DESIGNING A FLEXIBLE, CHOICE-BASED, INTEGRATED, PROFESSIONALLY CHALLENGING, MULTIDISCIPLINARY CURRICULUM

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ABSTRACT

In a lifelong learning society students need to deal with the responsibility to give their learning path direction, find motivation, and prove what they have learned. What pedagogics and what kind of didactic structure do you need to bring this about in higher education? What does it mean for the professionality of the teaching staff, the organization of the teams, and the needed facilities? A co-creational approach is applied in redesigning the curriculum of the undergraduate programme Industrial Design Engineering [Open] Innovator, which offers multidisciplinary projects in authentic learning environments, and caters for the professional profiling needs of our future students. Teaching staff, students, alumni, future students, industry (including the social profit sector), and educational scientists collaborate towards the flexible, integrated and choice-based 'Project M(odular) Curriculum'. This paper describes the arguments for the choices made from an educational point of view, taking the twelve CDIO standards and CDIO syllabus as a blue print. In certain standards, project M goes beyond the framework to fulfil the needs of stakeholders, take the newest useful (engineering) educational research outcomes into account, and come to a curriculum design that will be adaptable and versatile enough to hold value for the coming ten years at least.
Based on the experiences of Project M, considerations on refining CDIO standards 5, 8, 11 and 12 are presented in the discussion, together with a rationale to add a rubric score to the CDIO self-evaluation, and the discussion of minor gaps in the CDIO syllabus.

KEYWORDS

Flexible curriculum, choice-based modular curriculum, professional identity, curriculum design, multi-disciplinary education, standards: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

INTRODUCTION

There are two flexible curriculum initiatives within CDIO member Faculty of Technology, Innovation and Society (TIS) at The Hague University of Applied Sciences (THUAS). One of them concentrates on making it possible for students to choose courses at the affiliated programmes within the cluster along the way. In this way, the 4-year bachelor programmes

Climate and Management, Building Engineering and Civil Engineering are developing one joint 'Building Environment' nodal curriculum. Based on individual choices students pass by a number of nodes and in between learning takes place in professional, mixed-discipline, guided tasks. The other initiative concentrates on parallel course choices for students within the international 3-year bachelor programme of Industrial Design Engineering [Open] Innovator (IDE): a choice-based modular curriculum. Here also the professional, guided task and mixed-disciplinary teams are points of departure. Students will learn in a societal, authentic context, together and reciprocally with stakeholders from the professional field including users and (a hybrid) teaching staff. The IDE teaching staff refers to the development of this curriculum as Project M(odular), and approaches and executes it as a co-creational design process together with students, alumni, educationalists and industry.

REASONS FOR THE IDE CURRICULUM REDESIGN

The Industrial Design Engineering [Open] Innovator (IDE) curriculum is an international 3-year bachelor's programme. It is taught in English and about five years old. It teaches students the Industrial Design Engineering competencies with a focus on the fuzzy front end of innovation, sustainable development and impact in the realization phase. After the first students graduated two years ago an evaluation was done, and the quality of their learning results was compared with the principal pillars of the IDE curriculum: Design, Research, and Entrepreneurship. Entrepreneurship proved to be underrepresented. Several other aspects came to light in evaluations about the quality of the modules (10 week periods in which students do a project and have supportive theory and skills courses) and about the level of the graduation projects, see table 1.

Table 1. Issues to solve in the new IDE curriculum
(source: evaluation first graduation projects results).

Issue	Rationale
More attention for entrepreneurship in programme.	Graduates do not show enough entrepreneurship (either in attitude, or entrepreneurial projects)
The minor Entrepreneurship in Innovation should move to major.	It is important, and Entrepreneurship is already underexposed. Also, mandatory minors are basically major education to begin with.
Internship is missed in programme.	During internship students learn about the norms in the professional fields, e.g. level of finishing deliverables, graphic design etc.
IIR (International Insights Research): 12 EC is too little	If it were to be at least 15 EC, students could get external grants for their travel abroad.
Build in 'free space' for interesting projects that are offered during the school year.	With no room for electives in the programme, flexibility to participate in interesting projects disappears. Often students' motivation typically increases after doing competitions, projects like Bamboo city etc.
Restore balance in the programme.	First year students complain it takes too long before they can start to design something. Second year students complain the 2nd year is much heavier than the first year.

The curriculum commission, responsible for the quality and contents of the programme, looked into the possibility to make small adjustments to the current programme to fix these things, but found that was not possible. A reshuffle of the elements of the current programme was investigated and this seemed more promising, but it was challenging to cram it into 3 years (basically 2 years, as the third year is filled with a 30 EC (European Credit, ECTS system) minor and 30 EC graduation project). Thus, the idea for a choice-based, modular approach in the curriculum was born to prepare our curriculum to flexibly fit our vision on future education: Project M.

Collateral and strategic advantages and opportunities of project M

The choice for the modular approach offered several opportunities: a mix of strategic, procedural, pedagogic and didactic drivers, see table 2.

Table 2 Opportunities and benefits of project M.

