Chapter 8

Integrating the Academic and Professional Values in Engineering Education – Ideals and Tensions

Kristina Edström

8.1 Introduction: The Dual Nature of Higher Engineering Education

Higher engineering education is simultaneously *academic*, emphasising theory in a range of disciplines, and *professional*, preparing students for engineering practice. Harvey Brooks called this a *fundamental dilemma between science and art* in professional education. The term *art* implies that engineering is more than just applying science:

To the professional belongs the responsibility of using both existing and new knowledge to provide services that society wants and needs. This is an art because it demands action as well as thought, and action must always be taken on the basis of incomplete knowledge (Brooks 1967b p. 89).

When historian Bruce Seely studied several decades of consecutive curriculum reforms promoting *either* the theoretical *or* the practice-oriented side, he likened the effect to a swinging pendulum (1999). Given how this tension remains and seems to spark new curriculum reforms for each generation, he has also remarked that “*many of the challenges facing engineering educators have remained remarkably consistent over time*” (Seely 2005, p. 125).

The argument made in this chapter is that the theoretical knowledge and practice-oriented aspects should not be seen as opposites, nor as separate components. The ideal is a curriculum in which they are also in a meaningful *dual nature* relationship. By exploring how the theoretical and professional aspects can be integrated in the curriculum, this chapter suggests interpretations which can offer more productive understandings and opportunities for handling practical matters. The swinging pendulum metaphor is also disputed, since it reinforces the common misconception that

K. Edström (✉)
KTH Royal Institute of Technology, Stockholm, Sweden
e-mail: kristina@kth.se

engineering education must necessarily lean *either* to the academic *or* to the professional side. Rather than seeking balance and compromise, as the pendulum imagery would suggest, we should seek syntheses and synergies (Edström 2018). In particular, engineering education would benefit from fewer trench wars over “how much” should be theoretical or practice-oriented, and more effort to strengthen the meaningful relationship between these aspects in the curriculum.

This chapter explores how technical universities create opportunities for addressing the dual nature ideal in initiatives for curriculum reform, but also some associated challenges on the organisational level in the faculty. More than just a conflict within the curriculum, this dilemma is tied to, and often plays out as, a “*tension between scholarly autonomy and societal responsiveness*” of the university (Brooks 2001). It could be argued that this duality is what defines the niche for technical universities. They draw their strength from dual legitimacy that comes from successfully combining academic autonomy, the university as academia, with societal responsivity, the university as public service. But if the *raison d’être* is to straddle these aims, no wonder if some tensions are felt inside the technical university, and inside the engineering curriculum.

The aim of this chapter is to deepen the understanding of the dual nature ideal and its associated tensions by analysing them as expressions of different *institutional logics* in engineering education (Thornton et al. 2012). The issue under investigation is first how the dual nature ideal is addressed in curriculum development, and then how this work is limited by some related tensions in the organisation of the technical university.

The chapter is structured as follows: First, a concept for engineering education reform is described, the CDIO initiative, which illustrates curriculum development aiming to address the dual nature ideal. This is followed by a theoretical exposition to explore the organisational conditions for such ideal curricula. The institutional logics perspective is outlined and used to analyse the tensions in the engineering curriculum and in the faculty of the technical university. The tensions are interpreted in the light of the institutional logics of *the engineering profession* that we educate for, and of *the academic profession* of the educators. Finally, the CDIO initiative is revisited, and seen as a site for institutional innovation on the level of the organisational field.

8.2 The CDIO Initiative

8.2.1 Foundation

Within the engineering education community, the CDIO approach can be seen as a major attempt to productively integrate the academic and professional aims, according to the dual nature ideal. The initial idea was conceived at the Aero-Astro department at MIT, starting from the recognition that engineering education had become

increasingly distanced from engineering practice, as engineering science had replaced engineering practice as the dominant culture among faculty in the past decades (Crawley 2001). The ideas appealed to Swedish industrialist Peter Wallenberg, who encouraged MIT and three Swedish universities – KTH Royal Institute of Technology, Chalmers University of Technology, and Linköping University – to apply for a grant to develop a framework for engineering education reform (MIT 2000). The four project partners, calling themselves *the CDIO Initiative*, started jointly developing and testing a methodology through application in pilot programmes: at MIT the aerospace programme, at KTH vehicle engineering, at Chalmers mechanical engineering, and in Linköping the applied physics and electronics programme. The aim was to educate students in developing and deploying technology, or, using the words that gave the CDIO acronym: to *conceive, design, implement, and operate* technical products, processes and systems.

