POTENTIAL PRACTICES FOR ESTABLISHING CURRICULUM AGILITY THROUGH INDUSTRIAL ENGAGEMENT

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ABSTRACT

The present version of Curriculum Agility is described by 10 principles and is progressing to become a future CDIO Standard. The proposed standard, Curriculum Agility, is designed to be responsive to both future and current industrial requirements with the aim of ensuring that the curriculum contributes to developing so called "industry-ready graduates", i.e., engineering graduates that are competent, capable and confident with respect to technical and employability skills. This paper complements the ongoing work in the CDIO community in creating the optional Curriculum Agility standard.

At a workshop on industrial engagement in curriculum agility arranged at the 19th International CDIO Conference in Trondheim, Norway, the participating delegates highlighted both challenges and opportunities. Comments on challenges included, "Are their [industry] perspectives too short? In line with societal needs?" and "[Challenge] the industry to advocate for the future because sustainability is an obligation for us." Comments on opportunities included "[opportunity] bringing in industry, reverence, and authenticity" and "[opportunity for] alumni to provide feedback on courses... on new courses, potential [student] projects... possible research projects."

The paper will discuss possibilities for a framework to aid curriculum agility development and enable academic practitioners to effectively engage with industrial partners, recognizing that any learning outcomes of a curriculum need to be constructively aligned with industry's current and future requirements. The curriculum also needs to meet other competing stakeholder requirements, such as those from students, institutions, governments, and relevant Professional Statutory and Regulatory Bodies (PSRB), as well as demands from societal perspectives.

KEYWORDS

Curriculum Agility, Curriculum Change, quality development. Standards: 2, 3, 5, 7, 8, 9, 10, 11, 12, Optional Standard: Curriculum Agility

INTRODUCTION

Throughout the world governments have invested in technical institutions and universities during periods of industry revolution, as education became a necessity with a focus on addressing skills development of a workforce for regional economic industrial growth through mass manufacture (Geschwind and Broström, 2020), in addition to craft artisan learning (Wollschlager and Guggenheim, 2004)

However, today it is increasingly recognized that long established higher education engineering degree programs, focusing on technical and employability skills, are out of sync with current and future industry trends (Kamaruzamn, 2019). Half of engineers graduating in the UK lack necessary technical and non-technical skills (EngineeringUK, 2021), and this is also the case throughout Europe (Mannan, 2021). Allan and Rowsell (2017) highlight that engineering education curriculum re-design is critical to supporting the development of engineering graduates that are competent, capable, and technically skilled engineers, that embody professional behaviors with confidence, i.e., 'industry ready' candidates that also are able to challenge current and future unsustainable industrial practices. In the UK, the Engineering Council (2019) Aims for Higher Education Programs 4.0 (AHEP4.0) seek accredited curriculums to deliver world-class education that develops industry-relevant skills. In order to meet the changing demands, curriculums need to be agile in implementing learning opportunities to acquire new skills identified and forecast industry needs (EngineeringUK, 2021).

The world of engineering is changing rapidly, particularly with the dual impact of digitalization and the need to integrate sustainability issues both in education and in practice. Agile modules with flexible learning outcomes that addresses real engineering problems could enable graduates to develop both technical and non-technical competencies (Hart, 2020). Engineering education should be able to address the volatile, uncertain, complex, and ambiguous (VUCA) world through an implementation of a CDIO framework, promoting students to experiment and test solutions to problems (Latha and Christopher B, 2019).

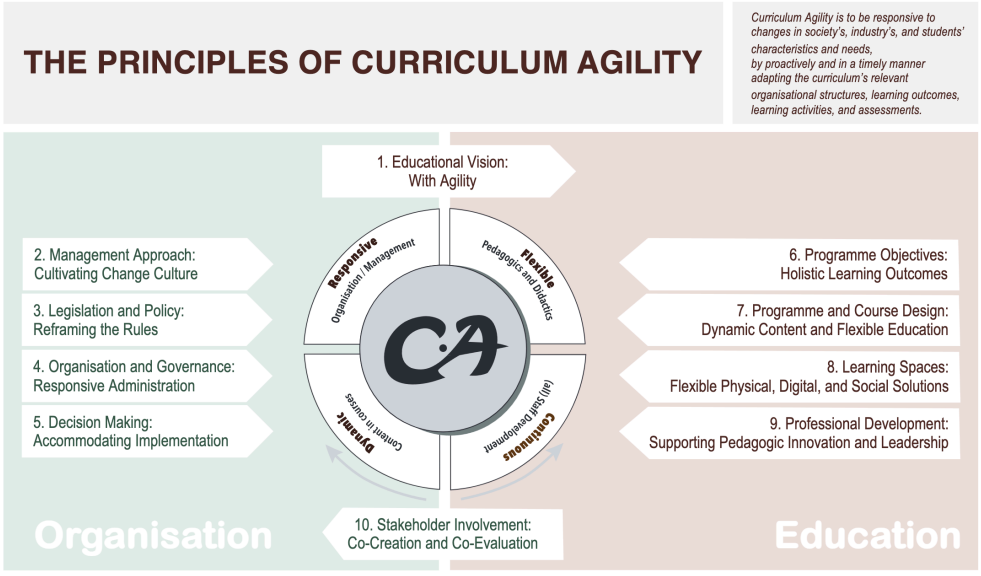

Figure 1. Curriculum Agility and its definition, characteristics, and principles. (Brink et al., 2023)