Opportunity	Rationale
Profiling and talent development: Students can develop a professional identity by flexibility in the programme to self-profile: T-shaped, U-shaped or W-shaped	In order to fit in the job market, students need an upside-down T-shaped profile: wide basis of skills with a specialty. When students can function in an interdisciplinary context and can combine 2 or maybe even 3 talents on top of their basis, they even get a U or W shaped profile; hence a multidisciplinary, choice-based programme.
Network learning: Keep project-based, client-involved, active learning elements of programme.	What we have works well, only flexibility needs to be incorporated to be able to take on opportunities for collaboration in the professional field. Every semester students do authentic projects for real clients.
Multidisciplinary: Make a flexible programme so collaborations with other programmes, faculties, research groups, universities and projects/ competitions becomes possible	In our programme, there are possibilities to work directly together with other parties within TIS and THUAS, as well as some (inter)national partners. For instance, other faculties have shown an interest in collaborating in entrepreneurship and interaction design semesters. Research groups can provide for projects. Thus, the international classroom becomes a multidisciplinary one.
Internationalization: Work in modular entities that make the exchange as easy as possible	We are working together with CDIO partners and offering an EPS minor to tap into a different pool of exchange students. Other international contacts: Berkeley (entrepreneurship), Idefix, China etc.
Didactics: Half year modules with less testing, freedom of choice and more autonomy.	A lot of tests often have not the desired effect, as they compete for the student's attention, do not offer the learning experience as it should at the end of the course and demotivate from an intrinsic motivation point of view. It elicits the consumerist and calculative attitude more than the active learning attitude. Instead of four separate tests within a week at the end of each quarter, students will now get one integral assessment every five weeks (three per semester). Also, for the next generation, negotiation and making choices are natural but also vital competences. Our education should tap into that autonomy, not take it away for 3 years.
Positioning: attracting (certain) students to enrol	We have a unique offer in the landscape of IDE programmes in the Netherlands for VWO-students: small scale, freedom of choice, entrepreneurship and world citizenship in a highly international setting, while working for real clients throughout the programme, building up your (career) network right away.

Based on literature research, trend reports in education, and benchmarking modular design programmes, a co-creation process started in study year 2015-2016. A number of decisions concerning the structure of the new curriculum were made, resulting in figure 1.

Students can choose their programme from a menu of semesters after completing the first 20 weeks of mandatory programme, 'the Basics of IDE'. Students can make choices based on the experiences and aroused interests of that half-year to continue to develop talents or work on weak spots, deepen or widen their knowledge and expertise, and steer their experience in the thematic direction they want.

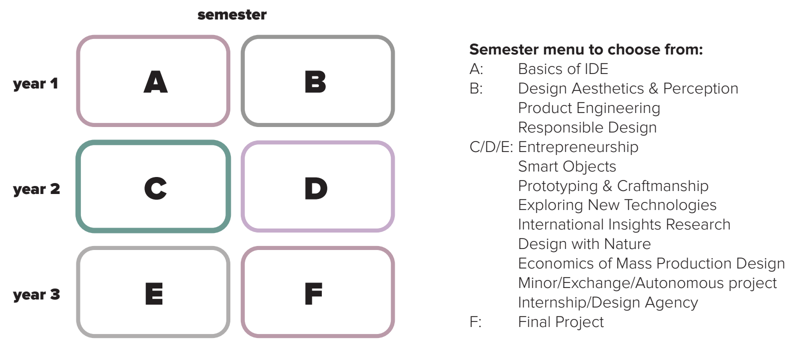

Figure 1. Basic structure of the Project M Curriculum of IDE

Organizationally, the choice-based semesters are 20 weeks each, of which 15 weeks are education and the last unit of 5 weeks is allocated to students' own bedside table projects, *freespace* projects from teachers, special excursions or international exchanges, portfolio development and resits. For the modular approach to work there should be no entry barriers to a semester (Sinke et. al., 2015). The only requirement is to have passed the introductory and selective Basics of IDE in semester A. A minimum and maximum of students who can enrol is predefined. Semesters can be offered twice a year if very popular. About four to six semesters will be offered per half year once the programme runs on full force. Students enrol for first, second and third choices as the programme cannot always guarantee first choice placement. Semesters have a profile: explorer, creator or entrepreneur, or any combination of these, which helps students to choose. As THUAS works within the major-minor system, one semester can be filled with a minor in semester C, D or E. This minor can but doesn't have to be unrelated to the IDE programme.

THE PROJECT M CURRICULUM DESCRIBED IN TWELVE CDIO STANDARDS

As mentioned, the designing of the Project M Curriculum is a co-creational process. In the academic year 2015-2016 three co-creation sessions were organized with the IDE teaching staff, students, alumni, future students, the work field and educational scientists. This resulted in an elaborate landscape of semester topics, personas of our (future) students, and brainstormed concept semester designs. With that input a semesters menu, semesters structure sketches, and semester labels could be generated, and again detailed in co-creation in year 2016-2017. Project M's curriculum design will be explained per CDIO standard. Occasionally the design process goes beyond the CDIO syllabus and standards version 2.0. This is described per standard and serves as input for the discussion at the end of this paper, for future development of the CDIO framework.