Soon after the CDIO Initiative started, other universities expressed interest to participate in the endeavour. From a four-year project with four partners, the CDIO Initiative evolved into a community, which kept growing. By 2018, more than 150 institutions have formally joined as collaborators. The annual international CDIO conference started in 2005, aiming to discuss and develop the ideas and methods for implementation, and to document and report experiences. Peer-review of conference contributions was introduced in 2009, and a track for engineering education research opened in 2016 (Edström 2019). A book about the CDIO approach is in its second edition (Crawley et al. 2007, 2014).

8.2.2 *The Integrated Curriculum*

The CDIO community advocates improving professional competence, and making the professional and disciplinary preparation mutually supporting. The first aim is to support students in achieving a *deeper working* understanding of disciplinary fundamentals, not least crucial as a preparation for practice. What sets CDIO apart from other concepts for engineering education development is the focus on combining and improving the contributions of both discipline-led and problem- or project-led (PBL) approaches in the curriculum (Edström and Kolmos 2014). This approach was intended to replace the constant tug-of-war over the curriculum, with its underpinning binary view on theory and practice. It also implied critique of any one-sided solution: just as a purely project-based curriculum risks resulting in fragmented knowledge, a purely discipline-based approach risks resulting in

poorly designed curricula, at worst consisting of disciplinary courses disconnected from each other, and as a whole, loosely coupled to espoused programme goals, professional practice, and student motivation (Edström and Kolmos 2014, p. 549).

The strategy formulated by the CDIO community is to develop a curriculum that integrates disciplinary theory and other professional aims, on the programme level, on the course level, and in faculty development (Crawley et al. 2014). The objective

is to achieve an *integrated curriculum*, meaning that students should develop professionally relevant competences hand in hand with their acquisition of deeper working understanding of disciplinary knowledge, throughout the programme. The CDIO approach is also programme-centric, intended to create the interconnected curriculum structures identified by Graham (2012) as a key factor associated with successful and sustainable change. An outcomes-based approach is used, and the integration of theoretical knowledge and professional competences applies to every stage of this system:

- The starting point is to formulate a vision of what engineers from this programme will be able to do.
- What students therefore need to learn is expressed as intended learning outcomes at the programme level.
- These are apportioned as the course learning objectives of both subject courses and project-based courses.
- The course learning objectives are finally reflected in the design of learning activities and assessment of student learning outcomes.
- These links are continuously improved through cycles of evaluation and development involving programme stakeholders.

8.2.3 *Micro Case: Mechanical Engineering at Chalmers*

The programme-centred approach in CDIO can be studied at Chalmers, one of the four founding universities. The Mechanical Engineering programme is a five-year combined Bachelor and Master of Science in Engineering. Here, the CDIO methodology is implemented to keep the programme unified, despite being a composite of courses from several departments and disciplines. The team has created capacity for programme development, enabling the programme leaders to constantly set new goals and pursue them in a relatively agile process.

The Mechanical Engineering curriculum is well documented in the programme description, showing how skills, such as communication, teamwork, and ethics are integrated in several courses with progression throughout the years (Malmqvist et al. 2006). One of many interesting developments in this case is the integration of computational mathematics, aiming to modernise the mathematical content while also strengthening the connection between engineering and mathematics. The rationale was that students need to learn to solve more general, real-world problems, while they can spend less time “*solving oversimplified problems that can be expressed analytically and with solutions that are already known in advance*” (Enelund et al. 2011). One of the guiding principles was that students should work on the complete problem: from setting up a mathematical model and solving it, to simulation of the system, using visualisation to assess the correctness of the model and the solution and make comparisons with physical reality. The interventions in the programme involved new basic math courses including an introduction to

programming in a technical computing language and environment (Matlab); production of new teaching materials (since few textbooks take advantage of the development in computing); integration of relevant mathematics topics in fundamental engineering courses such as mechanics and control theory; and cross-cutting exercises, assignments and team projects shared between the mechanics and strengths of materials courses and mathematics courses. Instead of framing this as a task for mathematics teachers to solve within the mathematics courses, the programme-driven approach was applied, where making connections to mathematics in engineering subjects was at least as important as making connections to engineering in mathematics. Similarly, the integration of sustainable development demonstrates how the programme approach enables systematic integration of important cross-cutting topics in several courses, linked to overall programme learning outcomes and ensuring progression (Enelund et al. 2013).

