3TU.CENTRE FOR ENGINEERING EDUCATION

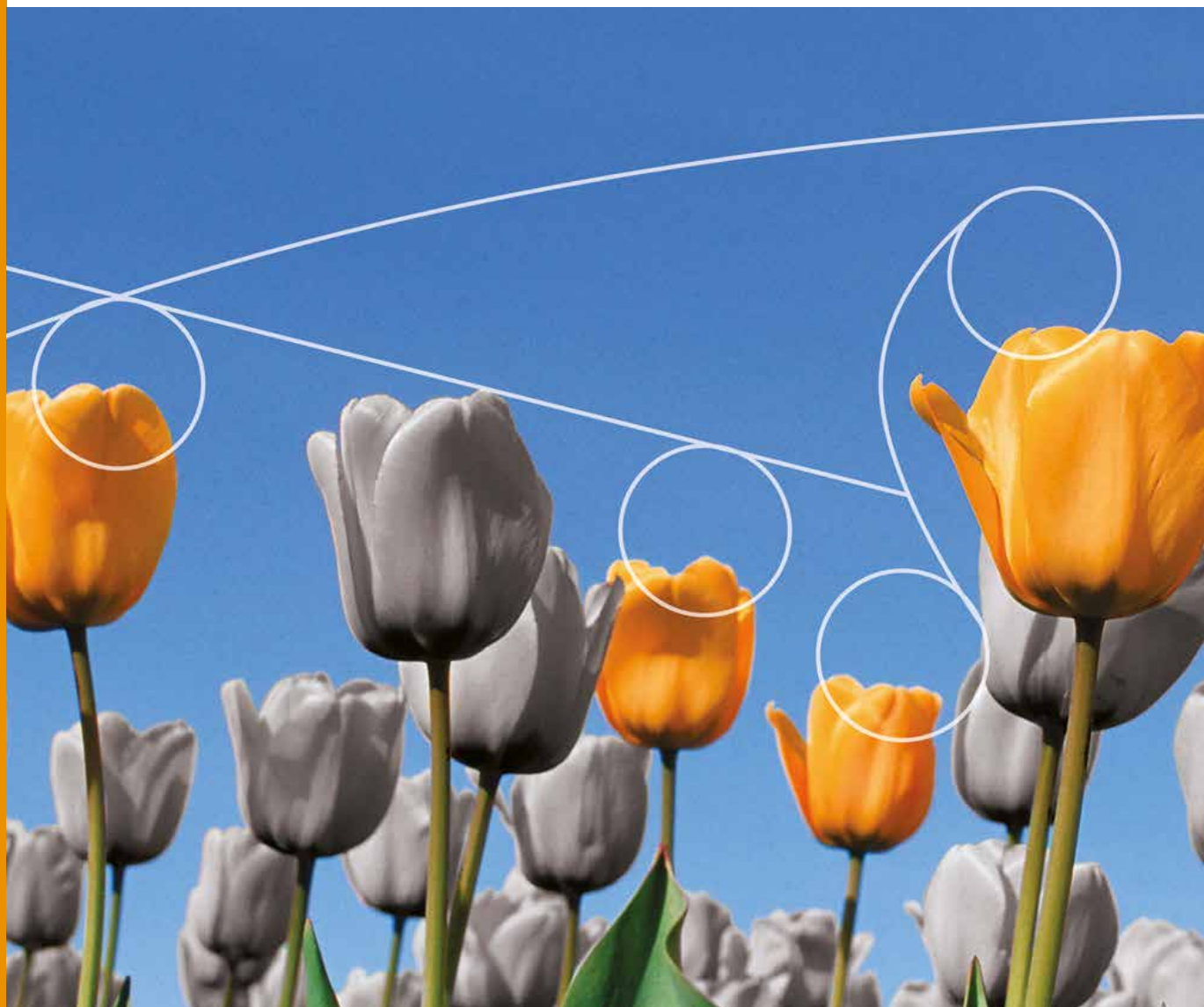
Comparing Bachelor Curriculum Innovations at Three Universities of Technology:

Implementing a new curriculum

TU Delft Delft University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.



3TU. CENTRE FOR ENGINEERING EDUCATION

Comparing Bachelor Curriculum Innovations at Three Universities of Technology

Implementing a new curriculum

Enschede, 12-2-2016
3TU.Centre for Engineering Education
Work Package 1:
Marie-José Verkroost (University of Twente, projectleader)
Maartje van den Bogaard (Delft University of Technology)
Charlotte Oude Alink (University of Twente)
Henk Schellen (Eindhoven University of Technology)

Foreword

This report describes research done for the 3TU.Centre for Engineering Education (CEE) in The Netherlands. The authors are employees of the three universities of technology participating in the CEE. They were given time to work on this project and develop themselves through the research they did. The authors would like to thank the CEE for this opportunity to work together and learn from each other. They hope that their work is of value to others in this field.

Executive Summary

Between September 2014 and November 2015, research was conducted at the three universities of technology in the Netherlands to learn from the curriculum innovation processes at these universities. This research builds upon earlier research (Gommer, Klaassen, & Brans, 2015) in which the curriculum innovations are described from the perspective of the "intended curriculum" (Van den Akker, 2010). In the research reported here, the focus is on what actually took place in the educational programmes after the universities had defined a new vision of and starting points for their Bachelor education programmes.

Three research questions were formulated, focusing on the process of development and implementation, the new curriculum and the results achieved. Two Bachelor programmes from each university were selected to be studied in detail. Electrical Engineering and Architecture and the Built Environment were studied at the Eindhoven University of Technology and the Delft University of Technology. Electrical Engineering and Civil Engineering were studied at the University of Twente. Matching disciplines were deliberately chosen to make the results more comparable and to eliminate the discipline as a variable in comparing the universities. The case study method was chosen to study in-depth what happened in these programmes.

A theoretical framework was developed for studying the cases, based on findings from the literature. The framework covers the faculty culture, need for changes, goals of the innovation, the development of the curriculum, the new curriculum, implementing the new programme, the results, the format of the new curriculum, student engagement and studiability.

The results show that the processes, goals and content of the educational innovation were very different across the cases. The shape of the processes and the results obtained depended on the individual situation of the educational programme: how it was embedded in the university and the requirements set at the university level. At the outset of this investigation, differences between programmes in different disciplines (Electrical Engineering versus Architecture and Built Environment) were expected to emerge. However, the findings show no real differences between disciplines; the university and the individual circumstances of the programme had greater influence on curriculum innovation.
The following general conclusions can be drawn from the case studies:

- Change must be needed, in order to get the process of curriculum innovation going. Without this need, the change will be minimal.
- The director of education is crucial for getting the staff headed in the same direction, managing the process and keeping momentum going during the change. If the director of education has a positive attitude regarding the educational innovation, there are better results. The director of education also functions as an intermediary between what happens at the university level and the educational programme. The director of education must show educational leadership. Educational leadership is defined by Frederiks and de Bie (2004) as the competency to steer the content of the change while constantly monitoring the quality of the education, the innovation project, the support of teachers and facilitation of their teaching.
- Successful curriculum innovation requires time and money and a director of education with a positive attitude. If the time pressure is great and/or teachers receive little time for re-development, there is less actual innovation. Larger curriculum innovation requires time to prepare things well, to inform people, and to let things digest a bit. The fact that teachers must do their regular work along with developing and implementing the curriculum innovation should be taken into account.

In all three cases, the curriculum innovation entailed motivating students to work harder in order to improve their success at their studies. The measures taken to realise this differed greatly and sometimes went in opposite directions. Curriculum innovation in a STEM education setting was approached as a large design project. An inventory was made of what needed be done and then this was organised.