Standard 1 The Context

"…Adoption of the principle that product, process, and system lifecycle development and deployment -- Conceiving, Designing, Implementing and Operating -- are the context for engineering education. Beginning engineers should be able to Conceive--Design--Implement--Operate complex value-added engineering products, processes, and systems in modern team-based environments. They should be able to participate in engineering processes, contribute to the development of engineering products, and do so while working to professional standards in any organization. This is the essence of the engineering profession." (Crawley et. al., 2011)

As Industrial Design Engineering [Open] Innovator (IDE) is a design programme, the life cycle of products and product-service combinations is a central theme. Students are taught beyond conceiving and designing in a theoretical or educational setting by working on real life cases from day one, designing products for real life clients, and including implementation and operation activities such as putting products in the market and truly manifesting themselves in the work field. Clients are industry partners, social domain partners, non-governmental organisations, design agencies etc. Students are expected from day one to show a professional standard of behaviour and results, be it by increasing requirements.
That being said, implement and operate are less often touched upon in typical design education. For that reason, some of the new semesters in Project M will focus on those two phases (for instance the semester Design Engineering), using results from C/D projects of other more strategic design semesters. This will empower the innovations thought up within our programme. Students can also set up their own enterprise within the entrepreneurial semester, work on prototyping and testing in others etc. For students to be aware of their choices in this direction, they start right away in the Basics of IDE with operate and implement units of 5 weeks (see figure 4). This way, students can decide if they want more by choosing one or more of the semesters focusing on the I and O of the design process.

Standard 2 Learning Outcomes

"…Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge, consistent with programme goals and validated by programme stakeholders. They […] are codified in the CDIO Syllabus. Setting specific learning outcomes helps to ensure that students acquire the appropriate foundation for their future. Professional engineering organizations and industry representatives identified key attributes of beginning engineers both in technical and professional areas. Moreover, many evaluation and accreditation bodies expect engineering programmes to identify programme outcomes in terms of their graduates' knowledge, skills, and attitudes." (Crawley et. al., 2011)

THUAS offers competency-based education, defining the learning outcomes as a combination of knowledge, skills and attitudes. Together with the Dutch twin IDE-programme at THUAS (a 4-year bachelor programme taught in Dutch called IPO) IDE has formulated a comprehensible set of 5 main competencies our students master, see figure 2.

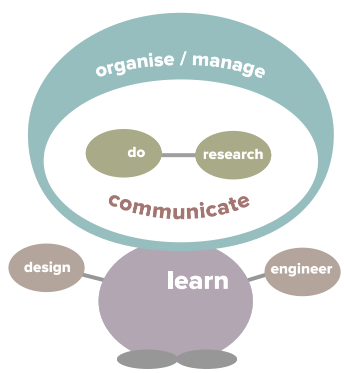

Figure 2. The competencies of IPO/IDE

This visualization of the competencies shows where each is nested: designing and engineering is hands-on, doing research provides glasses to look through, for organizing and managing students need to develop that frontal lobe of their brains, and learning is a matter of the (motivated) heart. And for all of these communication is important.

Each competency has several sub-competencies:

1. Do Research
    1.1. (Re)define problems and reason analytically
    1.2. Discover knowledge by investigating and experimenting
    1.3. Take external contexts into account (societal, environmental, entrepreneurial)
    1.4. Approach research in a (technical and) human-centred way
    1.5. Report on research using a practical scientific standard
2. Design & Engineer
    2.1. Formulate design briefs containing vision and requirements, based on primary and secondary research
    2.2. Use an iterative process with diverging and converging methods and techniques
    2.3. Integrate human, market, technological, and context values during the design process
    2.4. Consider desirability, viability, and feasibility while designing and engineering
    2.5. Create and optimize ideas, concepts, prototypes, and product proposals
    2.6. Evaluate ideas, concepts, and (end) products based on requirements
3. Organise & Manage
    3.1. Work methodologically
    3.2. Collaborate within a design team in a multidisciplinary (international) setting
    3.3. Show resourcefulness, flexibility and willingness to make decisions in fuzzy (complex) contexts
    3.4. Show entrepreneurship or intrapreneurship
    3.5. Practice project, stakeholder, time and resource management
    3.6. Break down and model systems and select relevant approaches
4. Communicate
    4.1. Manifest/present yourself in a (semi-) professional setting
    4.2. Communicate within a team on team dynamics and (your) role
    4.3. Make deliverables tangible in a refined, communicative way
    4.4. Communicate in a foreign language and/or in an international setting
5. Learn
    5.1. Reflect on your role in projects and your impact on society as an innovator
    5.2. Develop and adapt learning strategies
    5.3. Transfer and integrate acquired knowledge and experience in projects

The IDE competencies cover the entire Dutch national professional profile for IDE programmes in higher education, the Dublin Descriptors, and the CDIO Syllabus' learning goals (see table 3). This includes the later addition in version 2.0 of the learning goals Leadership and Entrepreneurship.

