times found that, vital as it is, faculty competence is not the only necessary consideration. Other conditions that can drive, enable, or hinder CDIO implementation are related to (the perceptions of) all kinds of legislation, accreditation schemes, regulations on every level, institutional processes, bureaucracy, governance, organisational structures, procedures, administrative practices, leaders and managers, power structures, traditions, and culture. Similar to how one tends to notice headwind more than tailwind, the quickest association is to think of these aspects as sources of barriers. However, it is equally true that they can likewise create forces that are highly conducive. They can therefore also be seen as tools or resources that can be mobilized in favour of the work.

The conceptualisation of Curriculum Agility is an attempt to address conditions for CDIO implementation with a more holistic approach, including but not limited to enhancement of faculty competence. Although CDIO implementation depend on these conditions, they are currently not addressed in the CDIO standards. Curriculum Agility is therefore an important extension of the CDIO framework. It aims to inspire and guide those who want to innovate their engineering education but meet obstacles and challenges along the way. The Curriculum Agility standard and rubric will be a new useful tool in the CDIO toolbox. Assessing the conditions for curriculum change is a first step to adopt CDIO productively. It will be even more necessary to enable any transformative curriculum innovations.

A novel, widely applicable program-level pedagogic approach, developed within the CDIO community, and reflecting ongoing development in several CDIO programs

The Curriculum Agility concept has been created in a joint pursuit to understand what is needed for a programme to be able to innovate its curriculum, whether it is incremental or transformational innovation. CA is directed at the programme or curriculum level, focusing on the conditions for agile development of the programme. However, those conditions are also shaped by factors on higher levels, and therefore CA also reaches out to the institutional level, and sometimes beyond.

The co-creation process started at the 14th CDIO International Conference in Kanazawa (Hallenga-Brink et al., 2018). Between 2018 and 2023, CA has continuously been co-defined, co-created, and co-evaluated during CDIO conferences, regional meetings, and fall meetings, see column 2 in Table 1. Each time, different groups of CDIO members participated in the Curriculum Agility workshops, roundtables and working group sessions, as indicated in column 3 of Table 1. The participants' geographical diversity becomes apparent in column 4. They were considered engineering education experts and practitioners in focus-group sessions, each contributing to the ultimate end result. In column 5, the preliminary results of each session are indicated, which led to the concept as it is presented in this paper.

Table 1. The co-creation of the concept of Curriculum Agility.