Contents

3TU.CEE

1. Introduction

The research described in this report was conducted within the context of the 3TU.Centre for Engineering Education (CEE) (3TU.Centre for Engineering Education, n.d.) in the Netherlands. The CEE is a collaborative effort by the three universities of technology in the Netherlands: the University of Twente (UT), Delft University of Technology (TU Delft), and Eindhoven University of Technology (TU/e). The purpose of the CEE is to gather, develop and implement up-to-date expertise in engineering education. This report contains the results of activities for Work Package 1 (WP1): Comparing Bachelor Curriculum Innovations.

The aim of WP1 is to learn from the Bachelor curriculum innovations that were implemented at the three universities of technology. Curriculum innovations in a university of technology setting might differ from curriculum innovations at regular universities. The work package builds on work done by Graham (2012), who investigated factors contributing to successful change at universities of technology and in their programmes. The research done in WP1 compares the Dutch setting with her findings and extends her theoretical framework.

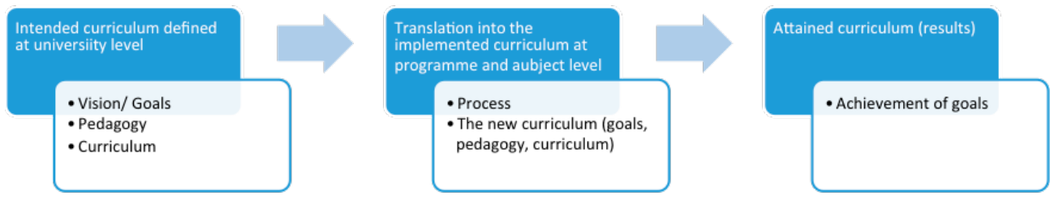
The work package consisted of three elements: a study of the intended curriculum, of the implemented curriculum, and of the attained curriculum, following the typology of Van den Akker (2010). At this point, only the studies on the intended and implemented curriculum have been conducted.

The results of the research on the intended curriculum were published separately, by Gommer, Klaassen, and Brans (2015). They conclude, among other findings, that the main drivers for change at the three universities of technology were national regulations and for some institutes a crisis in the market. Dutch universities of technology were urged to do a better job of profiling themselves (Commissie Toekomstbestendig Hoger Onderwijsstelsel, 2010), and in 2012 the universities were asked to formulate performance indicators for quality of education, student success, positioning and value-adding (Rijksoverheid, n.d.). These performance indicators are important because the distribution of the budget for education is based on the universities' performance.

Gommer et al. (2015) also concluded that the leadership styles guiding the innovation process at the university level matched an engineering curriculum design approach. At all three universities a top-down decision process took place and then moved down in the organisation, where staff and students were involved in further development. At all three universities, the intended curriculum gave attention to constructive alignment (Biggs, 1996) with student engagement and active methods for teaching and learning.

This report publishes the results related to the implemented curriculum: the processes that took place in developing and implementing the new curriculum at the programme level and their results.
The relationships among the different levels and types of curriculum in this research are presented in Figure 1.

Figure 1: Research scheme



Research questions

At all three universities of technology, a common vision and standards for the organisation of education were defined top-down for all Bachelor programmes. At all three universities, a vision statement document was produced describing the type of engineer to be educated and the types of teaching methods to be used. The documents also set standards for organising the educational programmes: number of EC per subject or module, majors and minors, learning tracks, and so forth. This is what the programmes were presented with and what had to be implemented in each programme. This research does not judge how well the programmes implemented these guidelines set at the university level. From a research perspective, it is most interesting to see which factors determined how this vision of education and standards for organising the educational programmes were implemented.

The research reported here took the intended curriculum as the given context, within which each Bachelor education programme, staff had to redevelop its curriculum. This research started at the point where the intended curriculum was first communicated to the director of education.

The following research questions were framed for investigating the implemented curriculum:

1. Which intended and unintended processes influenced the implementation of the intended curriculum at the programme and subject/module level?
2. To what extent was the intended curriculum implemented?
3. Were the changes in the curriculum effective for achieving the goals set by the university and the programme?

Chapter 2 describes the theoretical framework that was developed to study the cases of curriculum innovation at the three universities of technology. Chapter 3 elaborates on the method used in this research project. Chapter 4 compares the cases from the perspective of the research questions. In Chapter 5 conclusions are drawn and in Chapter 6 the research is discussed and plans for future research are suggested.

3TU.CEE

2. Theoretical Framework and Focus for Research

This chapter addresses the framework for investigating the cases of curriculum development at the three universities. The framework includes factors known from the research literature to be important in curriculum development.

2.1 The process of curriculum innovation

Literature on success-related factors in curriculum innovation in Science, Technology, Engineering and Mathematics (STEM) education settings was collected and compared, by looking at key publications on this topic in various journals and reports. Table 1 shows the success-related factors that were found in the literature.

Table 1: Success-related factors in curriculum innovation from research in STEM education settings

Success related factors	Details
The context for change	Need for changes: • Attitude toward change (Graham, 2012) • Upcoming restructuring or accreditation (Graham, 2012) • Staff experience or background (e.g., industry experience or recently appointed staff) (Graham, 2012)
	Faculty culture regarding education: • The disciplinary environment (culture, values and habits of mind) (Lattuca, Terenzini, Harper, & Yin, 2009) (Godfrey & Parker, 2010) • Individual values of staff (Stolk, Somerville, & Chachra, 2008) • Student characteristics (Chen, 2009) (Woodcock et al., 2013) • Organisational culture (Merton, Froyd, Clark, & Richardson, 2009)

Success related factors	Details
The process of change	Leadership and faculty engagement: • Commitment to reform and leadership of the process by the head of the department and university management (Graham, 2012) • Staff awareness that their reform efforts are noted by the management (Graham, 2012) • Choosing a combination of change strategies fitting the different levels of the organisation (Kezar, 2001; Borrego & Henderson, 2014) • Acceptance that change is a disorderly process. Ongoing local assessments and conversations to lay the groundwork for the innovation and to help the people involved to understand the change and develop a shared rationale for the change which is connected to the individual's and institute's identity (Kezar, 2001; Graham, 2012) • Creating a culture in which risk-taking is rewarded (Kezar, 2001) • Involvement of many staff members in the process (Graham, 2012) • No pressure on reluctant staff members (Graham, 2012)
	Educational design and implementation: • Re-assessment of the entire programme (Graham, 2012) • Adoption of a unique approach that is set as a benchmark (Graham, 2012) • Working out of the programme in detail by a small group of chosen staff members (Graham, 2012) • Adoption of team teaching (Graham, 2012)

These success-related factors were translated into topics to be used for describing the curriculum innovation process in the case studies. Table 2 in section 2.3 shows the variables addressed in the case studies.

2.2 The results of curriculum innovation

When considering the results of curriculum innovation, a link must be made between the initial goals of the innovation and the actual results obtained. Gommer et al. (2015) compared Bachelor programme innovations in three universities of technology in the Netherlands. They state that for all three universities, the main driver for change was a financial incentive set by the Ministry of Education, Culture and Science, promoting student success and quality of education.

Student success as defined by the Ministry was taken as the basis for the following measurable performance criteria:
- Graduation rate: the percentage of students completing their studies within 4 years.
- Dropout rate: the percentage of students dropping out of their course of study.
- Student switch rate: the percentage of students switching away from their study.
- BSA rate (binding recommendation for the continuation of studies): the percentage of students who obtained at least 75 percent of the first year number of European Credits (EC) Students who do not fulfil this requirement are not eligible for reenrolment in the second year of their programme.