Table 3. Overlap between the IDE Competencies and the CDIO Syllabus

IDE CDIO	Do Research	Design/Engineer	Organise/Manage	Communicate	Learn
1DISCIPLINARY KNOWLEDGE AND REASONING 1.1 KNOWLEDGE OF UNDERLYING MATHEMATICS AND SCIENCES 1.2 CORE ENGINEERING FUNDAMENTAL KNOWLEDGE 1.3 ADVANCED ENGINEERING FUNDAMENTAL KNOWLEDGE, METHODS AND TOOLS					

2 PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES	**Do Research**	**Design/Engineer**	**Organise/Manage**	**Communicate**	**Learn**
2.1 ANALYTICAL REASONING AND PROBLEM SOLVING	strong link	strong link	link present	no link	link present
2.2 EXPERIMENTATION, INVESTIGATION AND KNOWLEDGE DISCOVERY	strong link	strong link	link present	no link	strong link
2.3 SYSTEM THINKING	link present	strong link	strong link	no link	link present
2.4 ATTITUDES, THOUGHT AND LEARNING	no link	no link	link present	strong link	strong link
2.5 ETHICS, EQUITY AND OTHER RESPONSIBILITY	link present	no link	strong link	link present	strong link
3 INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION	**Do Research**	**Design/Engineer**	**Organise/Manage**	**Communicate**	**Learn**
3.1 TEAMWORK	no link	no link	strong link	strong link	link present
3.2 COMMUNICATIONS	link present	link present	link present	strong link	link present
3.3 COMMUNICATIONS IN FOREIGN LANGUAGES	link present	link present	link present	strong link	link present
4 CDIO IN THE ENTERPRISE, SOCIETAL AND ENVIRONMENTAL CONTEXT – THE INNOVATION PROCESS	**Do Research**	**Design/Engineer**	**Organise/Manage**	**Communicate**	**Learn**
4.1 EXTERNAL, SOCIETAL, AND ENVIRONMENTAL CONTEXT	strong link	strong link	strong link	strong link	link present
4.2 ENTERPRISE AND BUSINESS CONTEXT	strong link	strong link	strong link	strong link	link present
4.3 CONCEIVING	strong link	strong link	strong link	strong link	link present
4.4 DESIGNING	strong link	strong link	link present	link present	link present
4.5 IMPLEMENTING	link present	strong link	strong link	link present	link present
4.6 OPERATING	link present	strong link	strong link	link present	link present
4.7 LEADING ENGINEERING ENDEAVORS	link present	link present	strong link	link present	link present
4.8 ENTREPRENEURSHIP	link present	link present	strong link	strong link	link present

= strong link = link present = no link

Lawson & Dorst (2009) recognize different levels of expertise in design students, from a novice who can apply strict rules, via an advanced beginner who relies on general truths and can make connections, to a competent graduate who is a problems solver, learner and reflector able to adopt when needed, see table 4. These levels of expertise coincide with Feisel's Taxonomy (Feisel, 1986) and are used to specify the IDE Competencies, by providing students with a rubric of the sub-competencies on those three levels. The active verbs of Bloom's taxonomy are used in the sub-competencies and rubric-cells (Felder & Brent, 2004).

Table 4. Three levels of competency.

	Novice	**Advanced Beginner**	**Competent**
Lawson & Dorst	Follow and apply strict rules	Use of general truths	Problem solver, learning, reflecting
Feisel's Taxonomy	Define, Compute	Explain	Solve, Judge
General IPO/IDE interpretation	Checking the boxes	Connecting design steps, reflection	Judging, self-evaluating, reflecting, solving, adapting approach

Beyond the CDIO syllabus 2.0 referred to in Standard 2: Cultural differences and co-creational teamwork

Two elements in our learning outcomes go beyond what standard 2 advises. First of all, the CDIO Syllabus asks for team work, centred around a team of equals (fellow students). At IDE students learn how to work in co-creation teams with real stakeholders right away, including industry partners and users. And secondly, as most students are communicating daily in a foreign language (English), the learning goals for working in an international setting are more elaborate than the CDIO syllabus, focussing on teamwork while taking cultural differences into account both in process and results.

Standard 3 Integrated Curriculum

"…A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills. Faculty play an active role in designing the integrated curriculum by suggesting appropriate disciplinary linkages, as well as opportunities to address specific skills in their respective teaching areas. An explicit plan identifies ways in which the integration of skills and multidisciplinary connections are to be made, for example, by mapping the specified learning outcomes to courses and co-curricular activities that make up the curriculum." (Crawley et. al., 2011)

Figure 1 showed the structure of the curriculum. Each semester has a central, authentic project (a design or design research). Therefore, in each semester all main competencies will be addressed. In these competencies, disciplinary learning goals are already intertwined with personal and interpersonal skills. Because of the parallel choices, students each create their own path in the curriculum. Hence the explicit plan doesn't look like set lines throughout the courses offered in time. Instead a picture such as figure 3 appears.