	Meeting/ Conference, Date	**Session format, Title and, reference if accessible**	**Participants, Nationalities**	**(Preliminary) results after analysing the session outcomes**
1	14th International CDIO Conference at Kanazawa Institute of Technology, Japan, July 2018	Workshop: Developing A Rubric for Self-Assessment of Curriculum Agility	18 participants: From Australia, Canada, Denmark, France, Ireland, Japan, the Netherlands, Northern Ireland, Norway, Russia, Sweden, UK, USA	The name Curriculum Agility for what is needed for a HEEI to be able to transform curricula, 3 characteristics and four concepts for the definition of CA, of which one was chosen)
2	Regional CDIO meeting EU&UK/I, CESI Graduate School of Engineering La Rochelle, France, January 2019	Working lunch: Curriculum Agility	20 participants: From Denmark, France, Iceland, The Netherlands, Russia, Sweden, Tunisia, UK	Collection of important elements of CA, of good practice examples and of barriers for CA
3	15th International CDIO Conference, Aarhus University, Denmark, June 2019	Working group day: Self-Assessing Curriculum Agility	11 participants: From Indonesia, the Netherlands, Norway, Sweden, UK	A second prototype with refined definition of CA and the first seven principles of CA
4	CDIO EU & UK/I Regional Meeting, NTNU Norwegian University of Science and Technology, Trondheim, Norway, January 2021	Online Workshop: Curriculum Agility Principles, what do we prioritize and why?	14-25 active participants of 29 in total: From Denmark, the Netherlands, Norway, Sweden, Switzerland	Examples of CA activity at HEEIs pre and during pandemic and testing the value of the principles in light of the pandemic. Discussion on the culture of change, resulting in a sharped description of this principle
5	17th International CDIO Online Conference, Chulalongkorn University, Bangkok, Thailand, June 2021	Online roundtable: Roundtable on Curriculum Agility (Brink et al., 2020)	19 participants: From France, Japan, The Netherlands, Norway, Singapore, Spain, Sweden, Thailand, Tunisia, UK	The third iteration of the prototype, plus paper published in the proceedings of the conference on the seven principles of CA, validation and tweaks in definitions and wording
6	Frontiers in Education 2021 Envisioning Convergence in Engineering Education, University of Nebraska - Lincoln, College of Engineering, USA, October 2021	Hybrid Special Session: Curriculum Agility: Responsive organization, dynamic content, and flexible education (Brink et al., 2021)	8-10 active participants of 13 in total: From Canada, The Netherlands, Sweden, USA	The fourth iteration of the prototype, adding an 8th principle to the CA model, additional stakeholders based on cultural/regional differences.
7	CDIO Asian Regional meeting, Australian College of Kuwait, October 2021	Online interactive keynote: Curriculum Agility and the impact of the pandemic on its bears on the road	21-25 active participants from 107 in total: From the Middle East and the whole of Asia (affiliations were hidden)	Validating outcomes plus a fifth prototype of the CA model, with a ninth principle added. A pre-pilot approach to self-mapping, to be tried out at 1 university
8	The 18th Worldwide CDIO Conference, Reykjavik University, Iceland, June 2022	Working group day: Curriculum Agility - Self-Assessment on the Curriculum Agility Prin ciples	16 participants: From Estonia, France, The Netherlands, Norway, Sweden, UK	The sixth iteration of the prototype of the CA model, based on sixteen different principles configurations, 10th principle added and a 4th characteristic. Plus, self-mapping method proposals.
9	CDIO Fall Meeting in Turku, Finland November 2022	Fall meeting workshop: Bears and change agents… Curriculum Agility Workshop	9 participants: From Finland, Norway, the Netherlands, Singapore, Sweden	The 7th, tweaked prototype and visualisation of the CA model, as presented in this paper, including an extensive list of stakeholders and first rubric description
10	CDIO EU/UK Regional Meeting in Canterbury, UK, January 2023	Working Group meeting: Curriculum Agility	9 participants: From Ireland, Finland, Sweden, UK	The rubric description and a concept for optional standards as horizontals of the core standards
11	The 19th Worldwide CDIO Conference, NTNU, Trondheim, June 2023	Working Group Day: Curriculum Agility Working Group: The Self-Mapping Pilot	Expected participants From: France, India, Norway, The Netherlands, Sweden, UK	Expected: refined self-mapping method after testing it in 10 universities, publication for the next conference

In this continuous series of co-creation sessions, different CDIO members from different regions and engineering disciplines joined each time with a fresh look on the intermediary results that were presented for them to work with. A core group of co-creators remained active throughout the process and included outcomes of each former session into a new 'prototype' and a new plan for the next session. This process was led by the first author, as part of her doctoral studies. The diversity of the participants assured a pluralist angle on the resulting concept of Curriculum Agility. One session was held outside the CDIO community, for validation purposes.

Throughout the sessions, the design thinking steps of empathising, defining, ideation, prototyping and testing/validating came back in non-linear iterations, turning it into what it is today. For instance, when the model still had seven principles, it was mapped to the CDIO Standards 2.1 (Brink et al, 2020). The version presented in this paper has ten principles and is mapped to the CDIO Standards 3.0. The work triggered ongoing developments in several CDIO programs. The widespread interest in CA has shown that it is of importance to all engineering and design disciplines. In line with the idea that it is based on, agility, the authors warrant the model will continue to develop through time, but at this point it is stable enough to be offered to the whole CDIO community.

THE OPTIONAL STANDARD OF CURRICULUM AGILITY

In Figure 1, Curriculum Agility is portrayed by its definition and its four characteristics *flexible education, dynamic teaching contents, a responsive organisation, and continuous development of all staff*. The ten principles of Curriculum Agility shown are divided over and sometimes covering both the two main categories of organisation and education.