Gommer et al. (2015) distinguish 6 common measures for improving student success across the three universities of technology in the Netherlands:
1. Making the structure of the university's course calendar coherent;
2. Improving the selection of students in the first year of the programme and refer failing students to different options;
3. Implementing teaching strategies that promote active learning behaviour;

3TU.CEE

4. Creating facilities for coaching and counselling of students;
5. Using assessment as a driver for learning;
6. Creating greater opportunities for compensation of grades across the programme.

In their research on student success in engineering education Hulst & Jansen (2002) found that parallel scheduled courses, and a high number of theoretical courses have a negative effect on student success. Compensation regulations for exams have a positive effect on student success. Bogaard (2015) asked first-year engineering students for their perception of influencing factors in student success. The students reported that study behaviour, student dispositions, and perception of the education environment are most important factors. In the education environment, the spread of course load, the quality of materials, and the teacher's pedagogical competences were perceived as most important influencing factors.

Another perspective for looking at the purpose and results of curriculum innovation is the perspective of the "engineer of the future". According to (Goldberg & Somerville, 2014) the engineer of the future should have 'six minds': analytical, design, linguistic, people, body and mindful. (Sheppard, Macatangay, Colby, Sullivan, & Shulman, 2008) state that the engineer of the future should be able to deal with complex problems for which a deeper level of thinking is necessary. They put the future engineer in a societal context in which the engineer has to work together with many different actors.

Each university and each programme under study made different choices as to how to carry out the measures required by the Ministry and how they perceive and define the engineer of the future. To compare the programmes, variables were defined to be researched in all case studies. Table 2 in section 2.3 shows the variables addressed in the case studies.

2.3 A heuristic for conducting the case studies

Based on the findings presented in sections 2.1 and 2.2, a heuristic was developed to conduct the case studies in a uniform manner. The heuristic is displayed in Table 2.

Table 2: Heuristic with variables and topics for describing the case studies

The context for change	
Variable	**Topics for describing the case studies**
The need for change	The initial situation: 1. Attributes of faculty and course programme: a. Description of the programme b. Key statistics: graduation rates, length of study, percentage of switchers, negative recommendations on continuation of study, female/ male students. 2. The reason for change; external and/or internal pressure 3. Most important issues/problems related to the programme 4. Problems experienced by students, management, teachers and other agents such as the Department of Education, alumni, employers of graduates 5. Ownership of the problem(s)
	Goals of the innovation: 1. New vision 2. Goals formulated regarding the curriculum, the organisation of the curriculum and the faculty as a whole 3. Prioritisation of goals 4. Engineering-specific goals 5. Educational foundations supporting the goals 6. Goals as part of a vision 7. Projected results: 'must-haves' and 'wish-to-haves' 8. Final date when the goals need to be achieved
Faculty culture regarding education	1. Attitudes and beliefs of management and teachers regarding learning goals and final objectives 2. Attitudes of management and teachers regarding education in general 3. Proportion of time spent on research and education
The process of change	
Variable	**Topics for describing the case studies**
Leadership and faculty engagement	1. Sources/ documents consulted 2. Documents drawn up in the design process 3. Role of these documents in the design process 4. Things left unchanged in the programme 5. People involved in the design process: who, why and their role 6. Communication of design teams with each other and with the wider community 7. Resistance to the change within the organisation 8. Resources available for those involved in the design process 9. Evaluation and monitoring of the design process 10. Role of quality control in the design process 11. Preservation of momentum in the design process
Educational design and implementation	1. Implementation strategy and experiences 2. People involved in the implementation: who, why and their role 3. Catalysts and barriers in the implementation process 4. Communication of teams with the wider community 5. Resistance to the change within the organisation 6. Resources available for those involved in the implementation process 7. Involvement of administrative and supporting officers in preparing for the implementation 8. Guidelines for teachers 9. Monitoring of the implementation process 10. Role of quality control in the implementation process
Results of the curriculum innovation	
Variable	**Topics**
The new curriculum	1. Changes that were designed and implemented 2. New vision; vision of the characteristics of an engineer 3. Change in learning objectives 4. Alignment between the new learning objectives and the change 5. Integration of courses 6. The position of the arts and social sciences 7. Implementation at the programme level of the vision and directives from the central university level
Student engagement/ satisfaction with the curriculum	1. Teaching and learning activities intended to promote active learning 2. Student support 3. Student experiences 4. Challenging students to develop good study habits and a good attitude towards studying
Success with studies and studiability	1. The studiability of the programme 2. Dealing with resitting of exams, making up assignments and delays in progress through course of study 3. Spread of course load over the semesters 4. Frequency and timing of assessment 5. Monitoring of studiability and student engagement 6. Average EC obtained per semester and in the first year 7. On-time graduation rate, dropout rate, study switch rate, BSA 8. Grades obtained
Sustainability	1. Satisfaction with the new curriculum; what still needs to be done 2. Monitoring of the results of the change 3. Maintaining focus on the change after implementation 4. Dealing with unforeseen issues that result from the change

3TU.CEE

3. Method

The investigation of the implemented curriculum consists of six descriptive case studies, two at each university. The case studies focus on STEM education programmes, defined as programmes having a large component of mathematics, physics and design. The case studies were chosen to cover matching disciplines, to eliminate the discipline as a variable in the cross-case comparison of findings. In the case of Architecture, this was not possible because this programme is not offered at the University of Twente. Civil Engineering was chosen as a replacement because there are similarities between the focus of the Civil Engineering programme at UT and the Built Environment programme at TU/e.

- UT - Electrical Engineering; Civil Engineering
- TU Delft - Electrical Engineering; Architecture and the Built Environment
- TU/e - Electrical Engineering; Built Environment

The case study data were collected through interviews with stakeholders from the educational programmes, by document analysis, and by studying performance data from the quality assurance cycle. The focus was limited to the first year of the Bachelor programmes to delimit the research context.

For each case study, 4-7 people were interviewed about the curriculum innovation. These would typically include: the director of education, the Bachelor programme coordinator, teachers involved in the curriculum overhaul, the quality assurance officer and a student representative. The interviews were conducted using prestructured interview protocols for all stakeholders. The interview questions covered the framework described in Chapter 2. The interview protocol is summarised in Paragraph 2.3 and included in Dutch in Appendix I.

Transcripts were made of the interviews and the transcripts were coded using the topics from the heuristic (Paragraph 2.3).

The case studies were summarised in an overview by discipline in Appendices A and B, to support drawing conclusions across the case studies. The full case study descriptions are reported along the lines of the heuristic and they are presented in Appendices C to H.

Interview questions

The interview protocol in Appendix I is in Dutch. In the interview protocol, questions are organised by type of person interviewed: director of education, teacher, quality assurance officer. The questions asked of all interviewees are listed below, linked to the variables and topics described in the heuristic in Paragraph 2.3.

Background

1. When did you become involved in the curriculum innovation?
2. Were you involved in the development of the new curriculum, in its implementation or both?
3. Why were you involved? What was your role?

Need for change

4. Was the need for change clear to you?
5. Were there problems concerning studiability, student progress, drop-outs from course of study, quality of education, student complaints, or workload before the curriculum innovation?

3TU.CEE

Goals of the innovation

6. Were the goals of the innovation clear to you?
7. Did the education programme define its own goals for the innovation? If yes, which ones? Did/do you support these goals?

