DEVELOPING A DIDACTIC FOUNDATION FOR THE TECH FACULTY AT AARHUS UNIVERSITY

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ABSTRACT

In January 2022 the Faculty of Technical Sciences (TECH) at Aarhus University (AU) appointed a working group to develop a *didactic foundation* for teaching at TECH. The background was a need to develop a joint platform for teaching, pedagogical competence development, and other educational activities at the faculty, after a recent history of organizational mergers and changes, and subsequent development of a new joint strategy. The working group was to identify important factors that should characterize future teaching at TECH and propose a commonly recommended foundation upon which TECH teachers can collectively build, reflect, and improve their teaching. This paper will justify and describe the work process, present and reflect upon the outcome, relate the outcome to the CDIO Standards and Syllabus, discuss lessons learnt, and provide advice for others engaging in similar work.

KEYWORDS

Didactics, Pedagogy, Change Management, Teaching Practice, Faculty Competence, Standards: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12

INTRODUCTION AND BACKGROUND

In 2010 the Engineering School of Aarhus was merged with Aarhus University. The Engineering school was a university college educating professional bachelors (Ministerial order, 2013), and solely focused on teaching. Before 2010, Aarhus University and the Engineering School of Aarhus jointly had a master's program in technical IT; a programme that started in 2004 (Aarhus University, 2004). After the merger in 2010, one department (the Dept. of Engineering) and one school (the Aarhus School of Engineering) were formed. These two entities drifted further and further apart, so in 2021 the Department of Engineering and the School of Engineering were dissolved and four discipline-based departments were formed: the Department of Biological and Chemical Engineering, Department of Civil and Architectural Engineering, Department of Electrical and Computer Engineering, and Department of Mechanical and Production Engineering. These four departments make up the TECH faculty,

bringing together a quite diverse set of study programme types, teaching cultures, disciplines and thematic areas under common leadership. A strategy process was initiated and a new joint strategy was ready a year after the organizational change (The TECH Faculty, 2022).

The CDIO framework has been a foundation for the professional bachelor programmes since the Aarhus Engineering School joined the CDIO community in 2010. The CDIO principles were therefore, by many, seen as “the way to teach practice-based engineering”. However, especially within the former Department of Engineering, there was resistance towards CDIO. The faculty leadership, therefore, saw a need to develop a joint platform for teaching, pedagogical competence development, and other educational activities at the faculty, rather than just adapting CDIO as a basis for all programmes.

In January 2022 the vice dean of education at AU’s Faculty of Technical Sciences (TECH) therefore appointed a working group to develop a *didactic foundation* for the faculty. The group consisted of particularly engaged Directors of Studies, a Head of Programme, professors and associate professors with teaching duties, and a student – in all representing TECH’s diversity of organizational sections, study program types, teaching cultures, and disciplines. The group was supplemented by an international guest researcher with experience in strategic change processes in STEM education (Øien & Bodsberg, 2022; Øien et al., 2022). It was given the tentative mandate to identify important factors that should characterize future teaching at TECH - and propose a commonly recommended foundation upon which TECH teachers may collectively build, reflect, and improve their teaching. The starting point of the work was ‘*Which values should our teaching be built upon?*’ The stated goal was to develop something which could be seen as practically useful by the organization, and which over time would stimulate reflections, conversations, culture and competence building related to educational activities.

RELATED WORK

D'Andrea and Gosling (2005) note in their introduction (p. 7):

It seems that every higher education institution wants to boast that it offers 'high quality learning and teaching'. Mission statements consistently claim that universities and colleges seek to provide excellent teaching and a high quality learning environment. But it is less than obvious that institutions are either clear about what these goals mean or actually pursuing these goalswith strategic vision. In most cases neither of these key goals is well defined: what is excellent teaching and what constitutes a high quality learning environment? And the manner in which institutions are attempting to achieve these goals is many and varied. Often the approach simply reflects the historical traditions of a particular institution and its associated values and practices.

The present work can be seen in this light: As an attempt to gather and formulate elements that constitute and support excellent teaching and a high-quality learning environment.

