**ENGINEERING AND BUSINESS EDUCATION IS IN THE WHIRLWIND OF REFORMS**

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**Abstract**

**During the past ten years engineering and business education and research at the Turku University of Applied Sciences have changed remarkable. This study uses qualitative methods and describes a case study on the actions taken at the Turku University of Applied Sciences in the field of engineering and business for curricula reform and faculty development. The main research question is “How engineering and business education has been steered with curricula reforms during the faculty development process?”.**

**Early 2010 our university had three faculties offering engineering and business education, and we had a pedagogical framework called Innovation pedagogy. The faculty of Engineering, Environment and Business (EEB) was one of the key developers and implementers of this pedagogy. At the same time the faculty of Telecommunications and e-Business (TEB) focused on implementing the international CDIO framework. The third engineering faculty Life Sciences and Business (LIB) followed university’s general pedagogical framework. In addition, there were faculty for Arts and two faculties for health and well-being.**

**In 2013 two of these engineering and business faculties (TEB and LIB) where merged to a new faculty of Business, ICT and Chemical Engineering (BIC) and first major curricula reform was introduced. The reform leaned on the elements in the CDIO approach bringing for example Introductory and Capstone courses into the curricula.**

**In 2018 two remaining engineering and business faculties (EEB and BIC) were merged into the current format of Faculty of Engineering and Business. At the same time, second major curricula reform was implemented. It combined the main elements of Innovation Pedagogy and CDIO and created a common framework for all our bachelor programs in engineering and business.**

**At the end of 2022 third curricula reform was started with the aim of new curricula for autumn 2024. This reform had three main aims: 1) Professional core in focus, 2) Strengthen the quality of education and improve completion and 3) Personnel well-being.**

**Along with the mergers and curricula reforms the operational questions have been solved too as during this journey of ten years the number of students has increased heavily, the portfolio of degree programs has evolved, applied research has grown, and continuous learning has a bigger role. This paper describes how engineering and business activities have developed and how we have responded to the ever-growing demands and global challenges.**

**Keywords:** *Curricula reform, CDIO, Innovation pedagogy, faculty merger, case study*

**Introduction**

The Finnish higher education system consists of the universities and universities of applied sciences. A total of 13 universities and 22 universities of applied sciences operates in the Ministry of Education and Culture's administrative branch. Universities focus on scientific research and education based on it. Universities of applied sciences, on the other hand, offer a pragmatic education that responds to working life needs. The main emphasis of research, development and innovation at the universities of applied sciences is on applied research and development. (Ministry of Education and Culture, 2023) Turku University of Applied Sciences (TUAS) is a higher education institution of 12,000 experts, researchers, students, faculty members and teaching professionals located in Southwest Finland.  TUAS is a significant regional actor with close ties to businesses and municipalities in Southwest Finland. TUAS is the fourth largest technical university in Finland. (Turku University of Applied Sciences, 2023) The degree programmes of TUAS cover all major fields of engineering and business. The emphasis of TUAS education is in Bachelor degrees, where the engineering degree is four years and the business degree is three and half years. In addition, we offer Master degree as part-time studying while students work at the same time and studies are strongly connected with their work.

TUAS has a long tradition in pedagogical development. TUAS was the first Finnish higher education institute to join international CDIO initiative already in 2007. The CDIO approach aims at educating students with deeper working knowledge of the technical fundamentals and educating engineers that are capable of leading the creation and operation of new products and systems (CDIO, 2023a). The other major pedagogical framework we have developed by ourselves: Innovation Pedagogy. The core of innovation pedagogy emphasizes interactive dialogue between the educational organization, students, and surrounding working life and society. The core idea in innovation pedagogy is to bridge the gap between the educational context and working life. (Kettunen, 2011) Luckily both CDIO and Innovation pedagogy have similar goals and aims, and they complement each other (T. Penttilä & Kontio, 2014; Taru Penttilä, Kontio, Kairisto-Mertanen, & Mertanen, 2014).