Educational design and implementation process

8. Which decisions and documents existed at the point when you were involved and what was their status? Were the documents based on scientific literature?
9. Was there a strategy formulated for working on designing the curriculum: who would be involved in what manner and how things would be communicated?
10. How were teachers and/or students involved in the process?
11. With whom did you work together? Why were these people involved in the curriculum development process and what was their role?
12. Do you know how much time these people were given for their tasks? How much did you get? Was it sufficient?
13. Can you describe the actual process and strategy followed?
14. Did you encounter resistance during the innovation process? If yes, how? And how was this dealt with?
15. What was the role of quality assurance in the process?

Results

16. How would you evaluate the innovation? Is it successful? What do you consider most positive and what can be improved?
17. How are the results of the curriculum innovation being monitored by quality assurance?

4. Comparing the Case Studies

The case studies were compared to answer the research questions. An overview of all specific findings within the framework for each specific case can be found in Appendices A and B. The in-depth descriptions of the case studies can be found in Appendices C through H. This chapter contains a selection of research findings from the case studies, focusing on striking differences between cases and answering the main research questions.

4.1 Factors influencing the process of change

When looking at the processes of curriculum innovation in the different case studies, a set of influential factors emerged. Table 3 summarises the cases with regard to these factors.

Table 3: Comparison of the case studies on processes in curriculum development and implementation

Factor	Aspects of the process of change	Electrical Engineering			Architecture and Built Environment Civil Engineering		
		UT	TU/e	TU Delft	UT	TU/e	TU Delft
Leadership	The director of education had a positive attitude towards the innovation.	+	+	+	+	-	+
Faculty engagement	Need for change was felt by teaching staff.	+	+	+ -	+	-	+
	There was resistance against the change.	-	-	+ -	+	+	-
	Faculty focus on research influenced the process.	+-	-	+	+	+ -	-
	Teaching staff were involved in development at the curriculum level.	-	+	-	+ -	+ -	-
	The design of the new curriculum was carried out by a small group of people, representing the programme.	+	+	+ -	+	-	-
	After the design of the new curriculum, the teacher development teams received full autonomy.	+	+ -	+ -	+	+ -	+
Student engagement	Students were involved in the design of the new curriculum.	-	+	+ -	-	+	+
Planning	Length of the development process in years.	1	1	1	2	1	2
Available resources	Models of good practice outside the university were visited.	+	+	-	-	-	-
	A literature search was carried out.	+	+	+	-	-	+
	Extra money and/or time was available for teaching staff for development work.	+	-	+ -	+ -	-	+
	There was substantial attention to the professional development of teachers.	+ -	+ -	-	-	-	+

Legend: +: Yes; + -: More or less; -: No

Leadership

Leadership is an important element in all organizational change (Fullan, 2007). Educational leadership is defined by Frederiks & de Bie (2004) as the competency to steer the content while constantly monitoring the quality of the education, the innovation project and the support of teachers and facilitation of their teaching. In the Netherlands, the responsibility for the content of the educational programme is put with the director of education. The director of education is an intermediary between university and faculty level management and staff working in the programme. In case of a curriculum overhaul put upon the programme by the university level, he/she might be brought into a difficult position when he/she personally does not want to change the programme.

These cases show that this is not different from engineering education. With regard to the role of the director of education, differences were apparent in the attitudes towards the innovation process. The directors of education for all three EE programmes were positive regarding the innovation process. However, there were differences for the BE/CE programmes. The director of education for UT-CE was positive regarding the innovation process, but the director of education for TU/e-BE was negative. The director of education's attitude had an effect on commitment to the implementation of the innovation process.

Faculty engagement

In most cases, the need for change felt by staff members was inversely related to the level of resistance against the change. No felt need for change led to higher resistance. The severest case of resistance was observed in the case study of Built Environment at TU/e. The feeling that jobs were at stake (UT-EE) was a catalyst for the process. At TU Delft-A&BE a catalyst was that the new curriculum was communicated to students early in the process.

In all cases, a central group was formed to develop the new curriculum. This group was led by the director of education and contained selected staff members. Once the blueprint of the curriculum was ready, other staff members became involved to actually develop the new modules or subjects. This module or subject development often took in place in teacher teams. At the TU/e there was special attention for people working and learning together which created a good atmosphere for the process.

In most universities, research is valued much more than education. This difference creates a tension when it comes to spending extra time on curriculum innovation at the cost of doing research (Graham, 2012). In the cases where the emphasis on research was high, it was sometimes difficult to find staff to work on curriculum and course development. Then a small group of people was selected to work on the change, leaving the other staff members to do their regular work. In a later stage, a larger group of staff was involved in the development process. This approach was evident in all case studies.

Student engagement

When it comes to the curriculum how it is lived-out in the classroom, students are an important source of information. With increased attention for the student-centred learning, it seems obvious to take the students' voice into account. (Jagersma & Parsons, 2011). Students were involved in designing the new curriculum at TU/e-BE and to a certain extent at TU Delft-A&BE.

Planning

The time available for the curriculum innovation differed by university. If there is only a short window to develop a new curriculum, it creates pressure and this can be a driver for people to be committed and work very hard (TU Delft-EE, UT-EE). Sometimes it forced people to be pragmatic and push through. However, in some cases this high workload turned out to be a barrier to the curriculum implementation process (UT-EE, UT-CE, TU/e-EE, TU/e-BE).

Available resources

Extra money and time were available for teaching staff at UT and TU Delft-A&BE. In the other cases, the extra money was spent on central committees and officers, but not on the teaching staff. They had to work on curriculum development in their regular education time. The lack of teacher training was a barrier to the process at UT-CE.

At TU Delft-A&BE there were additional resources available in the form of teacher professionalization. Coinciding with the curriculum change, staff was required to do coursework for their University Teaching Qualification. This course was tailored to the overhaul and needs of the teachers. This way, the teachers had additional opportunities to discuss their ideas on the new curriculum and coordinate their efforts, while receiving a lot of feedback from the trainer who had a background in pedagogy and education.

Literature on education was consulted in almost all cases. In two cases, visits were made to other universities to see good practices there. Staff from UT-EE visited Aalborg University to see problem-based learning in practice. Staff from TU/e-EE visited universities with highly efficient science faculties. At TU Delft-A&BE, the head of education and student affairs office had been involved in the preparations for the universities' overhaul process and had consulted a lot of relevant literature in that other role. The teachers' professional development was taken more seriously and combined with working on their University Teaching Qualification.

Unexpected issues

During implementation, unexpected issues could arise, such as practical problems with rooms, equipment and systems (UT-EE). At UT, the new curriculum with a modular structure created problems for students who had started their studies earlier or students who failed parts of the curriculum (UT-EE, UT-CE). Similar situations came up in TU Delft, where the transition regulations were well prepared, but ended up creating many issues for the students who had started under the old regime. At TU Delft-A&BE the resit schedule had not been coordinated well and created many issues for the new students.

4.2 The implemented versus the intended curriculum

The standards for organising the education programmes, defined at university level, were implemented in all three case studies. This was necessary to be a part of the university and to let students switch between programmes of study.

The case study of Electrical Engineering at TU Delft stands out as being different from the others with regards to the innovation process. The programme had gone through a drastic curriculum reform a few years earlier and therefore the staff felt no urgency to change at first. Soon the director of education decided that the required change would be taken as an opportunity to get rid of the bugs in the programme. A small but dedicated committee consisting of some people who had been involved in the previous curriculum overhaul and some new people started to fine tune the programme to the requirements set by the university. In the other cases, the process was not precedented by recent changes.

The implementation of the new vision on education, however, was another matter. Table 4 compares the case studies on factors influencing the implementation of the new vision on education.