According to Gedda et al. (2016), *Luleå University of Technology* developed what was called “The Pedagogical Idea”. It was a *common pedagogical idea, communicating core values of teaching and learning for the whole university (including e.g. healthcare, art and teacher education).*- (p.306). It was developed after a not-so-successful development process leading to what they called *The Creative University,* including the concepts of Knowledge Building and Arena. According to the authors, the Creative University was a top-down process, creating resistance among the teachers. As they note, however, *the handover to the teachers who were expected to implement it in a teaching context was weak. As the concept was based on*

principles of student-centred learning, it made high demands on educational knowledge and teaching skills among the university professionals." (p. 305).

This indicates that when formulating guidelines and advice that are to be practically useful for university teachers, it is important to combine a top-down approach with bottom-up user involvement and to emphasize a practical, user-oriented approach, rather than a theoretical, research-oriented framework. Note that this does *not* imply that the guidelines and advice should not be based on sound research-based knowledge – it simply indicates that the formulations and wordings eventually presented to the target audience should be simple, context-specific and practically oriented, rather than heavily relying on scientific terms from educational development research and pedagogical theory.

The standards of the CDIO initiative (CDIO, 2023) can also be seen as a framework describing what is needed to enable and implement good teaching. It has previously been used at Aarhus University to initiate discussions about teaching, but in many cases, teachers found it to be abstract and too much focused on organizational matters. As an example, many teachers from the professional bachelor see e.g. standard 1 ("*A CDIO program is based on the principle that product, process, system, and service lifecycle development and deployment are the context for engineering education. Conceiving–Designing–Implementing–Operating is a model of the entire product, process, system, and service lifecycle. The Conceive stage includes defining customer and societal needs; considering technology, enterprise strategy, and regulations; and, developing conceptual, technical, and business plans. The Design stage focuses on designing a solution to the addressed need, that is, the plans, drawings, and algorithms that describe what will be implemented. The Implement stage refers to the transformation of the design into the product, process, system, or service, including manufacturing, coding, testing and validation. The final stage, Operate, uses the implemented product, process, system or service to deliver the intended value, including maintaining, evolving, recycling and retiring. The consideration of environmental, social, and economic sustainability is an integral part throughout the lifecycle*." (CDIO, 2023)) as stating the obvious. They have a background in practise, the students have an internship as an important and integral part of their studies (where the teachers serve as a link between the institution and the company), use Insights Discovery (A psychometric tool based on the psychology of Carl Jung, see (Insights, 2023)) and many more activities directed towards becoming "an engineer who can engineer".

PROCESS AND TIMELINE

During its 11-month working period, the working group held several meetings, commencing with a discussion on the working group members' individual experiences and perspectives on what constitutes great teaching. It was quickly agreed, however, that including international perspectives, and taking into account a knowledge-based approach to educational development, would enhance the quality of both discussions and content.

Subsequently, the focus was therefore shifted to identifying how other institutions internationally have explicated a didactic foundation for teaching and learning. For this purpose, educational strategies and pedagogical principles from several relevant universities abroad were surveyed (Luleå University of Technology (2023), NTNU (2018), DTU (2023), KTH (2012) TU Delft (no reference), Chalmers (no reference)). Perspectives from these were also reviewed against AU's and TECH's strategies. The following education-related key objectives from the AU strategy were particularly noted as important to comply with:

- *Engaging in teaching and learning*

- *Strengthening students' general competencies*
- *A future-proofed graduate competency profile*
- *More career-oriented elements in the degree programmes*

In the TECH strategy, it was noted that an important focal point is to '*accommodate all our students and meet them where they are. Our programmes and teaching must involve and activate students and support their academic and personal development in the direction they have chosen to take.'* Other education- and student-related goals in the TECH strategy relevant to the working group's mandate include

- *Meet our students where they are and support their academic and personal development*
- *Provide students with space and opportunity to engage in, and contribute to, solving major societal challenges in collaboration with other knowledge fields*
- *Facilitate in-depth academic qualifications and capabilities*
- *Foster a common culture for how we design education that supports these goals.*

International principles and practices broadly accepted as state-of-the-art were also mapped, most notably the CDIO Standards (The CDIO Initiative website, 2022). Relevant findings from the surveys and mappings were extracted and reformulated to fit the local context and use.