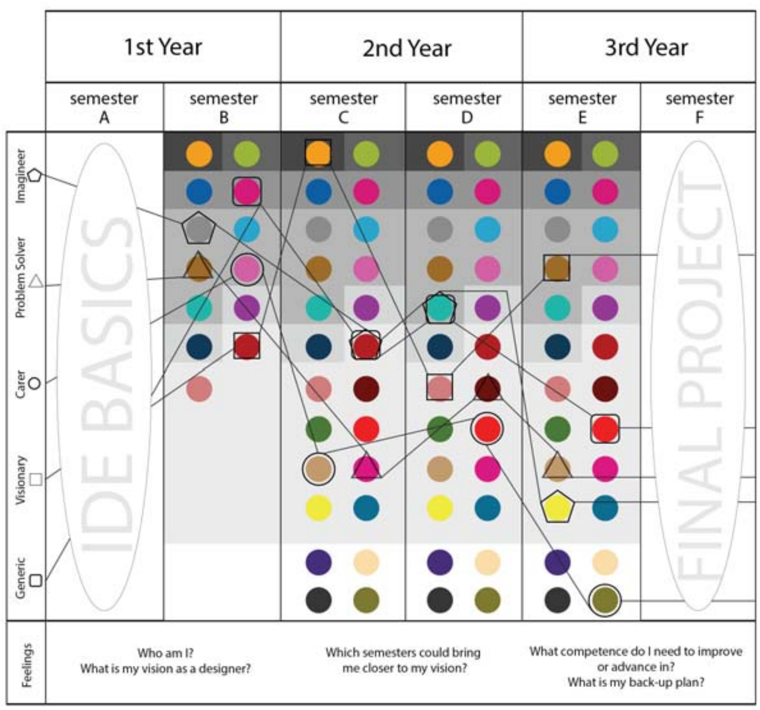

Figure 3. Mapping the integral learning path of the IDE persona students.

Standard 4 — Introduction to Engineering

"…An introductory course that provides the framework for engineering practice in product, process, and system building, and introduces essential personal and interpersonal skills.
Introductory courses aim to stimulate students' interest in, and strengthen their motivation for, the field of engineering by focusing on the application of relevant core engineering disciplines. Students usually select engineering programmes because they want to build things, and introductory courses can capitalize on this interest. In addition, introductory courses provide an early start to the development of the essential skills described in the CDIO Syllabus. (Crawley et. al., 2011)

In the Netherlands, the first year of a study programme is named the propaedeutic. By law it needs to be the introduction to the whole area of study/profession and it needs to be selective. At THUAS students even get a propaedeutic diploma after the completion of all its courses and projects, together worth 60 EC.

Within Project M the introduction and selection elements are offered in the mandatory Basics of IDE semester, see figure 4, and the first choice-based semester. The basics are offered in four units of 5 weeks, in all three profiles of IDE 'explorer', 'designer' and 'entrepreneur', and with a focus on all four stages of a CDIO design process. As one can see, the C and D are exchanged. First of all, 80% of our students come from abroad and need this first unit to get used to many things. Working with your hands on a prototype in the workshop is a nice change from all the thinking that is involved with that acclimatisation process. Also, in this first 'creator' unit, students will start calculating and constructing right away, testing their findings with their prototype. This gives them a clear introduction to the engineering part of the programme. And third, during the co-creation process current students indicated they wanted to do the designing right away when they entered the programme, as it fit their preconceptions of the profession best. The blue blocks are project coaching, and pink and yellow are supportive theory and skill classes for the project. Everything orange is integrated assessment and the yellow blocks are portfolio time.

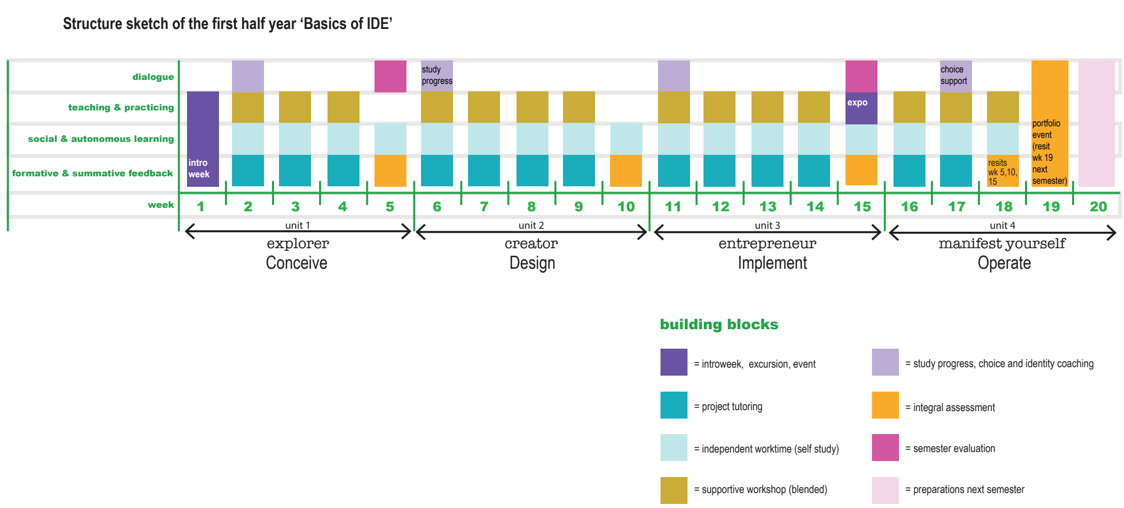

Figure 4. The Basics of IDE Semester, the first compulsory 20 weeks of the IDE programme.