Table 4: Comparison of the case studies on factors that influenced the implementation of the new vision.

Category	Aspects influencing the implementation of the new vision of education	Electrical Engineering			Architecture and Built Environment Civil Engineering		
		UT	TU/e	TU Delft	UT	TU/e	TU Delft
Faculty engagement	The teachers felt that they were autonomous and could make their own choices without someone else (director of education, university board) telling them what to do.	+	+	+	+	-	
	The programme and the position of staff was at risk.	+	+	-	-	-	+
	Teachers developed a shared vision of education by working in teams.	+	+	-	+	+	+
Extent of the curriculum overhaul	In the design of the new curriculum, courses were integrated into a module or subject.	+		-	+		+
	In the new curriculum, new pedagogies were added on top of the university-defined pedagogy.	+		-	-		-
Planning	Time pressure led to a more pragmatic approach.	+	+	-	-	+	-

Legend: +: Yes; +-; More or less; -: No

A faculty culture where teachers felt very autonomous and experienced high time pressure hindered the development and implementation of the new vision on education. A shared feeling that the programme was at risk and teachers developing a new curriculum together enhanced the development and implementation of the new vision on education.

4.3 Goals achieved

The goals set for the curriculum differed by university and by educational programme. All three universities wanted to enhance student success, and to educate engineers with certain characteristics. At all three universities student success was enhanced, using different measures. At the moment it is unclear whether the new type of engineer is being educated, because there are no graduates yet within the new programmes. Some programmes added goals of their own to these university-level goals. Attracting more students by offering the programme in English was added at UT-EE. At TU/e-EE more students were to be attracted by offering a programme designed for a more diverse group of students (not just science-oriented students, more female students). Table 5 shows the goals set to enhance student success in the cases.

Table 5: Comparison of goals set by the programmes to enhance student success

Category	Goals set to enhance student success	Electrical Engineering			Architecture and Built Environment Civil Engineering		
		UT	TU/e	TU Delft	UT	TU/e	TU Delft
Goals of the innovation	Greater variability in marks achieved by the students	+			+		
	Fewer courses in parallel		+			+	
	Use of intermediate tests		+			+	+
	Improvement of supervision and coaching		+			+	
	Smoother transition from secondary education to university		+				
	Less academic and more practical nature of the programmes		+				
	Fine-tuning of the curriculum		+	+			-
	A more integrated curriculum		+			+	+
	Implementation or improvement of problem-based and project-centred learning	+	+-	+	+	+	+
	Teacher professional development		+			+	+
	Fewer contact hours					+	
	Less redundancy in the programme, greater study efficiency	+			+	+	
	More choice options for students					+	
	Student drop-out concentrated in the first year			+	+		+
	Increased difficulty of the programme				+		

Legend: +: Yes; +-; More or less; Blank: No

Every programme defined its own measures to enhance student success. The most frequently chosen measures were the implementation or improvement of problem-based and project-centred learning, the introduction of intermediate tests, and removing redundancy in the programme and making it more efficient.

5. Conclusions

The processes, goals and content of the educational innovation at the three universities of technology were very different. The set-up of the processes and the results obtained depended on the individual situation of the educational programme: how it was embedded in the university and the requirements set at the university level. At the outset of this investigation, differences between programmes in different disciplines (Electrical Engineering versus Architecture and Built Environment) were expected to emerge. The findings show no real differences between the disciplines; the university and the local circumstances of the programme had greater influence on the curriculum innovation process than the discipline.

There are some lessons that can be learned from the case studies:

Change must be necessary for some reason, in order to get the curriculum innovation process going. Without this need, the change will be minimal. The case of Electrical Engineering at TU Delft is a good example of this. They had undergone a curriculum innovation just before the university asked them to innovate again. It was decided to make the best of the situation and try to get the bugs out of the new programme. In the end, the innovation itself was relatively small. The case of Built Environment at TU/e is also interesting: the students and the university felt a need for change that was not shared by the programme's teaching staff. Curriculum innovation there has been a difficult process.

All curriculum innovations were led by the director of education. The director of education is crucial for getting staff headed in the same direction, managing the process and maintaining the momentum for change. If the director of education has a positive attitude regarding the educational innovation, the results are better. The director of education also functions as an intermediary between the university level and the educational programme level. The director of education must show educational leadership. Although good planning and leadership are necessary, chance factors can positively or negatively influence the innovation process.

Successful curriculum innovation requires time and money. If the time pressure is high and/or teachers receive little time for re-development, the actual innovation is smaller. Significant curriculum innovation requires time to prepare things well, inform people, and let things digest a bit. The fact that teachers have to do their regular work along with working on the curriculum innovation should be taken into account.

In all three cases, the curriculum innovation entailed motivating students to work harder in order to improve their success in their studies because of the requirements set by the Ministry. The measures taken to create this differed to a large extent and sometimes went in opposite directions. For example, some programmes made the first year programme more academic, while another made it less academic. Although literature was consulted in all cases for evidence-based findings concerning student success, this did not lead to a common framework for good practice.

Curriculum innovation in a STEM setting was being approached pragmatically as a large design project. An inventory was made of what had to be done and then this was organised in an efficient manner. This matches the approach advocated by Frederiks and de Bie (2004).

6. Discussion

This research confirms some of the research findings noted in Paragraph 2.1 and adds two more success-related factors. Table 6 shows which elements of this framework were found in the case studies and which factors were added based on this research:

Table 6: Success-related factors for curriculum innovation found in the case studies

Success related factors	Details
The context for change	Need for changes: • Attitude toward change (Graham, 2012) • Upcoming restructuring or accreditation (Graham, 2012)
	Faculty culture regarding education: • The disciplinary environment (culture, values and habits of mind) (Lattuca, Terenzini, Harper, & Yin, 2009) (Godfrey & Parker, 2010) • Individual values of staff (Stolk, Somerville, & Chachra, 2008)
The process of change	Leadership and faculty engagement: • Commitment to reform and leadership of the process by the head of the department and university management (Graham, 2012) • Ongoing local assessments and conversations to lay the groundwork for the innovation and to help the people involved to understand the change and develop a shared rationale for the change which is connected to the individual's and institute's identity (Kezar, 2001; Graham, 2012) • Involvement of many staff members in the process (Graham, 2012) • No pressure on reluctant staff members (Graham, 2012) • Availability of sufficient time and money for the curriculum innovation process at all levels involved (this research)
	Educational design and implementation: • Re-assessment of the entire programme (Graham, 2012) • Adoption of a unique approach that is set as a benchmark (Graham, 2012) • Working out of the programme in detail by a small group of chosen staff members (Graham, 2012) • Adoption of team teaching (Graham, 2012) • Choosing a design approach for curriculum innovation (this research)

The case studies did not provide evidence of deliberate choices of a change strategy, or mentioning of faculty culture. The factors added to the theoretical framework are the use of a design approach for curriculum innovation and the availability of resources.

The theoretical framework has been elaborated with practical case studies that are interesting to read and to learn from. They offer a good opportunity for the individual programmes to learn from each other.

The added value of this research is that it shows the complexity of the subject of curriculum innovation. It also identifies a common design approach. Approaching curriculum innovation in the same way that students approach

3TU.CEE

a design assignment could well be a good way of dealing with the process of curriculum innovation, but what this means for the practice of curriculum innovation in a STEM education setting needs to be worked out better.
The findings of this research are limited to the six case studies conducted and the time frame that they cover. The curriculum innovation process is not finished; it is not clear what types of students are being educated in the new programmes and whether they differ from graduates of the old programmes. Future research could follow up on this.