Early 2010 TUAS had three faculties offering engineering and business education. The faculty of Engineering, Environment and Business (EEB) was one of the key developers and implementers of Innovation pedagogy. At the same time the faculty of Telecommunications and e-Business (TEB) focused on implementing the international CDIO framework. The third engineering faculty Life Sciences and Business (LIB) followed university’s general pedagogical framework. In addition, there were faculty for Arts and two faculties for health and well-being. Since then, the engineering and business education and research has had three major reforms during the last decade. The reforms have included both organizational and pedagogical changes. Along with the mergers and curricula reforms the operational questions have been solved too as during this journey of ten years the number of students has increased heavily, the portfolio of degree programs has evolved, applied research has grown, and continuous learning has a bigger role. The changes happened in TUAS can be reflected on the five general pathways of universities presented by Clark (1998). First, the strengthened steering core is needed because the complexity of universities has increased, and the pace of change has accelerated. Thus, there is a need for a greater managerial capacity. Second, the expanded developmental periphery refers to the need to reach across the old university boundaries, link with outside organizations and groups and build outreach structures such as research centres. Third, the diversified funding base becomes essential when the governmental funding base is hardly increasing. Fourth, the stimulated academic heartland emphasizes the need to achieve changes in the departmental level and turn them to entrepreneurial units reaching outside with new programs and relationship and promoting new income sources. Fifth, the integrated entrepreneurial culture refers to the work culture that embraces change and creates ground for new practices and innovations.

This paper describes how engineering and business activities have developed and how we have responded to the ever-growing demands and global challenges and how these changes reflect with the general pathways Clark (1998) presented.

**Research**

This study uses qualitative methods and describes a case study on the actions taken at the Turku University of Applied Sciences in the field of engineering and business for curricula reform and faculty development. The main research question of this study is “*How engineering and business education has been steered with curricula reforms during the faculty development process?*”.

A case study is a research method aiming for an in-depth analysis of a particular phenomenon (Cavaye, 1996). Methodologically this is a descriptive case study research. A descriptive case study presents a complete description of a phenomenon within its context (Yin, 2002). The unit of analysis is engineering and business education, RDI and organizational context at TUAS. This is studied through three development phases/cases:

* Case 1: Focus on CDIO
* Case 2: Common framework
* Case 3: Professional core.

In a typical case study research multiple data collection methods are used (Yin, 1994). In this research, data was mainly gathered from the existing documentation and archival records of the author from 2008 to this date. The data covered the memos of university’s management board, memos and other materials of faculty’s management team and personnel meeting materials. The author has been an active participant of all the three cases, but in this study the analysis will be done in a role of outside observer reflecting the things that have happened and done. The three cases represent changes happened in 2013, 2018 and 2022.

**Case 1 – Focus on CDIO**

Turku University of Applied Sciences reorganized themselves in 2004 when the number of faculties were decreased from ten to six. The main driver for this was to strengthen and clarify the managerial capacity to respond to the increased complexity of university operating environment. In 2013 it was time to take the next step when it was decided that TUAS would start as a limited company at the beginning of 2014. Before that change the university was part of the City of Turku. At the same time in 2014, the government funding dropped 14%. Both changes were initiated by the Ministry of Education. The dramatic decrease of funding forced university to take actions to balance the financials. At TUAS, 20 people were discharged and 27 were shifted to part-time employment contracts.

At the same time, it was also decided that two engineering and business faculties (TEB and LIB) will merge to a new faculty of Business, ICT and Chemical Engineering (BIC) starting at the beginning of 2014. The new faculty was a good example of a truly multidisciplinary organisation with around 3000 students and around 170 faculty members including teachers, researchers, project workers and all others. In practice, two former faculties worked as one faculty, but major organizational changes were delayed until the beginning of 2015. This change decreased the number of schools and defined stronger head of school positions to take responsibility of education and RDI within broader areas. Before the merger, we had research programmes led by Heads of RDI and these programmes included research groups. The merger stopped the research programmes and focus was placed in research groups. At the same time number of research group dropped from 12 to 7 and each remaining group had larger and more viable RDI focus.