Beyond Standard 5: *International, Multi-disciplinary Design-Implement Experiences*

"…A curriculum that includes two or more design-implement experiences, including one at a basic level and one at an advanced level. (Crawley et. al., 2011)

An IDE student has a conceive-implement, design-implement, or design-operate experience every semester of the major programme. What IDE added to standard 5 is to offer students international and multi-disciplinary experiences during these semesters. Because of the international classroom at the IDE programme (over 80% of students come from abroad), every semester could be seen as an international experience, but students also have the opportunity to go abroad to do a design or design research project, an exchange, or a minor elsewhere. The semesters are open to incoming exchange students as well. Some semester projects will be taken up by IDE students together with students from other disciplines such as mechanical engineering or non-engineering disciplines (health, social work etc.) from our own or one of our partner universities. This ensures an actual multi-disciplinary context for our students already during their studies.

Standard 6 Engineering Workspaces

"…Engineering workspaces and laboratories that support and encourage hands-on learning of product, process, and system building, disciplinary knowledge, and social learning." (Crawley et. al., 2011)

In the current IDE workspace lecturers and students share one big room with a large metal whiteboard wall for creative processes, office desks and student work tables, which is located next to the workshop. The university is in the middle of a refurbishing process of the 30-year-old building. This has given the faculty the chance to communicate the CDIO principles and plea for semi-professional labs, design studio spaces, and a professional reception area for clients. Lecture halls are used minimally by IDE, about 2 hours per week. When the refurbishing is done, students will have access to active learning labs such as 'project group landscapes' with group tables, video screens and lockers for project work, where they can sit and work in teams, meeting rooms where project stakeholders including tutors can come and visit, and an extended workshop and 3D printing lab.

Standard 7 Integrated Learning Experiences

"… Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills. [This] can be realized only if there are corresponding pedagogical approaches that make dual use of student learning time." (Crawley et. al., 2011)

Each semester is an integrated learning experience. The question is how to gradually increase the authenticity and complexity of the professional learning tasks, and the autonomy and self-direction of the student. Personal and interpersonal skills are interwoven with disciplinary knowledge and together offered within different contexts that prepare students for the complexity that awaits them in the professional field. But in our philosophy to educate 'engineers who can engineer' it is not enough to merely offer the authentic, professional context following John Dewey's theory of experiential learning (Fransen, 2005) and restore reflection in engineering education (Buch & Bucciarelli, 2015). When one 'throws students in at the deep end of the pool', as a Dutch saying goes, with minimally guided instructions for 'increased authenticity', this does not fit the cognitive architecture of our students' brains when they come in at age 17-19 (Kirschner et al, 2006). Kirschner found evidence for a higher effective learning by guided, just-in-time instruction, in order to deal properly with expert-novice differences and critical cognitive load. This led to the semester structure as seen in figure 5, where workshops offer just-in-time supportive theory and skills to the project groups, and together with the project tutoring offer the students the structure so work on the authentic design challenge of the semester. Also, regular coaching sessions are provided (the violet blocks), so the students are scaffolded in learning to define their own professional profile and prove their mastery of the competencies along the way via a development and professional portfolio.

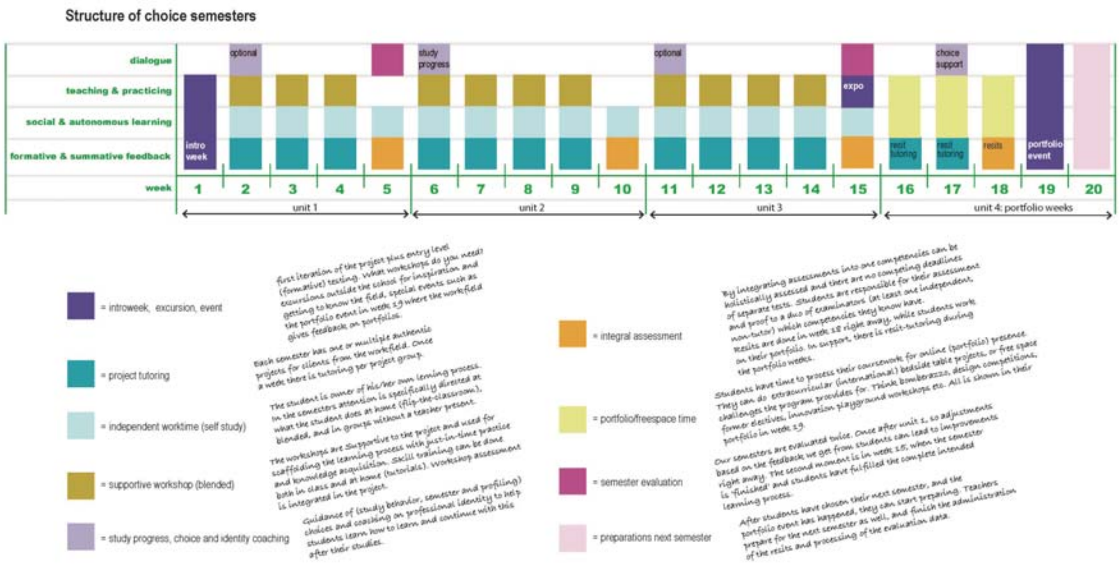

Figure 5. Structure sketch of the Project M choice semesters.