Curriculum Agility, described by the proposed future CDIO Standard, has the potential to assist engineering curriculum developers in being responsive to market requirements for students, government, and industry (Brink et al., 2020; 2021; 2023), and in the development of a resilient curriculum for the VUCA world (Rouvrals et al, 2022). Typically, institutional requirements for academic teams are mandated as part of the quality process for course validation/re-validation, requiring a demonstration of employer engagement in course design.

While universities are struggling to introduce agile practices there are a number of good practices among both public institutions and private companies that provide examples the universities could learn from.

LITERATURE REVIEW

Industrial Advisory Boards

Established programs and institutions have set up Industrial Advisory Boards (IAB) to assist in developing curriculum quality, equity, diversity, and inclusion, making timely adjustments to courses, and meeting industry requirements (Refae et al., 2016). The development of IAB into an industry partnership, investing in a program, can be mutually beneficial as it potentially yields higher quality graduates for the industry (Guggemos and Khattab, 2015). Such IAB typically consists of institution alumni engineering graduates, industry representatives, and parents of students (McIntyre and Fox, 2014), as well as industry engineering professionals of varying roles or levels (Jones, 2014). Programs are discussed and minuted at Industrial Advisory Board meetings (McIntyre and Fox, 2014), providing timely feedback into the curriculum – an agile approach. Good curriculum design involves industry experts and alumni (Bennett, 2019) with the aim of ensuring that the curriculum is current, future-proofed, and that graduates are employable.

Good Practice: Curriculum Design Revision

The CDIO community has reported revising curriculum design in response to industrial feedback, for example, to include common industry methods, practices, and management to develop student readiness for the industry (Sparsø et al, 2011). Jørgensen et al (2011) adopted an informal informed industry approach to curriculum program development, gathering requirements from research workshops with industry and academics. The approach of Törngren et al. (2016) to developing an industry-informed curriculum is through industry visits and talks. Kovacs et al. (2023) reported a survey of alumni of graduates from pre-CDIO and post-CDIO curriculum implementation, providing insightful results to inform periodic review and curriculum refreshment: while employers value current curriculum development of students' practical skills, there is a need to further embed employability skills development in the curriculum. In an employer survey Ormazabal et al. (2022) identified that industry valued graduates from courses employing CDIO curricula framework, as these graduates have experience in developing their technical and employability skills, but again it was noted that there is a need for increased skill proficiency.

Requirement Engineering

Good practice for Requirement Engineering for systems development recommends interviewing professionals individually (Sommerville and Sawyer, 1997). Research into commercial practice for Requirement Engineering found that an informal and semi-formal

Requirement Engineering approach led to more satisfactory software solutions with a greater customer fit (Neill and Laplante, 2003), while Hart (1987) highlighted that knowledge elicitation with a collective of experts in the room risks leading to falsehoods in the knowledge gathered. Therefore, adopting good practice for Requirement Engineering for systems engineering to gather input on industry requirements of engineering graduates and feedback on curriculum design is more likely to yield an informed industry curriculum. Just as with agile software Requirement Engineering, key artifacts can aid the process – for example, user stories, user cases, scenarios, and story cards (Schön et al., 2017), the carpe diem curriculum design approach (Salmon, 2013), or an initial overview of the core course developed by the academic team (Cheah and Yang, 2018).

Identifying Future Competencies

An alternative agile approach is to horizon scan the engineering community subject area, research activities and outputs to identify technical and non-technical competencies for the future. For example, the Urban Storm- and Wastewater Management research horizon scan has identified emerging curriculum subjects and future competencies of water engineers (Blumensaat et al., 2019). An integrated teaching-research nexus approach to the curriculum allows students to contribute to industry research projects, learn and apply disciplinary knowledge and skills that support their future employment (Magnell et al., 2016). In the UK, two research funding councils (UK RI and EPSRC) have commissioned an investigation into Tomorrow's Engineering Research Challenges Vision (Atkins and Bonfield, 2022), entailing roundtable meetings with numerous stakeholders, including industry Chief Technology Officers; the concluding report provides insights into technical and non-technical skills engineers will require to tackle tomorrow's engineering challenges.