One driver to merge the mentioned faculties was to strengthen the connection to local industries and provide broader connection point to the economy. The change meant that the number of superiors dropped from 15 to 5. These positions were full-time superior positions, but they had degree programme leaders and research group leaders to support daily operations although these were not superiors rather more like team leaders.

Table 1. Comparison of faculties

|  |  |  |  |
| --- | --- | --- | --- |
|  | **TEB** | **LIB** | **BIC** |
| Dean | 1 | 1 | 1 |
| Schools & Head of Education | 5 | 4 |  |
| Head of RDI | 1 | 1 |  |
| Head of continuing education | 1 | 1 |  |
| Schools & Head of Education and Research |  |  | 4 |
| **Total** | **8** | **7** | **5** |

At education there was an urgent need to move away from a fragmented curriculum towards learning that is based on problems and phenomena. There were two guiding tools in this reform: Innovation pedagogy and CDIO. However, CDIO approach was the most dominant guiding principle that was used in this reform. The reform put together two faculties that didn’t have any common elements in their curricula and the other one had already used CDIO approach while the other has mostly followed Innovation pedagogy. Thus, the reform started with a fundamental assessment of the curriculum-wide goals and involved a high-level re-alignment of the entire curriculum structure in the whole faculty. The reform work involved two Bachelor of Engineering programs (Information Technology and Chemical) and four Bachelor of Business Administration programs (Business, International Business, Library and information services and Business information systems).

The curricula reform implemented several principles to our curricula:

* Curricula is based on relatively large modules (15 ECTS) compared to the individual courses with relatively low number of credits.
* Study year is divided in two semesters and five periods (Autumn: 9 + 7 weeks, Spring: 9 + 7 + 7 weeks). This rescheduling balanced the workload of students and staff better between shorter autumn and longer spring semester.
* Introduction to – courses in first semester: This idea is directly from CDIO Standard 4 and this course should provide framework for the studies and engages students from the beginning of studies to his/her own study field. The implementation of these courses follows CDIO Standard 8. Active Learning (CDIO, 2023b).
* Multi-disciplinary innovation project (15 ECTS) in third year of studies for all faculty students. The project assignments are mainly from industry and the projects cover the whole life cycle of a product development process from an initial idea phase to closing the project. The implementation of this course follows CDIO Standard 5. Design-Implement Experiences.
* Elective modules included in the beginning of second and third year (15 ECTS each). This answered to the requirements of TUAS university degree regulations at that time. Furthermore, it supported the idea of having broader knowledge of the field than just deep knowledge on your own field.

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Figure 1. Common curricula framework for BIC.

Altogether the CDIO approach was widely utilized in the curricula reform work supported with workshops organized by external experts. The whole curricula reform case is described in Kontio (2014).

**Case 2 – Common framework**

Since 2014 TUAS had four faculties: Faculty of Engineering, Environment and Business (EEB), Faculty of Business, ICT and Chemical Engineering (BIC), Faculty of Health and Wellbeing and Art Academy. In 2015 work for creating a new university strategy started. The strategy had four main areas of which one focused especially on the engineering and business field. The title of this area was “Future technological innovation university”. This basically implicated that TUAS need to build new faculty that takes care of all professional engineering and business education and applied research to support and improve the industry and well-being in Southwest Finland. It also defined four broad spearheads to focus university activities: Maritime cluster, circular economy, sales, and digitalization. The introduction of the new strategy and this idea of new unmentioned faculty started active work on necessary development actions on education and research. A concept of “Engineering excellence in action” was introduced and connected to the existing pedagogical and practical approaches of Innovation pedagogy and CDIO.

Four different viewpoints were identified for the areas of improvement:

* The structures of programmes: flexible curricula, active learning with projects
* New learner: supporting intrinsic motivation, provide individual learning paths
* New teacher: moving towards coaching, connections to industry
* New culture: raise the level of requirements, strengthen and renew learning and study culture.