Beyond standard 8: Not Just Active Learning for Life Long Learning.

"…Teaching and learning based on active experiential learning methods. By engaging students in thinking about concepts, particularly new ideas, and requiring them to make an overt response, students not only learn more, they recognize for themselves what and how they learn. This process helps to increase students' motivation to achieve programme learning outcomes and form habits of lifelong learning." (Crawley et. al., 2011)

Active learning has long been a priority of THUAS. Because of the design-focused engineering education at IDE and IPO experiential learning has been the focus in teaching methods. Applying active learning techniques in lecture hall settings is still a field of development, for those scarce moments IDE offers lecture hall classes. However, next to active learning there are more important didactical choices to encourage the lifelong learning abilities of our students by increasing motivation. One is making them familiar with blended learning during their studies, in a 'flip the classroom' set up, using several suitable platforms. Another is giving room for autonomy, from the perspective of self-determination theory (Gagné & Deci, 2005). When students can show autonomous behaviour, they voluntarily function and take on working or learning tasks. In a lifelong learning setting, which will not always be a formal educational setting with grades and credits as extrinsic motivators, this is vital. IDE likes to give students the chance to tap into their personal drivers during that stage, by letting them choose their own path via the semester menu and build up their own professional identity. Meijers et. al. (2010) identified three main conditions for developing a professional identity: learning should take place in an authentic setting, students should have the opportunity to choose part of their study activities according to their personal developing goals and there should be a professional, reciprocal dialogue between students and teachers about their development. The latter is addressed in the core values of our programme: Creative & Curious (think divergent), Experimental & Integrated (iterative approach), Structured & Critical (keep improving), Inspiring & Convincing (in communication), People

Planet Prosperity Partnership Peace & Future Oriented (be engaged). Not only are the core values used to describe attitude components in learning, they are also practiced as preached by the staff in their interaction with students.

Standard 9 Enhancement of Faculty Competence and Standard 10 Enhancement of Faculty Teaching Competence

"…Actions that enhance faculty competence in personal and interpersonal skills, and product, process, and system building skills." "…Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning." (Crawley et. al., 2011)

Once TIS became a CDIO member, an internal, informal professional learning community around CDIO was started. Several workshops by CDIO-gurus, a CDIO- experimentation work group for lecturers of the 12 different programmes, and a teaching staff training in Active Blended Learning have been initiated. IDE teaching staff has taken part in several of these initiatives, working on constructive alignment of teaching, learning, and assessment. Part of them are hybrid teachers, designing or doing research next to teaching, or both. As Industrial Design Engineering is a multidisciplinary field on its own, combining engineering with design, cognitive psychology, ergonomics and business, the members of staff who studied IDE themselves are familiar with working multi-disciplinary. Yet society sees a changing role of the 21st century teacher, not as expert on a certain specialization only, but as co-designer in an open innovation network setting, facilitating innovations by reciprocal learning of all stakeholders including the students (Hallenga-Brink & Vervoort, 2015). The co-creation of the Project M Curriculum offers the opportunity to work on enhancement of faculty (teaching) competences at the same time, which is necessary to innovate the curriculum design.

Beyond standard 11: Student ownership to prove learning goals, less assessment and formative entry level testing

"…Assessment of student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge… Different categories of learning outcomes require different assessment methods. These methods may include written and oral tests, observations of student performance, rating scales, student reflections, journals, portfolios, and peer and self-assessment." (Crawley et. al., 2011)

Current IDE student have 4 exams in week 8 and 9 of every 10-week module, plus resits of the former module in week 10. It can be written exams, handing in reports or portfolios, presenting project work or a combination of these. Each exam has a list of 5-10 learning goals. Cohen-Schotanus (2010) proved in her research of multiple cohorts of medical students that students typically start preparing for a written exam three weeks before the deadline and study hardest for the first test they have, to the disadvantage of the remaining assessments in the same test week (see also Schmidt et. al., 2009). At IDE teaching staff indeed sees the quality of project work decrease when written exams are planned around the same time. Therefore, in the Project M Curriculum semesters purposefully have a 5-week unit structure, see figures 4 and 5. During the first week of the semester students participate in a benign pressure-cooker kick-off session, which function as a formative entry-level test, to discover how far they get based on what they already know. This shows them how they can benefit from supportive theory and skills workshops offered throughout the semester. Each 5-week unit is concluded with one integrated assessment only, in which students have the responsibility themselves to prove on which level they master a self-chosen selection of six sub-competencies/learning goals, using their project and workshop work as proof. Three assessment methods are aligned with the type of sub-competencies students have to prove and the offered learning activities during the units: handing in a specific deliverable with supportive process steps that led to it, explain the process in an oral exam while showing the steps taken, or reflect in an oral exam on the observations made by project tutors and workshop lecturers during the unit. Assessors are always grading in duos: the student's tutor and an independent assessor.