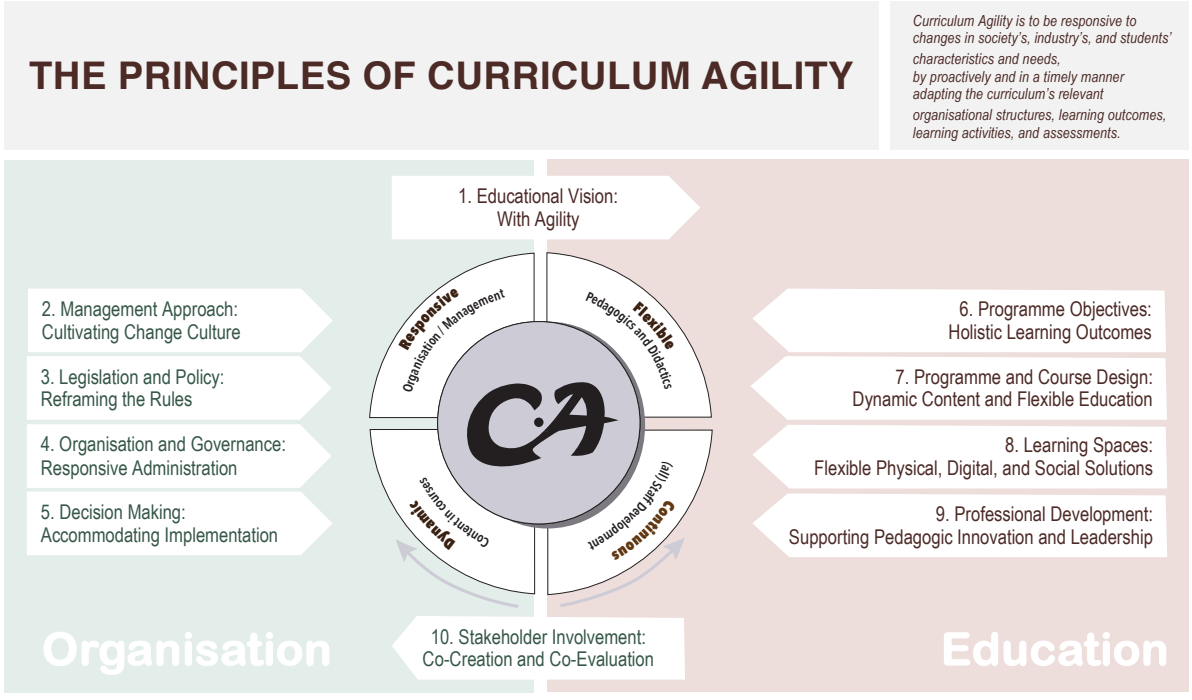

Figure 1. Curriculum Agility and its definition, characteristics, and principles

For the optional standard of Curriculum Agility, the program applies the four characteristics of Curriculum Agility in the adoption of the CDIO principles as the mechanism to proactively and timely adjust or alter the curriculum, adapting to the latest demands in engineering education (addition to Standard 1).

A program's goals and learning outcomes are recurringly fine-tuned on the shortest timespan allowed by the institution's policies to the latest version of the CDIO syllabus, to changes in technology and other disciplinary developments, and to relevant developments in society and in student characteristics (how to manage standard 2 with agility).

The learning contents of a program's integrated curriculum, which include but are not limited to personal and interpersonal skills, and product, process, system, and service building skills, are regarded as being dynamic and are altered when needed due to changes in technological and disciplinary shifts, developments in society, and changes in students' needs, (how to keep standard 3 updated), and consequently adjusted to what is needed for the different students' introductory engineering courses (how to keep standard 4 updated) and in the authentic, contextualised learning activities in collaboration with industry during the program's projects (how to keep standard 5 updated), adding interdisciplinarity in integrated learning experiences (addition to standard 7), or even trans-disciplinarity.

A program should have pedagogic and didactic flexibility built into its curriculum to be able to tailor to this dynamic interdisciplinarity (addition to standard 7), but also to meet diverse students' needs in a personalised way (beyond standard 8). A flexible education is supported by flexible physical and digital learning space configurations, such as hybrid teaching (simultaneously on-site and online), and authentic learning environments in industry or society, but also by flexible social learning spaces, such as student ownership of collaboration/group formation and reciprocal learning interaction (addition to standard 6). The way that students are assessed has to be equally flexible, personalized, and authentic to be in line with the flexible pedagogics and didactics (standard 11).

In this optional standard, the program is not only enhancing disciplinary faculty competence and teaching competence of the academic staff that teaches on the program, but rewards pedagogic leadership and innovation, amongst others by means of scholarship of teaching and learning (SoTL) (beyond standard 10). The program also expedites enhancement of all academic, supportive, and administrative staff involved in decisions to make changes in the curriculum (beyond standards 9 and 10). One fundamental way to enhance the competency of all staff is by inclusive, participatory curriculum refinement, (re)design, and innovation processes, in design-thinking co-creation with all relevant stakeholders within and outside the university. This approach adds feedforward about the program's quality to the feedback mechanisms as suggested in core standard 12, making it possible to adjust education (co-creation of and during learning) to the needs of its participants (beyond standard 12).