This programme was developed and refined over a long time, by a team of faculty with high legitimacy and the resource allocation system in their hands. The coupling between the programme and its courses creates both structural capital and agility, which allows the programme team to set and reach new goals. There is no doubt that many other programmes, despite similar intentions, have failed to achieve such development.

8.2.4 CDIO and Faculty Competence

A key component of the CDIO framework is a recognition of the need to enhance faculty competence. This is because the implementation of the integrated curriculum is enabled and limited by faculty *engineering competence* and faculty *teaching competence*. First, on the course level, the success of the integration strategy depends on the willingness and ability of individual faculty members to unite the theoretical and the professional aspects. This works only to the extent that the educators are prepared to attend also to professionally relevant aspects that are not necessarily part of the teaching traditions of their subject. Then, on the programme level, CDIO devises a process for establishing structures to hold the curriculum together, making the programme a joint collegial project, where every course has an explicit function towards the programme goals, and where a programme approach can be used to address learning needs, like in the Chalmers case above. Whether the integration can be realised and sustained on the programme level is then also dependent on the capacity to coordinate the work of faculty members.

One general challenge when recommending faculty development as part of a programme-centred reform concept is that although it is an important condition for success – often the most critical – it can be a domain in which the programme has little influence. This is also the area where least progress has been reported by CDIO implementers (Malmqvist et al. 2015). At Chalmers, a programme commissions courses from departments but has no formal influence over the processes that ensure teacher competence, such as hiring and promotion (Malmqvist et al. 2010).

Nevertheless, in many institutions implementing CDIO, cautious steps are taken on the university-wide level to strengthen faculty engineering competence. At MIT, a limited number of *Professors of the Practice* can be hired (de Weck 2004; MIT 2017). To support faculty development of engineering competence, some strategies implemented by CDIO collaborators are: sabbaticals to work in industry and public sector, partnerships with industry in research and education projects, allowing and encouraging consultancy work, and professional development activities at the university (Malmqvist et al. 2008). Other activities aim to strengthen faculty teaching competence. At Chalmers, the appointment regulation specifies Lecturer positions based on professional skills, as well as positions up to Professor (not holding a chair) with emphasis on pedagogical expertise (Chalmers 2013). Further, in every hiring or promotion case at Chalmers, at least one of the external evaluators is a teaching expert focusing on candidates' teaching competence. In the Swedish context, most universities also offer courses on teaching and learning to faculty. One reason is that 10 weeks of such education was for many years a national eligibility requirement for senior lecturers and professors (Lindberg-Sand et al. 2005) and the practice was continued even when this regulation was removed in a reform to increase autonomy.

8.3 Organisational Conditions – A Theoretical Framework

8.3.1 *An Organisational Perspective Is Needed*

Up to this point, this chapter has discussed how a global community of engineering educators created and adopted the CDIO approach to develop the integrated curriculum, in order to pursue the dual nature ideal. While there is great awareness of the importance of faculty competence, the endeavour has still been quite focused on the curriculum development in itself. It is possible to critique the CDIO approach for being too limited, just like Harvey Brooks admonished engineering educators in 1967 for focusing too much on the curriculum and course content:

What kind of faculty? What kind of research? What kind of curriculum and courses? I raise these questions in that order because I think this is the order of their significance and importance. In fact, I would say that the main fault of engineering education is the excessive preoccupation with curriculum... In my view, the heart of the problem lies in the character and orientation of the engineering faculty. In the long run the courses and curriculum, and the knowledge and motivations of the students, are bound to reflect the research interests, the consulting experience, and the values of the faculty (Brooks 1967b).

Following Brooks' advice, the next section will place the issue on the organisational level, by considering the forces that shape the faculty and the setup of the organisation. A theoretical framework is then needed to understand the university as organisation, and in particular as an environment for the kind of educational development that is in focus here. The ability to develop the integrated curriculum depends on how well the organisational conditions are understood.