Appendix A: Overview of the EE Case Studies

The three Electrical Engineering case studies were compared using the variables described in Chapter 2. Table 7 compares the results for the Electrical Engineering case studies. The full text of the case studies can be found in Appendices B, C and D

Table 7: Comparison of the Electrical Engineering case studies using the framework defined in Chapter 2.

Faculty culture regarding education	**UT**	**TU/e**	**TU Delft**
Attitude regarding objectives	Positive	Positive	Positive
Attitude regarding education in general	Engaged staff	Engaged staff	Engaged staff
Research versus education	Research as main task and priority for most teachers	Proportion spent on education/research/ management 40/40/20.	Focus on generating research money
Need for changes	**UT**	**TU/e**	**TU Delft**
Reasons for change	University-developed concept for the Bachelor programme, the Twente Education Model Negative results of programme re-accreditation	Increasing the studiability and the efficiency of education within TU/e Money based on student numbers Threat of shutdown High drop-out rates Low studiability of the programme No students in the Master. Need for electro-technical engineers in the region Low number of female students Only scienceoriented students	University-imposed innovation, following upon curriculum innovation that had taken place in the previous years
Most important problems	Planning of thesis writing More time spent on the thesis than intended A schedule that is too full High level of responsibility placed on the student The students' attitude toward learning; it is the norm to take much longer to complete the course of studies than the official length of studies	Bad image Too many students experiencing delay in their studies Drop-out rates too high Efficiency too low Course pass rates too low Choice options too few Too little focus on societal needs Not enough intake of students. Low score in the National Student Survey	Decision by the Board of Executives that retention is a problem
Ownership of the problem(s)	The director of education All staff members and departments in the programme	Director of education	The director of education and the dean

Goals of the innovation	UT	TU/e	TU Delft
New vision	Twente Education Model (TEM) Problem-based and project-centred learning.	Vision of education of engineers: developments in engineering education and the future engineer and his role in industry	Formulation of new vision and learning goals before the start of the university-led curriculum innovation No new vision developed for second round of innovation
Main goals	Increase the number of students graduating on time Have students graduating with a pass mark, not only high marks Increase the number of students entering the programme by teaching the programme in English	Improved studiability: fewer lectures in parallel and use of intermediate tests. Improved supervision of first year students Smoother transition from secondary education to university Less academic nature of programs A more differentiated type of engineer	Main purpose of fine-tuning new curriculum, increasing student progress
Main purpose of fine-tuning new curriculum, increasing student progress	Initial implementation of pilot phase modules (1-3) in September 2012 Implementation of TEM university-wide in September 2013 Development of first modules in a short period of time; 6 months	Advice from taskforce to use a period of 2 years for the implementation of the Bachelor curriculum Decision by rector magnificus to take only 1 year for this process	Implementation of first new curriculum in 2011, second new curriculum in 2014
Preparation – Development of the curriculum	**UT**	**TU/e**	**TU Delft**
Sources used	Literature on problem-based learning and strategies for innovation in education Staff visits to Aalborg university Re-use of experiences and materials from the old curriculum	KIVI reports on the engineer of the future Consultation of IEEE and American research Study of models at Boston, MIT Visits to universities with highly efficient science faculties	An advanced course on educational leadership taken by director of education Study of seminal works in the field of education research.

Preparation – Development of the curriculum	UT	TU/e	TU Delft
Documents drawn up	Numerous versions of the new curriculum.	An analysis of the current situation and a vision of education Research regarding manageability, education in blocks or in ribbons, science orientation of students ACQA (Academic Competences Quality Assurance) exercise at another programme	Many reports drawn up during the process within the committees
Changes in the curriculum	Building new curriculum upon the old curriculum. A time reduction of 10% per topic Modular system with 15 EC per module Re-use in modules of the teaching methods of the “old” subjects A university-wide math learning track Some topics left out, some topics re-introduced Introduction of a project in each module	Keeping the final terms of the Bachelor programme the same Three parallel courses, 5 EC each Introduction of summer schools More opportunities for choice by students Opportunities to retake exams with minimal competition with regular courses Simplified course schedule An entrance programme that precedes the 1st curricular year and incorporates math training material	Much left unchanged, because the first new curriculum already represented major changes A redistribution of EC over courses Slightly different organisation of courses.
People involved in development at programme level	Director of education Core team: director of education, Bachelor coordinator and study advisor Committee on curriculum innovation Module teams	Director of education Education committee Students Lecturers Working group consisting of students and lecturers Programme management team: the secretaries of the taskforces Curriculum working group representing all disciplines Lecturers with experience in designing a programme from ACQA perspective. Core group, chaired by the director of education Groups of lecturers around themes	

Preparation – Development of the curriculum	UT	TU/e	TU Delft
Catalysts	Sense of urgency that your job is at stake due to the reorganisation of the faculty and the accreditation results	Faculties previously mostly autonomous Bonding of people spread all over the university as a consequence of the communication within several groups Bondings created by horizontal layer within BC People learning from each other First major change since introduction of OGO (design oriented education) in 1995	Desire by Board of Executives and the dean to have the new curriculum implemented in September 2013, September 2014 at the latest Commitment by many staff members in the faculty to education
Barriers	Practical problems with rooms, equipment and systems Transitional arrangements for students from the old curriculum Lack of clarity about how to deal with students' personal circumstances High teacher workload, mainly due to assessment No point of contact at UT central for practical problems	No extra time for the redesign High workloads due to redesign, intermediate examinations, and so forth Communication at the beginning of the 'what' question, but not the 'why' question Focus by lecturers on the consequences of changing from 3 to 5 EC, not on the need for change Improved communication later on, using the experience of the Communication Expertise Centre, resulting in newsletter and a kind of road show by the director of BC Difficult top-down communication; lecturers who must execute the changes only reached at the end	Existence of a new curriculum already Difficulty of involving faculty in another overhaul Main focus by faculty on research, rather than education. Greater staff involvement with regard to Master programmes Guidelines drawn up by a think tank that was involved in the previous curriculum overhaul No guidelines for professionalising teachers
Communication	Faculty steering group (education directors) Management team (director of education, Bachelor and Master coordinators, study advisor) Departments Teachers Module coordinators (meet 4 times a year) Students (lunch meeting at the start of the pilot, email)	Development of a website for general communication Education Days organised by the faculties Communication within faculties of results mostly by directors of education Other communication by newsletters Organisation within EE of lecturer lunches, where lecturers deal with problems and inspire each other to find ways to solve difficulties using variation or alternation	

Preparation – Development of the curriculum	UT	TU/e	TU Delft
Resources	Appreciation of education by the Dean Dinner at the end of the pilot year for all staff Training programmes for teachers on problem-based learning		
Monitoring	Coordination of quality assurance by Bachelor coordinator Evaluation of modules by module coordinators UT central evaluation of all modules (student survey and group discussion with module team) Conceptual test to assess whether students reach the desired level of understanding	Uniform course evaluation system Consultation of educational commissioner students from a student association twice each quarter. Reports of results two times a year Database with all types of data regarding number of first year students, drop-outs, switchers, number of graduates, number of EC, and so forth BSA report each year Evaluation report by Ruth Graham about the first 3 years of the Bachelor College PhD project on intermediate exams	Monitoring of the curriculum as a whole; implementation of a software package to support the completion of the full cycle of the quality process Evaluation of courses currently, evaluation of entire curriclum in the first year.
Keeping momentum		Preservation of momentum due to very short time limit (within one year) for introduction of changes). In retrospect, perceived as best approach, otherwise could have been a lingering procedure. Formation of peer-support groups of lecturers to exchange experiences in year 1, 2 and 3 during the different quarters Great involvement by lecturers with the whole spectrum of education, the curriculum	Little effort to preserve momentum because Master programmes overhaul now demanding attention