The former paragraph relates to the fourth characteristic of Curriculum Agility, a responsive organisation, which is an important prerequisite as well as facilitator for the curriculum changes that a higher education institution wants to make while adopting the CDIO framework. Cultivating a change culture within the organisation, openness to exploring and reframing the rules that drive university policies, creating administrative agility, and accommodating implementations are all important principles of Curriculum Agility.

Appendix 1 contains the proposal for the full description, rationale, and rubric of the optional standard of Curriculum Agility.

DISCUSSION

In the previous section, the supplements to the Core Standards have four appearances: Addition to Standard X, How to Manage Standard X, How to Keep Standard X updated, and Beyond Standard X. The latter category was first used in one of the transformative curriculum innovation cases that led to the start of the Curriculum Agility process (Hallenga-Brink, 2018) (Hallenga-Brink & Sjoer, 2017) and which used the twelve core standards of CDIO as a basis for the innovation process. Here it was concluded that for CDIO-standard related curriculum changes that prove more transformative in the context that they happen in, something more is needed. This 'something more' is now covered by the Optional Standard of Curriculum Agility.

Curriculum Agility supplements all the core standards of CDIO. Therefore, this paper suggests it is considered as a 'horizontal' under the twelve core standards. There are existing and will be future optional standards that have this same structure, such as the Sustainability standard. Curriculum Agility also adds new elements to the CDIO framework, on the organisational aspects of education. It appears to lie close to standard 12, but when comparing the two standard descriptions, Curriculum Agility implies pro-active, co-creation with stakeholders, and not just providing feedback to them. It implies rethinking the goals, not just evaluating whether CDIO goals are reached. And it includes adaptation of the organisational structures of the programme, not just the programme itself.

Curriculum Agility can be seen as 'the motor oil of curriculum change'. Being developed by, within, and for the CDIO network, it has been carefully set up to serve all CDIO members as an optional standard.

Future developments

In line with the CDIO standard format, the evaluation of Curriculum Agility is captured in one rubric. However, higher education institutes may already do well on certain aspects of Curriculum Agility, whereas other aspects need more attention. To be able to identify what aspects to focus on and how to work on increasing the Curriculum Agility at one's institute effectively, a more in-depth self-mapping tool will be introduced in the near future. With this tool, the institute will be guided to reach rubric levels 1 and 2, co-evaluating and co-creating throughout the layers of the organisation and with multiple stakeholders. A pilot of this method is discussed at the working group session at the CDIO Conference in Trondheim.