8.3.2 *The University Is Not a Machine*

The mental models, concepts, and theories that we hold can function as lenses for discerning and interpreting things that may otherwise have gone unnoticed, or they may limit our view, because to highlight some aspects is also to relegate others to the background. A technical university is dominated by engineers, who, at least according to Picon (2004, p. 429), have a strong tendency to see functionalist rationality as the natural guideline for action. A suitable metaphor for the organisation would then be a factory or a machine, suggesting an organisation optimised for effective operation, structured along the organisational chart, and designed to coordinate its activities “*in a routinized, efficient, reliable and predictable way*” (Morgan 2006, p. 13). While this view is not necessarily wrong, it lacks explanatory power for many aspects of university life. Weick (1976, p. 1) observed that people often find that their experiences in educational organisations “*prove intractable to analysis through rational assumptions*”, as the rational view simply does not “*explain much of what goes on within the organisation*”. An alternative framework will be needed, that is more appropriate to analyse the university as an organisation and to assess the implications for educational development.

8.3.3 *Institutional Logics*

The following section draws on theory that describes organisations as embedded in and infused by *institutional logics* (Friedland and Alford 1991; Thornton and Ocasio 2008; Thornton et al. 2012). Institutional logics can be succinctly expressed as “*the way a particular social world works*” (Jackall, cited in Thornton et al. 2012, p. 46). If the machine metaphor focuses on the formal and visible structures, resources, activities and outputs, the institutional logics perspective helps explain organisational behaviours that defy rational assumptions, because it *also* takes into account the subtler roles played by norms, values, culture and identities. A comprehensive definition shows that both the material and normative dimensions are incorporated in the institutional logics:

the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality (Thornton and Ocasio 2008, p. 101).

On the highest level, Thornton et al. (2012, p. 73) list seven ideal types of institutional logics in society: *state, market, community, profession, corporation, family, and religion*, each with its own set of norms and sources of legitimacy and authority. On the next level is the institutional field, where combinations of these societal logics are at play. For instance, in the higher education sector, some practices are shaped by professional logics (e.g. peer review is shaped by the academic profession), while other aspects are shaped by market logics (e.g. technology transfer) or

state logics (e.g. degree frameworks). An individual university may have its own instantiation of the field-level logics. In a complex institutional environment with incoherent demands, there may be tensions between different logics, leading also to tensions between the logics embedded within any particular university. In the following, the institutional logics of two different professions will be in focus: the engineering profession and the academic profession.

8.3.4 *Practices and Identities*

Practices are intimately connected to the institutional logics of the organisation, in

a fundamental duality between logics and practice, where constellations of relatively stable practices provide core manifestations of institutional logics (Thornton et al. 2012).

Practices may reflect the institutional logics differently, as they align with different parts of the institutional environment, for instance, uncoordinated constituents. This can create tensions between practices, within practices, and between institutional rules and the effectiveness of the practice. Further, practices may be conceptualised as interdependent, so that changes in one practice may have ramifications for other practices in the organisation (p. 141). Here, the interdependence of education and research is in focus. There is also a close relationship between practices and identities; we can say that they are co-produced.

The availability of standardised social identities in higher education has great importance. Henkel (2005) refers to Bernstein in saying:

identities are strongest and most stable within the context of strong classification, the maintenance of strong boundaries protecting the space between groups, disciplines or discourses.

The classifications of individuals are important in higher education; it is something that university organisations pay much attention to and spend much effort on. In fact, education can be seen as a process where students pass through a series of stages, with carefully controlled transitions, e.g. admission, examination, degrees. The classification of academics is no less important; just think of disciplines, titles, appointments and promotions.

The tight link between identity and practice is also evident when we consider how *status* is attached to both. Complex institutional environments can generate patterns of differentiated status between organisations, and between practices and groups within the organisations. Status also affects the relationships with the resource environment. Kodeih and Greenwood (2014, p. 10) note that high-status actors can be expected to have priority access to the most valuable resources. This applies to the organisation as a whole, such as when high-status universities attract funding, and the most talented researchers and students; it also applies to groups and individuals on the inside. In summary:

each institutional field consists of one or more available logics, as well as an array of appropriate collective organizational identities and practices from which individual organizations assemble their particular identities and practices (Thornton et al. 2012, p. 135).