After implementation	UT	TU/e	TU Delft
Staff satisfaction	Satisfaction with the new curriculum Questions about too much content in the second year Satisfaction with PBL modules Success rates	Successes at EE with number of students entering and efficiency Possibilities of switching to another course of studies in the first semester experienced as positive Perception of USE courses as substandard Plan to introduce career policy in USE courses, together with professional skills Failure of Design, a basic course Expectation of improvement for Modelling Perception of Applied Physics and Calculus as ok Difficulties for lecturers and students with time-scheduled blocks of 4 hours Lack of interest/capacity for 4 hour lectures Questions about how to deal with these blocks, what to do with the time Introduction of a lot of work by having intermediate exams Quantity of exams (200) a lot to deal with, solved mostly by having PhD's help. Growth in number of first year students from about 60 to 250 Increase in efficiency from 2% to 50% Large problem raised by loss of OGO (design oriented education) in the compulsory programme	Some minor issues in fine-tuning between courses and projects Successful implementation overall Teachers' responsibility to stay in touch and to continue to align with each other on what is taught, and so forth No learning track coordinators in the design and implementation phase, coordination done by the director of education Perception by full professors of being left out, suggestion to take on learning line responsibilities, but not everyone satisfied with this Consideration of arranging greater involvement by professors in a more meaningful way for them, and for the programme and the students as well
What remains to be done and sustainability	Fine-tuning of the modules Integration of the mathematics learning track	Examination by a special group of the possibility of getting OGO back in the compulsory programme	Shift in focus, to overhaul of Master programmes Complaints about Bachelor programme as not preparing students for Master, as Bachelor programme currently stands

Description of the curriculum change	UT	TU/e	TU Delft
The curriculum change	No change in learning outcomes and content Modular system, with 15 EC per module Teaching in English Inclusion of a project in modules More academic teaching and learning approach in first modules 2 problem-based modules	Development of skeleton with compulsory and elective courses Large 5 EC courses instead of 1, 2 or 3 EC courses Basic courses USE courses Application of EVO (digital learning environment) in Calculus and Applied Physics	See above Full integration of courses
The engineer		Importance of the attributes of an engineer No such thing as the engineer profile of the future; rather a number of engineers, with certain characteristics: multidisciplinarity; a 'unique selling point' or specialisation; strong analytical skills; innovative and solution-oriented; links between technology and society, works in a globalising world Bachelor programme as preparing for lifelong learning.	Engineer as expert and connection to other disciplines

Student engagement/ satisfaction with the curriculum	UT	TU/e	TU Delft
Student engagement	Varies by module; most engaged in PBL modules Weekly tests in the first modules to motivate students to study High engagement with the projects in each module.	Tutor groups for mathematics and physics An introductory access examination; remedial programme for those who do not pass Use of rubrics to give students more feedback than just a grade Provision of individual choices for students within their curriculum Introduction of clickers (voting system) to get feedback during lectures Coaching support for students Student invitations to individual sessions with matching talks Pilot with alumni coaching students Speed dates with alumni in the 2nd year. Coaching from professors in the 3rd year professors to prepare students for their Master programme Treating students coming right from secondary education in the type of academic way they are used to Fewer examinations, a maximum of three Increase of studiability by having fewer parallel courses and examinations (a maximum of three), as well as a limited number of re-sits. If the students were not successful, despite these measures, they had to start from the beginning with the course and participate in the intermediate exams.	Design projects, lectures, working groups (for example, in mathematics to work on calculations and for lab work, as with linear circuits, where students build a circuit and use it for measurement and analysis for programming) Teaching and learning activities and assessment aimed at supporting the student to become an electrical engineer who can independently operate and study new topics Additional services for non-education related matters and matters that cannot be resolved in the classroom supplied by student support officers Important to have first semester as a good representation of what the programme is like Aim of retaining as many students as possible, having those not suited find that out as soon as possible to enable good transition to another programme Assessment design based on non-uniformity, as students likely to adapt to such a system, but with same bonus system for every course Non-competition of assessments important.

Student engagement/ satisfaction with the curriculum	UT	TU/e	TU Delft
Student satisfaction	"Guinea pig" experience of first cohort Current curriculum seen as best solution within the TEM framework Less content in the curriculum than before Decreased level of some subjects Variability in module evaluations, depending on the teacher's motivation Third year seen as a bit empty Inefficiency of problem-based learning as a method of learning Less learning about social skills in the new curriculum Greater efficiency of learning in the modular system, but less time for consolidation of knowledge Less time to do things besides your studies	Trying for bond with students, rousing enthusiasm for the programme and the social life around it before students start Very informal atmosphere, with programme's own café, the Walhalla, open every day Students very satisfied with their environment, according to the NSE survey	
Studiability	**UT**	**TU/e**	**TU Delft**
Studiability	Studiability increased through better alignment of the subjects and separation of thesis writing and taking courses. Students instructed to report special circumstances immediately . Studiability increased because of more academic teaching approach at the beginning of the programme. Bending of TEM rules to prevent students from falling out of the system Studiability for students who started in the old curriculum decreased, no clear transitional arrangements. Students with different learning styles supported by variation of teaching and learning methods. Greater variability in marks. Target success rate set at 50-60% for year one and 80-90% for year two First year target reached, but not second year target. Number of drop-outs considered as non-issue by staff and students; dropping out viewed as appropriate for students who do not belong in the programme.	Studiability increased by fewer parallel courses and examinations. Culture more positive. Students forced to keep on working and stay concerned with courses. Earning of 15 EC each quarter, 60 per year. Decrease in drop-outs from about 50 to 20%. An average of 28 hours per 1 EC spent by students.	Limiting of projects to a single education period to avoid competition with the theoretical courses. Assessment of students in every course, most having assignments, partial exams and a final exam. Assessment in projects including students' contributions to the group work, the final presentation, individual questioning about the technical details of the final project and the final report Timing of students' leaving the programme nearly all in first semester Passing first project linked with obtaining positive BSA recommendation for nearly all students . Students' lack of experience with having to work hard to be successful. About one-fourth of students behind in work, not sure how to make up for it, in evaluation in week 4 of first year.

Appendix B: Overview of the Architecture and Built Environment and Civil Engineering Case Studies

Table 8: Comparison of the Architecture and Built Environment and Civil Engineering case studies using the framework defined in Paragraph 2.3.