This development work was influenced strongly by the work of Goldberg and Somerville (2014) and the study provided by Graham (2012). Graham (2012) reported that to achieve long-term change in engineering education a) typically 20% of curriculum, or less, is non-traditional, but curriculum is strongly interconnected, with multiple dependencies, where faculty and students have a clear understanding about the education as a whole and b) faculty should not be forced to deliver non-traditional courses but are aware of the positive impact they have on students.

During 2015 until 2017 the programs in the BIC faculty constantly improved their curricula according to the existing general common curricula structure and considered pedagogical emphasis provided in Innovation Pedagogy and CDIO. Along this development work in the BIC faculty a deeper collaboration started with the EEB faculty.

In the summer of 2017 work for new administrative structure was started. Now it was clearly stated that we would have only on engineering and business faculty. The main idea was to further enhance the integration of education and research, strengthen networking in our region and strengthen relevance to regional industry and their needs. This new organization started at the beginning of 2018. Two remaining engineering and business faculties (EEB and BIC) were merged into the Faculty of Engineering and Business (EB). The faculty had 310 experts and about 5800 students, 20 research groups. The merger was planned and worked during 2017 and 2018. In 2018, the organisational structures stayed but the faculty was managed as one entity and school and their leaders started working for the new faculty.

The reorganized faculty started at the beginning of 2019 with seven schools and seven Heads of Education and Research. The research groups were reorganized too, and the number of research groups decreased from 20 to 14 at the beginning of 2019.

Early 2018 the new faculty agreed common curricula principles that simplified the guidelines the two earlier faculties had jointly. Three of the principles defined mandatory courses to all curricula: Project hatchery 5 cr (first autumn), Introduction to your own study field –module (first year), Innovation project – 10cr + 5 cr (third year). Furthermore, it was agreed that we will focus on additional student guidance, take care of special competence needs and organize 2nd and 3rd years in module days. At the same time, we dropped the idea of having five period rather we just have autumn and spring semesters. Furthermore, the provision of faculty wide elective modules was stopped, and we will encourage students to choose free elective studies from the normal courses offered by other programmes.

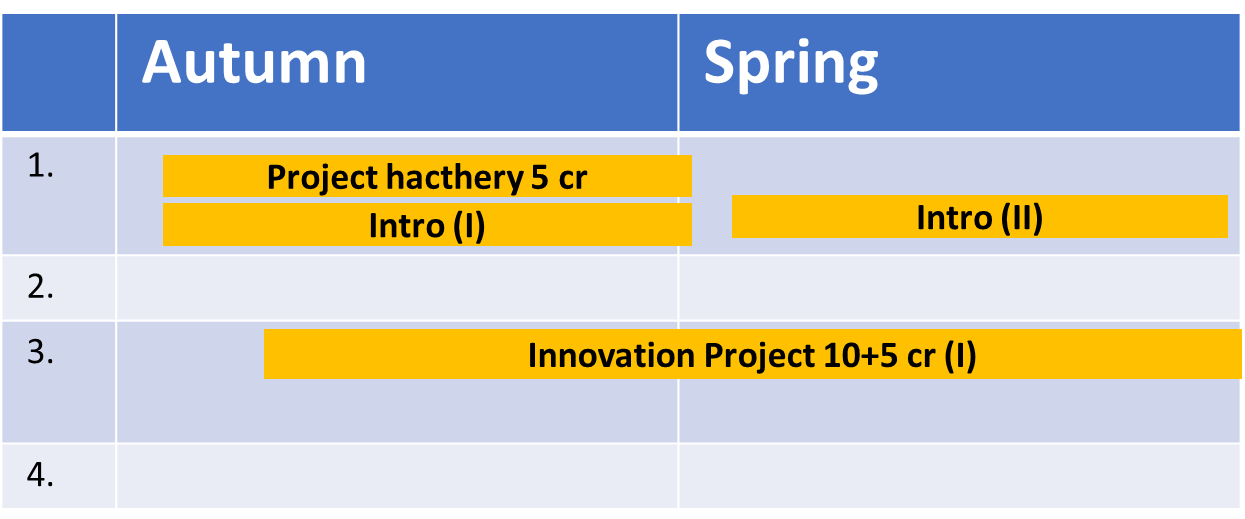


Figure 2. Simplified curricula framework for EB.