8.3.5 *Identity and Status in Curriculum Change*

The development of engineering education advocated by the CDIO initiative is precisely an attempt to change one of the practices of the university. As we saw above, both the practices in the organisation, *what we do*, and the identities, *how we see ourselves*, are related to each other and to institutional logics. It is then a key concern how the proposed curriculum models relate to the institutional logics, to other practices – research in particular, and to identities in the organisation. If we consider the curriculum also as an expression of educators' identity, it is clear that changes can be seen as more or less valuable and meaningful, or improper and threatening. Status plays an important role, and change may be strongly resisted if it is perceived as a threat to the status of organisations, groups, or individuals. Status can, however, also favour change, since those who are perceived as successful and legitimate are role models likely to be imitated by peers – and this applies to organisations (DiMaggio and Powell 1983) as well as to individuals and groups within the organisation (Deephouse and Suchman 2008, p. 61). In her influential study of academic identities, Henkel concluded that the *discipline* and *academic freedom* were the two things that mattered most, “*in many cases the sources of meaning and self-esteem, as well as being what was most valued*” (Henkel 2005, p. 166). Seeing the curriculum as an expression of faculty identity, it is also obvious that any change in practices and structures will be strongly resisted if it is perceived to threaten these values. In the light of Henkel's findings, CDIO programme development seems particularly challenging, as the strategy to integrate professional aspects in courses will most likely differ from the traditions of the discipline, and the need for coordination across the curriculum can be seen to limit academic freedom.

8.4 *Analysing the Dual Nature Ideal*

8.4.1 *Competing Professional Logics in Engineering Education*

Drawing on the institutional logics theory, we will now consider the academic-professional duality in engineering education, the ideal as well as the tensions. We saw that institutional logics – patterns of material practices, assumptions, values, beliefs, and rules – are embedded in the practices and identities within the university. The dominant *practices* in higher education – in principle the practices that define a university – are research and education, with intimately related *identities* for faculty, as researchers and educators (see Fig. 8.1).

Fig. 8.1 The major practices in higher education and the co-produced faculty identities (Edström 2019)

Fig. 8.2 Education as a practice expressing two professional logics (Edström 2019)

In complex institutional environments, the logics embedded within a particular practice can contain contradictions. The proposition here is that the engineering curriculum expresses tensions between the institutional logics of two professions: *the logics of the engineering profession* that we educate for, and *the logics of the academic profession* of the educators. These logics come with slightly different assumptions, beliefs and values regarding the educational mission and the role of the educators. The logic of the engineering profession reasonably assumes that the educational mission is about teaching the next generation of engineering professionals. Drawing on the logic of the academic profession it could instead be reasonable to see the teaching mission as conveying the theory of their discipline (see Fig. 8.2).

To elaborate some aspects in which the institutional logics of the two professions differ: In the logics of the *engineering profession*, the educator teaches future professionals. Some educators will embrace the engineering profession as a part of their identity, and they may therefore have a more positive attitude to integrating professional aspects. The engineering identity of faculty can be strengthened if they have experience of professional practice. Knowledge is seen as relevant if it is useful for engineering practice, for industry and society. Education should prepare students for professional practice, i.e. working on real problems in real contexts, which includes a deep working understanding of theory, and the ability to integrate and apply it. In contrast, according to the logics of the *academic profession*, the educator mainly teaches disciplinary theory. Educators' academic identity is developed through a PhD in a discipline, followed by a research career. Knowledge is seen as relevant if it is part of the disciplinary canon, and problems and questions are interesting if they have a potential to lead to new discoveries furthering the disciplinary

Table 8.1 Analysis of different curriculum emphases, in the logics of the engineering profession and the academic profession (Edström 2019)

Institutional logics	The engineering profession that we educate for	The academic profession of the educators
The role of the educator	Teaching future engineers	Teaching theory
Relevant knowledge	Knowledge useful for engineering practice	The disciplinary fundamentals
Interesting problems and questions	Real problems, consequential issues in industry and society	Pure problems, close to the disciplinary frontier
Students are prepared for	Engineering practice, through deep working knowledge and professional competences	Engineering practice, through theoretical knowledge Research education – disciplinary depth

frontier. Engineering students should learn disciplinary theory, and become prepared for research education. These factors are summarised in Table 8.1.