It quickly became clear during this phase that the scope of the group's mandate neither could nor should be limited only to course-level teaching practices: The students' role, not to mention study programme perspectives, must also be considered. To clarify the *students*' roles, expectations and needs, groups of students from selected programmes were therefore invited to several workshops. Initially, the students were invited both to give their views on good teaching and the state of today's education, and to describe their wishes for concrete improvement. One important finding from these student workshops was that students' perception of quality is heavily influenced not only by teaching practices and curriculum design but also by the *infrastructure, facilities and practical framework conditions* under which teaching takes place. It was therefore decided to broaden the working group's scope to also include advice to the faculty on *institutional framework conditions.* It may perhaps be argued that this broadening of scope stretches the term 'didactical foundation' quite far, but since this term had been used from the start it was decided to continue using it for the process outcome.

The students' additions and modifications to the draft didactic foundation were subsequently used as one of the starting points for discussion in a subsequent *Head of Programme* workshop. The main focus of this workshop was on discussing, from a study programme perspective, the current strengths and weaknesses of TECH's education portfolio, desired future development, and programme design principles. Subsequently, to ensure that individual teachers' and course responsibles' perspectives, views and concerns were properly included in the process, all *academic staff* at TECH were invited to participate in a questionnaire, giving their responses to the following questions:

1) Which aspect of your teaching is most important for you to maintain in the future?
2) If you were to change one thing about your teaching, what would that be?
3) Name one thing that you believe students should do to contribute to their learning.

Responses from the questionnaire, which had a response rate of more than 25%, were subsequently analyzed by the working group, and thereafter discussed with student representatives. A second workshop was also held with those teachers who had signaled in their questionnaire responses that they were interested in giving further input to the process. The analysis of responses showed that time for, dialogue with, and activation of their students were in general high on the teachers' agenda. The need for variation in teaching methods and

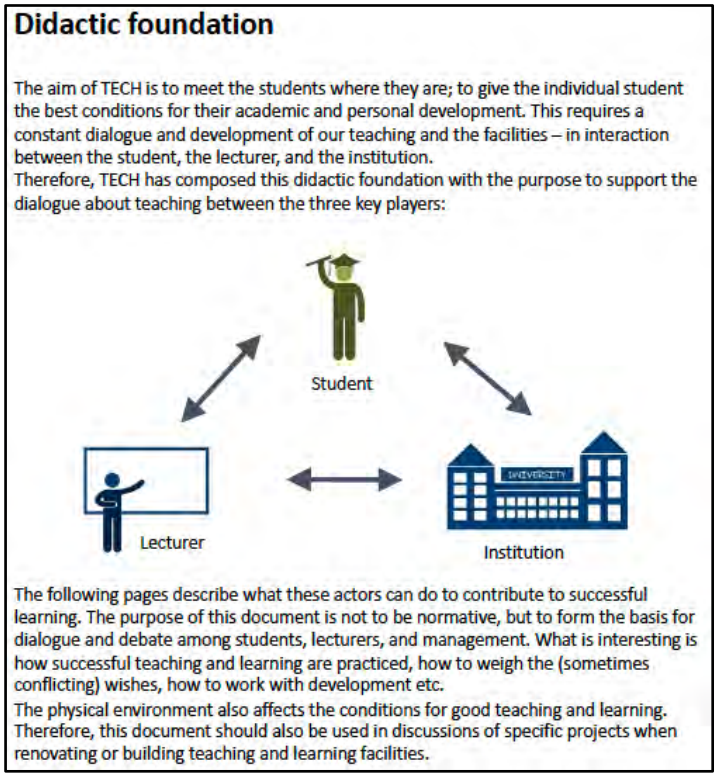
learning activities, coupling of theory to practice, and improvement of institutional framework conditions, including more time for development and improvement of their teaching, were also mentioned by many. The importance of students' engagement, steady work, curiosity, independence, critical thinking ability, and responsibility for their learning was also highlighted.