In conclusion, there is a potential opportunity to develop an agile industrial engagement framework to aid academic teams in curriculum agility. A framework that enables academic practitioners to effectively engage with industrial partners, to enable constructive alignment of curriculum learning outcomes with competing stakeholder requirements—industry, students, institutions, Governments, and relevant Professional Statutory and Regulatory Bodies (PSRB), and society.

RESEARCH METHODOLOGY

The methodology that has been adopted involves using a hybrid agile requirements engineering approach (Kumar et al., 2013) designed as a World Café workshop (Schiele et al., 2022). The World Café workshop on industrial engagement in curriculum agility, arranged at the 19th International CDIO Conference in Trondheim, Norway, provided an opportunity for conference delegates to share their industrial engagement practices with respect to curriculum design. The delegates were asked about curriculum co-creation between curriculum developers and the industry:

- What are the challenges?
- What are the opportunities?

RESULTS AND DISCUSSION

The workshop was attended by 12 delegates, divided in three World Café tables. Each table was provided with yellow/green post-it notes for opportunities and pink for challenges. Each table was asked to reflect on and identify the challenges and opportunities of co-creating curriculum between developers and industry. Also, they were asked to collate and cluster common reflection themes. The identified common themes from all three tables on the challenges and opportunities are as follows:

- Time and money are both challenges and opportunities for academics and industry, representing potential resources for projects leading to industrially relevant project outputs.
- Horizon scan graduate roles and competencies; IAB with breadth and relevancy (local vs. global).
- Industry engagement brings relevancy and authenticity into the curriculum but also requires industry and academic time.
- Industry is agile compared to academic bureaucracy and 3-5 year degree programs.
- Learning communities, reciprocal learning, and lifelong learning.
- Competing priorities in curriculum design involving students, industry, R&D projects, academics, and academic management requirements.

An appointed table representative summarized their World Café table discussion, identifying key challenges and opportunities themes:

Table 1: Reciprocal learning is key to building constructive industry engagement and relationships between academics, students, industry, government parks, non-government organizations, etc. A reciprocal learning environment leads to internships, graduate roles, course co-design, leading to a continuing open-ended environment and relationship in line with the need for lifelong learning for alumni.

Table 2: Alumni (course graduates, also academics' own graduate peers in industry) are key to building company contacts and a network to support curriculum co-design as a valuable source of curriculum feedback, CDIO, and research projects.

Table 3: Industry engagement can be key to accessing funding for learning opportunities, research, and projects. It represents a symbiotic relationship opportunity to bring challenge, relevancy, and authenticity to the study programs, i.e., sustainability obligation to academia versus an option for industry, real-world problems.

The outcome of the World Café format at Table 1 stressed reciprocity as an opportunity for establishing curriculum agility, in line with several principles in the proposed optional standard for Curriculum Agility shown in Fig.1 (Brink et al., 2020; 2021; 2023). In particular Principle 10 (Stakeholder Involvement: Co-Creation and Co-Development), but also the principles concerning Program and Course Design (7) and Professional Development (9), not only for the students but also for staff.

Table 2 stressed alumni as the bridge between university and work place, providing a network that can engage staff, present and former students, and work places, both public and private in the Co-Creation and Co-Evaluation of Study Programs. This can be related to principle 1 (Educational Vision: With Agility), but likely would also necessitate a discussion of

Legislation and Policy concerning formats for such work (Principle 3: Legislation and Policy: Reframing the Rules).

Table 3, finally, focused on the opportunities for collaboration around learning and research with respect to real-world problems, such as sustainability challenges, which are most often characterized by wickedness and hard to mimic for learning opportunities in textbooks.

Overall, the short session at the 19th International CDIO Conference in Trondheim was surprisingly productive in providing a starting point for creating a framework to aid curriculum agility development. There is good reason to trust that future iterations of the World Café approach, possibly accompanied by other agile requirements engineering formats may continue to

CONCLUSION

The World Café results provided three key points that can be harnessed to support agile industrial engagement activities from curriculum design to curriculum operation:

- Work closely with your alumni, concurring with McIntyre and Fox (2014).
- Build and develop an active industry network and relationships pertinent to the Co-Creation and Co-Evaluation of Study Programs, and also to the development of staff competence
- Identify and provide reciprocal opportunities, such as talks and industry visits, (Törngren et al., 2016); identify and develop learning resources and projects, (Säisä et al., 2020; Manna et al., 2023); establish internships and graduate roles (Tiewtoy et al., 2019).

While these results were clear, the World Cafe format in this case was found to be limited, however it has been effective in yielding an initial basis, from which further iterations can be made through CDIO working group at regional and international meetings to create a framework.

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