This analytic scheme is not meant to set these two sides of education against each other. Instead, the point here is precisely that *both sides are necessary*, and that according to the dual nature ideal, they should also be in a *meaningful relationship*. This does not, however, prevent contradictions and tensions between the logics. Simply put, the capacity to teach disciplinary theory is strengthened by the academic logics, while the professional logics strengthen the capacity for addressing also the other necessary aims of the curriculum. When the professional logics are weakly represented among the faculty, it is more difficult to satisfy the related aspects in the curriculum – for instance, integration, application, and real problems in context.

8.4.2 Competing Logics in Research

Research, the other defining practice in the technical university, can be characterised by a similar tension within its institutional logics, where two beliefs about the aims of research exist simultaneously: one that research aims to further knowledge for its own sake, and one that research is guided by a consideration for usefulness in society. The first belief can be expressed as *the university as academia*. Because the academic career depends on peer recognition, seeking knowledge “for its own sake” quickly translates to the same thing as furthering a discipline. Peer approval is a *sine qua non*, and those whose work does not pass peer review, the disciplinary quality control, will be marginalised. Quite aptly, Gibbons et al. (1994) called disciplines the “*homes to which scientists must return for recognition or rewards*”. The disciplines can be seen as sites for controlling the resources necessary for survival in academia. The academic capital comes in hard currency, such as having publications accepted, passing a thesis defense, being appointed and promoted,

and receiving grants, prizes and invitations. These academic decisions contribute to classifications of individuals, which is a particularly important component of identity. Research merits dominate every step in the career system (see, for instance, Geschwind and Broström 2015) and the academic pursuit can become very personal:

A key element for many academics is the narcissism involved in doing and publishing research. The self is invested in the work and research publications function as reinforcers and stabilizers of a sense of self susceptible to the insecurities and vulnerabilities of a profession constantly exposed to assessment and a level of competition where failures greatly outscore successes for most people (Alvesson et al. 2017).

All this helps explain the strong socialisation of faculty into the discipline-based identity, values and beliefs.

The other prevailing belief, *the university as public service*, implies that research is guided by *consideration for use*. The challenge is then how to evaluate the usefulness dimension of the work, and who should be seen as the legitimate judge. It is quite suggestive that even funding for highly applied research is often dispensed based on academic peer review. While there are efforts to pay more attention to societal impact in academic career evaluations, it seems seldom conceptualised as a main consideration within research and education, but as a separate third task, service, and the discourse often has a distinctly commercial character (cf. Dill 2012) (see Fig. 8.3).

Because the resources under academic control are so vital, the proposition here is that “university as academia” has stronger support in the institutional logics than does the “university as public service”. While the former is highly consistent with the logics of the academic profession, the latter has strong similarities with the logics of the engineering profession, for instance, the values attached to integration, application, the interest in real problems that are consequential in society and industry, and their real solutions. These two beliefs are not mutually exclusive, as research can simultaneously be directed toward applied goals and lead to significant new understandings (Brooks 1967a; Stokes 1997). There is, however, still a core distinction, similar to the description by Williams (2002, p. 44):

In science, the fundamental unit of accomplishment remains the discovery; in engineering, the fundamental unit of accomplishment is problem-solving.

Fig. 8.3 Two aims of research, with corresponding beliefs (Edström 2019)

The conclusion here is that in the research practice, *the logics of the academic profession enjoy the strongest support in the institutional environment*, both normatively and materially.

8.4.3 Interplay Between Education and Research

Education and research have until now been discussed separately, focusing on some tensions within each practice due to inconsistent demands in the embedded logics. What remains is to consider their *interdependence* (see Fig. 8.4). There is much scholarship addressing the relationship – often called the *nexus* – between research and teaching (for a recent overview, see Geschwind 2015). In focus here, following the theoretical framework, are the different conditions for the practices, and how research influences the dual nature of engineering education. Due to inconsistent institutional demands, we can expect patterns of *differentiated status* between these practices and between groups within the organisations. According to Meyer and Rowan (1977), we can further expect tensions *between* practices, and between institutional rules and the *effectiveness* of the practice.