Finally, meetings were held with the NAT-TECH Study Administration and the NAT-TECH Building Services, to get input in particular on the part of the foundation document dealing with *institutional responsibility* in the collective work towards better teaching and learning and, ultimately, improved educational quality. Finally, the faculty management were invited to comment upon the overall results before the group's deliverable was finalized.

Throughout the whole process, a draft of the deliverable document had been maintained, discussed in the working group, and iteratively refined and improved as new perspectives, responses, findings and insights as described above were continuously added. The final deliverable was submitted to the TECH management in December; its contents are detailed in the next section. The deliverable is a concise 4-page document, describing in succinct and concrete bullet points important expectations, principles, guidelines and recommendations that respectively students, lecturers, and the institution (in particular faculty management and administration) should heed to *collectively* contribute to excellent education quality.

RESULTS AND LINKS TO THE CDIO FRAMEWORK

The front page of the final deliverable document, as presented to the target audience, is shown in Figure 1. It briefly describes the context and strategic motivation for the work and also provides some pointers on the intended use of the document.



Didactic foundation

The aim of TECH is to meet the students where they are; to give the individual student the best conditions for their academic and personal development. This requires a constant dialogue and development of our teaching and the facilities – in interaction between the student, the lecturer, and the institution.
Therefore, TECH has composed this didactic foundation with the purpose to support the dialogue about teaching between the three key players:

The following pages describe what these actors can do to contribute to successful learning. The purpose of this document is not to be normative, but to form the basis for dialogue and debate among students, lecturers, and management. What is interesting is how successful teaching and learning are practiced, how to weigh the (sometimes conflicting) wishes, how to work with development etc.
The physical environment also affects the conditions for good teaching and learning. Therefore, this document should also be used in discussions of specific projects when renovating or building teaching and learning facilities.

Figure 1. Front page of the final delivered document

In Tables 1 – 3, the first two (leftmost) columns list all the bullet-point format recommendations that follow on the subsequent pages of the deliverable document, for respective students, teachers, and the institution. In the third (rightmost) column, we have indicated (for each bullet point listed in the foundation document) which CDIO Standards and/or areas in the CDIO Syllabus we believe it most strongly supports, relates to, depends on, or is relevant for (if at all). As stated earlier, although the foundation document as a whole is in principle independent of any particular didactical 'school of thought', the CDIO principles as reflected through the Standards and the Syllabus have been one important inspiration, and a reference for excellent international practice, throughout (The CDIO Initiative website, 2022).

The working group also believe – as illustrated by the rightmost column in Tables 1-3 - that the document's recommendations as a whole comply with, are supportive and enabling of, and in some cases rest on CDIO principles. Thus the recommendations may help develop *good practice* in line with both the CDIO Standards and the CDIO Syllabus. In some cases, they may also serve as *motivation* for development in line with CDIO Standards, e.g., when it comes to developing engineering learning spaces or faculty competence development programmes.

However, it will be seen that the CDIO standards or syllabus are *not explicitly referred to* in the foundation document, and neither are the recommendations designed to ensure full CDIO compliance *as a goal in itself*. The development process uncovered that the CDIO concepts as formulated in the standards and syllabus are not necessarily easy to grasp or operationalize for individual teachers and students without a background in educational development or strategy. Central CDIO principles turn out to be more easily understood - and thus probably easier to convert into practice - if reformulated into simpler wordings that are adapted to the specific local context, language, culture, and target audience.

Also, this work has dimensions that go beyond the scope of the CDIO standards and syllabus, as it also pinpoints a number of practical and cultural aspects linked to physical framework conditions and human behaviour. Some of these aspects (marked with '-' in Tables 1 – 3) deal with practical issues related to well-being, health, safety, human relations, individual mindsets, and psychosocial learning environments. However, we argue that resolving such issues are important, sometimes necessary (but of course not sufficient), conditions for efficiently enabling practical implementation of CDIO principles. Thus we believe that the foundation document can be used both to 'prepare the ground' for CDIO implementation as well as providing useful guidelines for how to do such implementation in practice - if that is the goal.

Table 1. Recommendations for students, with links to the CDIO Standard and Syllabus.