Once the common framework was defined, we wanted to involve whole faculty personnel in a series of workshops to think how we can do better in education and research. This process is well documented in Kontio (2018). The workshops identified several possible areas where we could do better:

* Use of time and resourcing: how to create a feeling of increased time and resource – decrease options and more standardized study modules?
* Integration of research and teaching&learning activities should be further strengthened already in the project application phase
* Standards and student engagement: Requirement level and mastering studies from the beginning – learning to learn the UAS way
* Create opportunities and places to share good practices
* Everyone can think whether 1’m doing my best with the given conditions
* Co-teaching is an accepted way of teaching&learning – could we use it more?
* Keep competence-based approach at the centre of teaching and learning
* Student guidance: we need to recognize when early intervention is needed, and we need to act like superheroes capable of supporting students as well as possible.

These themes have been in constant discussion on our daily work and they have given us guidelines to remember in our daily activities since 2018 reform.

**Case 3 – Professional core**

Early 2022 the Board of the University decided that the university strategy needs updates and work to define new strategy was started. New strategy work started since we had reached many of the key goals in advance such as the implementation of “Future technological innovation university”. The strategy work partly activated another curricula reform at the end of 2022 with the aim of new curricula for autumn 2024. This reform had three main aims: 1) Professional core in focus, 2) Strengthen the quality of education and improve completion and 3) Personnel well-being. With the first aim, we wanted to highlight more the professional core of our programs and to reflect our new strategy as well as megatrends and national level general competences. Furthermore, we challenged all programs to really strengthen the quality of education and find reasoned solutions to learning. The key competences of each program should be emphasized and critically reflect the number of modules/courses/topics included in the curricula. We also encouraged programs to find joint modules/courses and standardize courses common to all. We wanted to improve and support personnel well-being with enhancing cooperation, get rid of fragmented work duties and give personnel opportunity to focus and strengthen their competences.

We also defined the general principles for the new curricula. The curricula should make a wholeness and show how students grow professionally within their studies. Overall, the curricula should be a more coherent entity instead of a collection of courses. The curricula will have four project entities:

* 1st year: Introduction to your own study field (10-15 ECTS)
* 2nd year: updated project hatchery focusing in Unesco’s sustainable development goals (3 ECTS).
* 3rd: Capstone Innovation project (10 ECTS)
* 4th: RDI-project (5-20 ECTS).

Second- and third-year projects are multidisciplinary and all students participate. First and fourth year projects are program specific activities.

In 2020, we concentrated our activities on one campus and we introduced new campus building with up-to-date laboratories and research facilities. With the curricula reform we wanted to take full advantage of this infrastructure. Furthermore, active learning should play even a bigger role in our teaching and learning than earlier. All these changes require that our personnel are competent and have the latest knowledge available. Therefore, our personnel should join RDI-activities and acquire the latest knowledge and know-how. In addition, we identified needs to support digital competences, language skills and multicultural competences. Finally, the curricula must fulfil the idea of constructive alignment (Biggs, 1996) where learning outcomes, teaching and learning activities and assessment for a mutually supportive whole.

Together with the curricula reform we decided to introduce three new fully English engineering degree programs in addition to the existing Degree programme in Information and Communications Technology and Degree programme in Business Administration. Autumn 2023 will start Bachelor of Engineering programs in Industrial Management and Engineering, Energy and Environmental Engineering and in the autumn of 2024 Degree program in Mechanical Engineering.

At the beginning of 2023, the Faculty of Engineering and Business had grown remarkable from the starting phase in 2018. The number of students is now almost 8000 and we have over 350 staff members within the seven schools. Thus, we initiated an organizational change as well early 2023. We decided to introduce a new school called the School of Common Studies. It will take responsibility maths, physics, languages, and our common project courses (project hatchery and capstone innovation project) plus tutoring in the beginning.