When a technical university is viewed from the outside, research and engineering education both enjoy high status. The research activity corresponds to the role of the university as producer of new knowledge and is an important source of status and identity, not least for the international reputation and brand. Engineering education is a prominent source of legitimacy for the technical university, as a supplier of elite professionals to society and industry. However, *within* the university, while there is certainly status in excellent teaching, the status of research is generally higher. We are reminded of the imperatives created by the “university as academia” described above. While teaching merits are increasingly emphasised in hiring and promotion criteria, it seems sufficient from a career point of view to be above a threshold level (Graham 2015). Another reason can be found in the different resource environments. Education funding is distributed internally, often based on quantitative factors without rewarding quality. Research funding varies considerably between research fields, in terms of availability, and whether a grant affords freedom or

Fig. 8.4 Competing institutional logics in education and research (Edström 2019)

comes with strings attached. But in contrast to education, research funding is often sought externally and in competition based on peer review; here, the rewards for excellence are considerable both in terms of resources and status. In short, the dominance of research is guaranteed by the reproduction and socialisation of the faculty, as well as strongly incentivised by the resource environment. In conclusion, *research has stronger institutional support than education, both normatively and materially*. This affects the conditions for education generally, including related matters such as the attention paid to teaching competence, teaching quality, and educational development.

8.4.4 *Imbalances in Engineering Education*

While the imbalance between education and research is important for shaping the conditions of engineering education, the focus here is the dual nature of engineering education. The academic-professional duality was conceptualised above as competing logics *within* the education practice: teaching theory and teaching professionals. Because of the crucial role played by research in shaping the faculty, research will also come to limit and enable what is possible in education. If it has been perceived as provocative that the needs of education are increasingly taken into account in the appointment and promotion of faculty, it seems even more daring to make suggestions about the research. But the interdependence of education and research does raise the question about what kind of research could strengthen the educational mission in a university, since the reproduction of the faculty in a technical university is largely under the auspices of the research enterprise. It should be interesting for funding agencies to consider how the research they support affects conditions for the professional aspects of engineering education. While some research and researchers focus on endeavours emanating from a purely academic interest, furthering a discipline, there are also researchers who work on matters with a more direct consideration for use. The analysis above suggested that such research shares some key aspects with the engineering profession, e.g. the values attached to integration, application, and focus on real problems in naturalistic contexts. In the technical university, there are applied and cross-disciplinary fields closer to professional practice. It can be presumed that faculty with such research interests can have more engineering capital, for instance, through contacts with industry (including the public sector). In their *role as educators* they might therefore find it more natural to take on also the role of educating professionals (see also Table 8.1).

The suggestion here is that the institutional logics of research, being the dominant practice, strongly influences the institutional logics of the education, by shaping the faculty. Hence, *the more the research practice is dominated by the academic logics*, over the consideration for use, *the more it will also tilt the balance in education, in favour of teaching theory*, rather than teaching professionals. When the balance is too heavily tilted, it will be difficult to achieve the productive relationship between the academic and professional aims. It is possible to see the initiatives like CDIO as attempts to address precisely this imbalance.

8.5 CDIO as Institutional Innovation

8.5.1 *Active Institutional Innovation*

After highlighting the tensions within the practices inside the university, we will now return to the institutional logics theory. Some additional conceptual tools are needed to consider the role of the CDIO initiative as an actor in the organisational field.

It is easy to think of institutional norms and rules as mostly limiting the autonomy of organisations and individual actors. Focusing instead on the opportunities, institutional logics can also be seen as *resources that can be invoked* for making identities and practices legitimate. For instance, a reform may increase its chances of success if it manages to draw on values aligned with the prevailing institutional logics. Especially in organisations with multiple institutional logics, there are also opportunities for individuals and organisations to actively exploit any inconsistencies and contradictions (Thornton et al. 2012). Opportunities for institutional innovation are available at all levels, for a whole organisation, for any particular activity, or for individuals:

Logics are not purely top-down: real people, in real contexts, with consequential past experiences of their own, play with them, question them, combine them with institutional logics from other domains, take what they can from them, and make them fit their needs (Binder 2007, p. 568).

Actors and sub-groups can, and do, utilise such opportunities selectively, making the organisation a mosaic of groups, with more or less potential for enabling or resisting change (Greenwood and Hinings 1996).