The student …		**Related CDIO Standard(s) and/or Syllabus areas**
Engages in own learning	*Participates actively: Asks about what is not understood, discusses with the teacher and fellow students, seeks out knowledge, seeks feedback*	Standards 8, 11 and Syllabus 2.4
	Prepares according to the expectations	Standard 8
	Assesses which learning resources best support own learning – both physical and digital	Standard 8, Syllabus 2.4
	Is curious – preferably also outside materials	Standard 8
Establishes good conditions for own learning	*Reflects on own learning*	Standards 8, 11
	Accepts that learning requires a (large) effort	Standard 8 Syllabus 2.4
	Prioritizes own time, including prioritization between work, leisure and studies	-
	Is open to opportunities (student jobs, research, ...)	-
	Shows up well-rested	(Syllabus 3.1)

Contributes to a good learning environment	*Respects fellow students and contribute to a professional environment*	Syllabus 3.1
	Contributes to a good social environment	Standard 6 Syllabus 3.1
	Contributes to a safe environment	Standard 6
	Collaborates with fellow students	Standards 6, 8, Syllabus 2.4 and 3.1
	Contributes to systematic quality assurance work, for example by answering evaluations	Standard 12

Table 2. Recommendations for teachers, with links to the CDIO Standard and Syllabus.

The lecturer …		**Related CDIO Standard(s) and/or Syllabus areas**
Has an eye for the student(s)	*Shows respect for the student*	-
	Shows an interest in the student	-
	Challenges the student	Standard 8
	Believes in the student's potential to develop	-
	Keeps her/his agreements with the students	-
	Is available and spends time with the students	-
	Differentiates the teaching so that it is based on the student's competences	Standard 8
Creates an inspiring learning environment	*Provides specific, well-founded, focused, forward-looking, and timely feedback*	Standard 11. Syllabus 3.1
	Creates commitment in the teaching situation	Standard 6
	Has an active stance on the form of instruction that provides the best learning	Standards 7, 8
	Stimulates dialogue/interaction in the important physical teaching	Standard 8
	Avoids monotony by varying the teaching methods	Standards 5, 7, 8, 9, 10
	Make good use of digital possibilities	Standard 6
	Deliberately integrates personal, interpersonal and professional competencies	Standard 7
	Supports learning in communities (group work, project work)	Standard 6, Syllabus 3
	Supports a culture characterized by "no stupid question" and "acceptance of errors"	Standards 8, 11
	Ensures freedom of choice for the students, for example in relation to project assignments, learning resources, open assignments, ...	-
	Aligns teaching, exams, and learning activities to learning outcome, and discusses these with the students	Standards 2, 7, 8, 11
	Awareness of the balance between practical elements and theoretical elements	Standards 5, 7, 8 Syllabus 4
	Awareness of the balance between types of teaching activities (lecture, lab work, problem solving, ...)	Standards 6, 8
Demonstrates high subject knowledge	*Keeps the teaching content relevant in relation to the employers' needs, as well as to development and research within the area*	Standards 1, 2. Syllabus 1.1 – 1.3 + 2.1 - 2.3 + 4.2
	Motivates her/his course, puts it into context	Standards 1, 4. Syllabus 1.4 + 2.1 – 2.3 + 4
	Creates a link between practical and theoretical elements	Standards 3, 4, 5, 7, 8 Syllabus 4

Ensures coherence with other disciplines and society	*Ensures a common thread within the semester and across semesters by having knowledge of and providing explicit references to other elements of the study programme*	Standards 2, 3
	Ensures awareness of the societal relevance of the programme	Standards 1, 2 + Syllabus 1.4, 2.3, 4.1 – 4.3
	Coordinates with other lecturers in relation to deadlines, etc.	-
	Ensures progression in the study programme	Standard 3
	The actual workload of the course corresponds to the formal scope	Standard 12

Table 3. Recommendations for the institution, with links to the CDIO Standard and Syllabus.