**Discussion**

The study showed three major phases in the development of engineering and business education and other activities at the Turku University of Applied Sciences. Alongside these phases, the faculty structure has had two rounds of mergers as shown in figure 3.

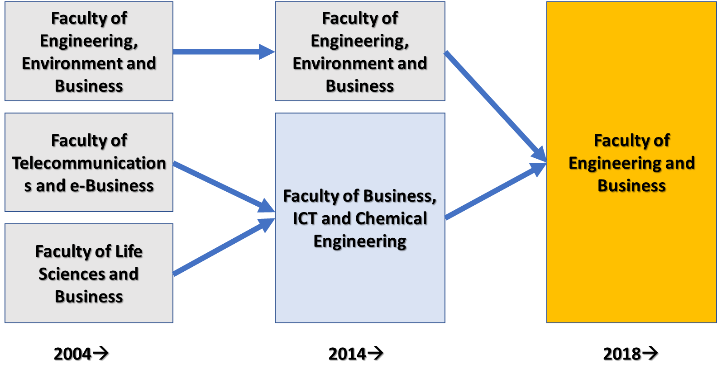


Figure 3. Faculty mergers at TUAS..

Clark (1998) presented five different pathways for universities when transforming themselves towards enterprising universities which actively seek to move away from close governmental regulation and sector standardization. At TUAS the first steps were taken already in 2004 when number of the faculties were cut to six and managerial capacity was stregthened. Already in 2004, we saw the need to strengthen our RDI-activities and new positions in RDI were introduced as Head of RDI at faculty level together with RDI manager at university level. Since then, the RDI outreach has expanded and external funding has increased heavily. In 2014 we stopped the research programmes and placed our RDI focus on research groups. At the same time, the provision of continuing education and industry personnel trainings were active part of TUAS. In practice, it was time of expanding peripheral development in Clark’s terms. 2014 was also the time when governmental funding decreased 14% and our university became a limited company. All these changes can be reflected on our attempt to diversify our funding base and that work is still continuing. Introduction of English degree programmes is a good example on that as degree students coming outside European Union have tuition fee instead of free education for Finnish and EU students.

Our change in 2018 was another typical example of Clark’s pathway definitions. The merger of two faculties made each school more focused and coherent units giving them more power to solutions in education and RDI. The common curricula guideline only defined 15 ECTS exactly and several general guidelines. The research groups were strongly integrated into education. The school financials were monitored as whole instead of each element separately. The schools started acting like entrepreneurial units that had a lot of freedom together with responsibilities too. This period reflects well with Clark’s definition of the stimulated academic heartland.

The latest reform at TUAS has elements echoing the fifth pathway: the integrated entrepreneurial culture. It is the very first time that the whole curricula reform is projected as a faculty wide exercise. All schools have a common project group for agreeing and finding common structures and principles on curricula. Schools are developing and implementing elements that embrace change such as faculty wide math tests at the beginning of studies and faculty wide first math course in all our engineering programs. Furthermore, the introduction of a new school taking care of certain element in all other schools and creation of a matrix organisation is a new cultural agreement in the Faculty of Engineering and Business.

**Conclusions**

This paper has presented a longitudinal case study on engineering and business education, RDI and organizational context at the Turku University of Applied Sciences. The paper presented three development phases and described the steps and paths between the phases.

The study showed that organizational changes support and facilitate steering of reforms in education and curricula. The organizational changes and mergers justify the inspection of curricula and how education is done in general. The mergers have also given good opportunities to strengthen managerial structures by making larger units with larger responsibilities and thus creating more space to operate in.

Reflecting back to this period of over 10 years show that Turku University of Applied Sciences has succeeded in merging their engineering and business faculties. The success is proven by the increased number of students and graduates, more than doubled external research funding, and shared goals and ways of working.

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