Standard 12 Beyond Programme Evaluation

"…A system that evaluates programmes against these twelve standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement… Evidence of overall programme value can be collected with course evaluations, instructor reflections, entry and exit interviews, reports of external reviewers, and follow-up studies with graduates and employers. The evidence can be regularly reported back to instructors, students, programme administrators, alumni, and other key stakeholders. This feedback forms the basis of decisions about the programme and its plans for continuous improvement." (Crawley et. al., 2011)

IDE has done the first self-evaluation on the 12 standards in 2014 and the second in 2016. Current regular programme evaluation cycles for multiple stakeholders around the programme, plus extra evaluations for accreditation purposes, help pinpoint the evidence for the self-evaluation. Because CDIO is integrated in the project M curriculum redesign, the evaluation automatically takes CDIO-principles along.
Instead of developing plans and implementing them and then ask industry to evaluate this, IDE has taken the route to co-create the new curriculum in a group of teaching staff, (prospective) students, alumni, industry, educationalists, and other stakeholders. During the semesters evaluations with students, clients and teaching staff will help to adapt while teaching, and make plans for the next run. This co-creation setup results in not only *feedback* afterwards, but also *feedforward* and *feedduring*.

CONCLUSION

In innovating the IDE curriculum towards a flexible, choice-based, integrated, professionally challenging, and multidisciplinary curriculum the CDIO framework has proven to be a match to the ambitions of the undergraduate programme Industrial Design Engineering [Open] Innovator of THUAS. As the terms conceive, design, implement and operate are closely related to the realms of an open innovator, they effortlessly found a spot in the structure of the curriculum. The CDIO syllabus 2.0 also fitted to the competencies of an industrial design engineer which were formulated on a national level in 2011 and completed within THUAS with entrepreneurship-elements. And there are more CDIO merits to the IDE curriculum: Collaboration with CDIO partners is set up to offer students the multidisciplinary context they will find in their professional life already during their studies. During open days CDIO shows (prospective) students the international anchors of the programme. The next step is to take our work field network along in our CDIO endeavours.

Several times IDE needed to go beyond the CDIO framework interpretation: in taking student teamwork in the CDIO syllabus to the next level of co-creation for them to become engineers who can engineer, and add intercultural competences beyond communicating in a different language, and by refining several standards (2, 5, 8, and 11). Also, there was a need for a score of '6' in the CDIO self-evaluation rubric when co-developing a standard in co-creation with all stakeholders instead of thinking it up first and then checking with the stakeholders if they would be willing to support. This indicates an opportunity of growth for the CDIO framework. In line with the reciprocal learning that happens in co-creation in multi-stakeholder networks, this paper is an invitation for further investigation and discussion for the continuous development of the framework.

DISCUSSION

A top score of 5 in the rubric of the CDIO self-evaluation on the 12 standards is geared towards stakeholder evaluation and review of plans and implementation. When involving industry, students and other stakeholders in this way it is a common challenge to truly close the PDCA-cycle and let stakeholders benefit from the evaluation findings directly, and not only the next cohort or next project. The development of the Project M Curriculum shows that by co-creating with the stakeholders from day one onwards, acknowledging the needs, making plans, execute them, finding evidence and evaluating the results together, one can offer a solution for this challenge. Simultaneously, it elicits reciprocal learning between all stakeholders during the process, enhancing faculty competency in the professional field and faculty teaching skills for the 21st century (CDIO standards 9, 10) and a better understanding of education and coaching by the professional field. The suggestion could be considered to let co-creation with the stakeholders on the standards be a score 6 in the rubric.

Secondly, standard 5 could be enhanced by making at least one of the design-implement experiences multi-disciplinary. That way students learn to work together with other types of engineers before entering the workforce. From an (open) innovation point of view this is what future engineers will encounter in daily practice (Chesborough, 2003).

In this line of thinking, the teamwork learning goals (3.1) of the CDIO Syllabus could be more geared towards co-creation in multidisciplinary teams with interdisciplinary team members, as students need these competencies as well. And the international element can be found back somewhat in learning goal 3.3 “communication in a foreign language”, but not all intercultural competencies are integrated in the syllabus. Internationally oriented CDIO programmes in higher education do see the need to offer them to students.

Standard 8 is called ‘Active Learning’ at the moment. In developing Project M multiple ‘Lifelong Learning Didactic methods’ were applied, such as blended learning and the flexible choice-based professional profiling. Active learning is one example which could fulfil a standard formulated on a higher abstract level indicating its intent better.

Finally, in standard 11 Project M demonstrated a number of requirements around integrated assessment which could improve its quality and success rate, such as putting the responsibility for proving competencies at the student instead of the teacher, integral assessment, formative entry level testing and timing constrains on exam schedules.

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