8.5.2 *The Organisational Field as a Site for Mobilising*

Actors within an organisation can turn to the institutional field as a source of institutional innovation. For instance, Thornton et al. (2012, p. 110) mention how people with experience from different institutional contexts are less likely to take things for granted in their local organisation, and therefore may have capacity to create institutional change. Greenwood et al. (2002) pointed out the role of professional associations in legitimating change, by hosting debate, justifying and endorsing new practices. This is the function of *theorization*, “*the process whereby organizational failings are conceptualized and linked to potential solutions*” (p. 58). Such collective sense-making can support change in organisations by recognising the weakness of existing arrangements and building the capacity for action. This means, for instance, developing sufficient understanding of the new conceptual destination, the skills and competencies required to function in that new destination, and the ability to manage how to get to that destination (Greenwood and Hinings 1996, pp. 1039–1040). The organisational field can also offer concrete exemplars of

structures and practices that reflect ideas and values in the institutional field. Thornton et al. (2012, p. 159) refer to field-level *vocabularies of practice*, which

guide attention, decision making, and mobilization, and provide members of social groups with a sense of their collective identity.

This can create common ground, and facilitate sense-making and collective action.

8.5.3 *CDIO as a Driver of Institutional Innovation*

Taking a new look at CDIO in the light of these concepts, the CDIO initiative can now be seen as a driver for institutional innovation, situated in the organisational field, and promoting new logics through collective mobilisation. It is a site for jointly crafting and sharing narratives, and for developing certain vocabularies of practice. Successful implementations serve as exemplars and proofs-of concept, and individuals as role-models. When the CDIO community shares experiences from different institutional contexts, it also exposes individuals to a wider repertoire of institutional values, practices and identities, which can then also make them less likely to take things for granted in their home environment. Local innovators can invoke CDIO as a legitimate template, to strengthen the legitimacy of their local work, and as a part of their identity. The legitimacy of CDIO is also partly mimetic, as the presence of high-status technical universities among founders and adopters has played an important role in the growth of the community. Whether CDIO can also achieve normative or cognitive legitimacy depends on the match between the values and norms that are communicated by the CDIO community, and the prevailing institutional logics.

The strategy to embrace discipline-led teaching as the major part of the integrated curriculum can make CDIO a more legitimate innovation, in the sense that it is understandable and consistent with widespread practices. It is therefore potentially less threatening to faculty identities, than, for instance, advocating educational models purely based on PBL. While CDIO obviously does challenge programmes that consist of loosely coupled theoretical courses, the proposed interventions still stay on common ground. PBL is an important component of the integrated curriculum, but CDIO does not advocate a pure PBL curriculum. CDIO could thus be seen as balancing different expectations with compromise strategies (cf. Oliver 1991). Another compromise is to stress the need for a deeper working understanding of disciplinary theory. This is acceptable to those who emphasise disciplinary theory, as well as those who emphasise what students can do with their understanding. The rhetoric is aligned with both the academic and engineering professional logics.

8.6 Conclusions

The theme of this chapter was the dual nature ideal for engineering education, or the idea that the academic and professional preparation can be productively combined. The argument was that it is feasible to realise the ideal in engineering curricula, by integrating disciplinary theory and professional aims in a meaningful relationship. Both types of learning outcomes are already present in the stated aims of engineering curricula, and there are approaches that readily support such implementation, for instance the CDIO model with its integrated curriculum. There are however limitations. First, the productive relationship can be realised and sustained in courses only to the extent that individual faculty members are willing and able. Then, whether the integration can be realised and sustained on the curriculum level further depends on the capacity to coordinate the courses, or in other words to coordinate the work of faculty members. Hence, the challenges facing the integrated curriculum lie on the organisational level.

Using an institutional logics perspective, a tension was discussed within the technical university, between the engineering profession that we educate for, and the academic profession of the educators. Their respective institutional logics were analysed separately, showing two ways to see engineering education, but making the point that both sets of values are needed. An image of the university organisation was elaborated, where research holds a primary position and education is positioned as a secondary practice. The academic profession seems to have the upper hand, not only in research, where disciplinary interests take priority over considerations for use, but also in education, where disciplinary theory takes priority over other aspects of professional preparation. This “spill over” happens through the faculty, whose academic identity is stronger than their engineering identity. This is unsurprising, as disciplinary research is the birthplace of new faculty, and research success is crucial for survival in the university. While it is understandable that the organisation needs to spend considerable attention to its own academic reproduction processes, there is a point where this takes a life of its own and precedence over the educational mission of the university. The rise of a movement like the CDIO initiative can be seen as a sign of these imbalances inflicted on engineering education, and its dynamic growth shows efforts to defend the dual nature ideal.

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