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BIOGRAPHICAL INFORMATION

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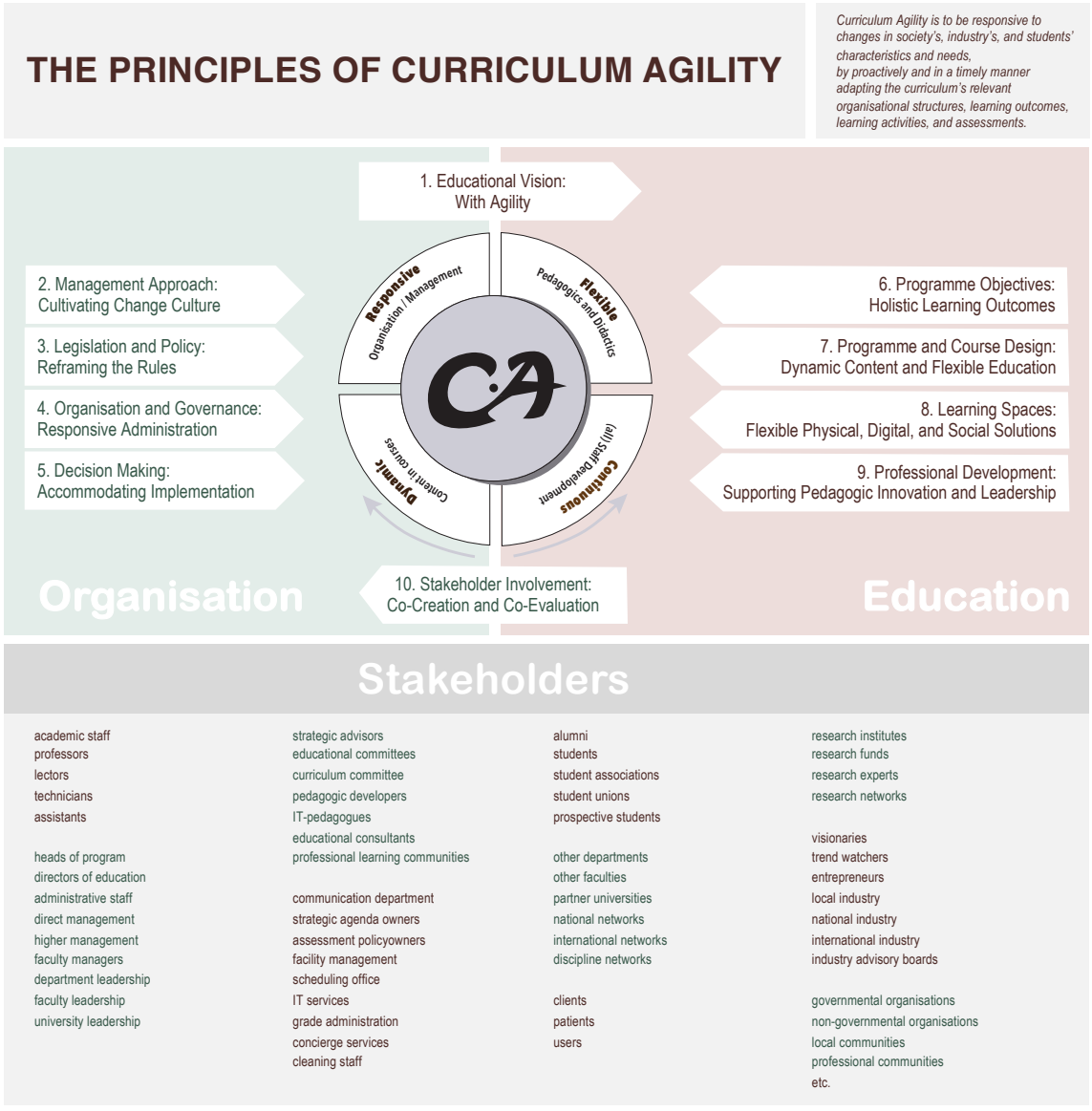
THE OPTIONAL STANDARD FOR CURRICULUM AGILITY

Characterisation

Curriculum Agility

Engineering programmes that are responsive to changes in industry and society, and in student characteristics and needs, by proactively and in a timely manner adapting the relevant organisational structures of the curriculum, as well as the learning outcomes, learning activities, and assessments.

Description



Rationale

In higher engineering and design education, there is a growing willingness and need to carry this responsibility of constantly adapting the curricula to the fast changes in technology and society. The causes for transformative curriculum changes vary widely and can be both economically and ethically driven. For instance, in certain engineering disciplines some knowledge & skills become obsolete shortly after students finish their studies. This calls for the need to dynamically change the contents of learning and keep a close eye on when those changes are solicited. Flexible education and responsive governance are necessary to deal also with sudden, impactful changes in society (as experienced during the pandemic). Student populations become increasingly diverse due to other changes in society. Norms have changed, bringing about developments such as increased accessibility and the focus on equality, diversity, and inclusion in accepting and supporting students' learning path while in university. Other drivers are globalisation, decolonisation, and the increasing need for lifelong learning opportunities as the general population on average gets older and has to work longer. Behind many of these developments lie changing values in our society and in individuals. Sustainability and ethics change the objectives and approaches of the engineering and design professions to the core, and it adds complexity that students need to learn how to deal with, often in interdisciplinary or even transdisciplinary ways. This in its turn adds complexity and wickedness to the curriculum design, making transformative curriculum changes a must. And for that, the higher education institution needs Curriculum Agility.

Rubric for self-assessment

0	There is no agility in the curriculum design, organization, and development processes
1	There is awareness of the need for adopting Curriculum Agility by means of a holistic approach involving academic, technical, managerial, and administrative staff in co-creation with all key stakeholders.
2	There is a plan on institutional level to widely introduce and implement continuous curriculum review and enhancement and do this in a holistic, co-creational approach with relevant stakeholders. CA Principles have been prioritized.
3	There is documented evidence of an integrated organizational system for responsive, dynamic, and flexible curriculum design and its continuous development, including facilitating academic, technical, and administrative staff continuously in their congruent developments.
4	There is documented evidence of ongoing improvements and adjustments in the curriculum design at program level and module level. Developing, teaching, and administrative staff are recognized and merited for their efforts in Curriculum Agility.
5	There is a cyclical and evidence-based co-creation and co-evaluation system of both feedforward and feedback in place, involving all stakeholders, which continuously feeds the curriculum development processes and decisions.