The institution …		**Related CDIO Standard(s) and/or Syllabus areas**
Ensures good educational facilities and physical surroundings	*Ensures good indoor climate, cleanliness, power, well-functioning AV equipment, well-functioning tables and chairs*	Standard 9
	Ensures good workshops and laboratories for practical work	Standards 5, 9
	Makes study spaces and group rooms available to students (where possible, 24/7)	-
	Ensures well-functioning digital learning tools	Standard 9
	Ensures areas of identity for students on the same study programme	Standard 6
	Ensures (universal) availability	Standard 6
	Ensures good opportunities for food etc.	-
	Ensures good physical infrastructure	Standard 6, 9
	Ensures exams spread out over the exam period	-
Ensures optimal planning	*Ensures that the teaching schedule is available quickly*	-
	Ensures that planning involves the wishes of lecturers and students	-
	Ensures that it is possible for the student to create a schedule without conflicts	-
	Ensures the necessary number of teaching hours per student	-
Facilitates co-operation between relevant stakeholders	*Facilitates co-operation between lecturers*	Standard 3
	Facilitates co-operation between lecturers and administration	Standards 3, 12
	Facilitates co-operation between lecturers and heads of programmes	Standards 1, 2, 3, 12
Ensures opportunities for upgrading of qualifications and competency development	*Ensures forums for discussions about teaching*	Standards 10, 11
	Ensures ongoing competency development within didactics and other fields based on the individual's wishes and needs	Standards 10, 11

In Tables 1 - 3, all 12 CDIO standards are addressed. Naturally, some standards are represented more than others, e.g., standard 8 (active learning) is very dominant in the "Student" and "Lecturer" recommendations.

PLANS FOR FUTURE USE OF THE RESULTS

The document was, as noted previously, delivered at the end of 2022. It was very well received by the faculty management, but the obvious question is: "How will it be used"? How will the faculty members see the document? In January 2023, a workshop in one of the departments was held using the document as a starting point for discussion. Feedback from the workshop is still to be analysed. At the faculty, an "educational day" is to be implemented at each

department. There are plans to use the didactical foundation as a point of departure for discussion and sharing of good practice.

SUMMARY, REFLECTIONS AND TAKEAWAY MESSAGES

We have developed a joint didactical foundation document for The Faculty of Technical Sciences at Aarhus University. Taking the existing strategic objectives of the university and faculty as a starting point, and anchoring the work in international state-of-the-art practices and principles, we have followed an inclusive, iterative working process and a 'whole-institution approach' involving all university-internal stakeholder perspectives – teachers, students, programme directors, and institutional framework condition providers. Literature studies, stakeholder workshops and interviews, multi-stakeholder discussions, and questionnaires have all given significant input to the discussions and the final results.

Among the most important take-away messages and lessons learnt along the way are:

- The quality, understanding, anchoring and usefulness of a work such as this benefit greatly from an iterative 'top-down-meets-bottom-up' refinement process based on input from multiple stakeholder perspectives, paving the way for a subsequent collective interaction towards improved educational quality.
- To ensure both quality and usefulness it is important to actively anchor recommendations and advice in research-based knowledge and international state-of-the-art principles, but at the same time take care to formulate the message in a simple, context-adapted, practice-oriented way which is suited to the target audience's needs and background.
- Expectations and advice to teachers should not be separated from expectations and advice to students, or the institution's support and facilitation: All these stakeholders should be stimulated to efficiently interact and make a *collective* effort to improve educational quality, ensuring a 'whole institution approach' (D'Andrea & Gosling, 2005).
- The viewpoints of teachers and students wrt. good teaching practices and student behaviour which facilitates learning are quite similar – and mostly also in line with international state-of-the-art knowledge on learning, as well as compliant with basic CDIO principles (Crawley et al., 2014).
- Bottlenecks hindering improved practices are arguably more related to resource limitations than to any lack of motivation for change among teachers and students or at the institutional level.

It is the working group's hope and belief that the process described in this paper has created a useful and living document which will stimulate more and better discussions about and interactions centred around teaching, learning and educational quality at the faculty. We also hope and expect the foundation document to evolve due to reflections, conversations, culture and competence-building inspired by this first version. Finally, we hope that our takeaway messages and lessons learnt may be of use as advice to others engaging in similar work.

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

Geir Egil Dahle Øien gratefully acknowledges the mobility support from NTNU, and the guest researcher invitation from AU TECH, which made his contribution to this work possible.

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BIOGRAPHICAL INFORMATION

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