Faculty culture regarding education	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Attitude regarding objectives	No change in final qualifications of the programme	Generally positive/critical attitude towards the final objectives of the programme	Generally positive attitude towards the final objectives of the programme No change in final objectives when the curriculum was altered
Attitude regarding education in general	High teacher loyalty to students Teachers' desire that students not be disadvantaged by being TEM students	Very positive and engaged attitude regarding education evident in management and lecturers at TU/e Consensus on the topics to be taught in the curriculum	Tradition of high engagement in the education programmes by staff, including professors, at TU-D-A&BE
Research versus education	Research tasks for most teachers Difficulty of getting more time for education (organised so that teacher supervisors are heads of op departments with a research focus) Work for a module sometimes done by member of a different group, but not financed by that specific group	For the more technical units of the faculty, about a 40/40/20 proportion spent on education/ research/management Outcomes from research introduced into education Research fraction clearly less at AUDE (Architecture)	Equal proportion of full-time teaching staff and staff with a scientific appointment Difficult to state any further proportions
Need for changes	**UT Civil Engineering**	**TU/e Built Environment**	**TU Delft Architecture and Built Environment**
Reasons for change	Development by the university of a new concept for all Bachelor programmes called the Twente Education Model (TEM) Long period of time without change in curriculum of Civil Engineering Need for change felt overall by staff of Civil Engineering Common message in exit-interviews with graduating students that programme was too easy Introduction of BSA recommendations Experienced by staff mostly as top-down decision to change, although they knew something had to change in the programme	Ministry plans indicated clear need for general increase of studiability and efficiency of education within TU/e; efficiency should be increased from about 40% to 70% Money distribution relative to programme market share Limited number of students for several faculties; 250 total for 5 faculties. No sense of urgency within BE faculty; large number of students from a broad field of interest Ministry demands regarding efficiency and studiability communicated to the directors of education, but not well-communicated within the field of education Perception that changes imposed by executive board to deal with and maintain the small faculties with few students	Internal pressure due to students being invited to take things slowly External pressure building when change initiated

Need for changes	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Most important problems	Over time, management aspect of Civil Engineering more and more filled in with standard courses, offered by a different faculty Desire by both students and staff to strengthen technical side of the programme; also mentioned to the programme committee during last accreditation Message from students during exit interviews that the programme was too easy Programme too easy	Delay of studies too large Drop-out rates too high Efficiency too low Course pass rates too low Too many lectures Programme redundant, inefficient, in need of current update, partially incoherent Several lectures no longer interesting High number of contract hours at Built Environment (BE), about 40 hours per week Difficulty in studying the programme according to the schedule; extensive time spent on some projects interfering with ability to attend lectures Good chance to re-do some lectures from scratch, think about having one or possibly more majors Full programme, few choices Low student satisfaction, as clearly shown in NSE survey Complaints about the study load, information, quality control and preparation for career Discussion of these issues in so-called bilateral consultation between the executive board and the faculty board.	Programme not 'doable' Too many courses scheduled in parallel Too many exams Programme organisation such that students spent too much time on their design projects, which took time away from other courses. Problems most pressing for students, less so for staff No information on problems for alumni or employers
Ownership of the problem(s)	Director of education.	Director of education	The dean of the faculty and the directors of education and of education and student affairs

Goals of the innovation	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
New vision	Curriculum innovation process guided by TEM requirements Aim to educate engineers with science-based engineering background, entrepreneurial attitude, ability to work in interdisciplinary and multidisciplinary contexts, view of social issues	Vision statement for education written within first taskforce Money questions to be left out of decisions Greater importance placed on engineering education and the future engineer and his role in industry Engineer as multidisciplinary (with knowledge of both technical and non-technical disciplines); having a 'unique selling point' or specialisation; strong analytical skills, innovative and solution-oriented Engineer as a link between technology and society who must be able to work in a globalising world (communication and cooperation) Completion of TU/e programme as starting point for career of continuous innovation and development (lifelong learning) BE faculty considering more than 1 major, change from 4 corners (urban planning, technique, architecture and management) to 3 corners (TOP: technique, design, and process) Argument made within architecture to include process part within USE, have choice of 2 majors. Rejected by director of education and dean, who argued that Bachelor should remain a broad education	Integrated curriculum, consisting of 6 lines of learning 5-10 week courses Design assignments as leading for the other elements in the programme

Goals of the innovation	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Main goals	Increase the number of students graduating on time Concentrate student drop out in the first semester of the Bachelor Increase programme difficulty	Improvement of studiability Reduction in number of parallel lectures, use of intermediate tests More efficient programme Less redundancy Fewer contact hours More coaching Greater focus on technology by faculty Change project work within BE to have a more introductory character, providing orientation and introducing more basic knowledge and skills. More choices, possibility for each student to follow a unique path	Equally important goals: use of different types of assessment, teacher professional development Vision of integrated curriculum with leading position of design assignments fits in well with engineering programme as training designers, with process of design central in the curriculum. Development of vision within small team, but then widely communicated Convincing graphic representation of the set-up and philosophy behind it, for faculty staff Initial focus on retention rates, shifted towards designing an integrated and doable programme.
Planning	University-wide committee put together in 2010 to design what would become TEM Committee included director of education of Civil Engineering Programme committee put together in 2011 to design the blueprint for Civil Engineering. Module teams formed in the summer of 2012 and started designing Discussion of designs with the curriculum committee in January 2013 Implementation of new curriculum began in September of 2013	Advice from taskforce to use 2 years for implementation of the Bachelor curriculum Decision by rector magnificus to take only 1 year for this process.	Decision made early on to change entire Bachelor curriculum on September 1 2013.

Preparation – Development of the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Sources used	Document with TEM description Old curriculum TEM carousels (inspiring lunch meetings) lunch meeting	Consultation of the Dublin descriptors (learning outcomes defined by the European Union for Bachelor programmes) More frequent mention of MIT(Massachusetts Institute of Technology) Lack of consultation of scientific literature within BE faculty for redesign; more solid analysis within BC, did not seem to reach decision-makers. Lack of knowledge by (most?) people from BE of documents drawn up during planning phase Apparently no solid analysis of the current programme, noanalysis of strengths, weaknesses, opportunities and threats	Participation by director of education and student affairs on an advisory board afforded possibiity to read seminal literature on student success Advisory board report contained the basic requirements of the new programme
Documents drawn up	Blueprint for whole Bachelor programme written by programme committee Set of subjects and project idea for each module distributed; blueprintgiven to all module coordinators Blueprint for the academic skills line as well as blueprint for whole programme	At BC level, analysis of the current situation made and vision for education written within first taskforce. Orientational research done within taskforce 2 regarding studiability (fewer parallel lectures related to higher efficiency,introduction of intermediate tests overall) Research on education in blocks or in ribbons Fesearch on the science orientation of students Results from ACQA exercise at 2 faculties used Clear structure of taskforces, dealing with problems from teaching schedules, to professional skills, presentations, websites and so forth Some at TU/e level, others at faculty level	Small number of documents drawn up Broad outline of the programme and plan for how to design the curriculum published in June 2012 Detailed plan for the curriculum and all the relevant organisational procedures issued in March 2013

Preparation – Development of the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Changes in the curriculum	New curriculum based on content of the old programme, shuffled to make integrated modules possible Introduction of more projects in the curriculum (project-based learning)	Redesign based on general skeleton of the BC New curriculum based on content of the old programme Combination of 1, 2, and 3 EC courses to create 5 EC courses Complete rewrite of some courses, such as Building Technology and Real Estate Education made more applied, by including as common practice within BE a number of types of active work, such as project work, instructions, practices, work lectures Conceptual matters made more clear by application, which is traditionally included in BE education Complete redesign of first year project work, making technology more important	Nothing left unchanged

Preparation – Development of the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
People involved in development at programme level	Director of education Curriculum committee Educational committee Module teams Staff of Civil Engineering	Request from rector magnificus for theStudent Service Centre (STU) to establish a focus group of students studying according to the schedule and students not studying according to the schedule, to get their opinion on how the programme should look Involvement by the director of education of BE right from the start of the redesign, working together with his colleague directors of education, the rector magnificus and later the director of the BC Project Management Team formed by the secretaries of several taskforces, who met each week and coordinated linking Curriculum work group formed by people from different faculties. Assistance from Modelling lecturers with design of programme from ACQA perspective, from their background with ACQA (Academic Competences Quality Assurance) Core group formed within the BC, chaired by the director of BC Quality assurance group KWAZO held peer-supervision meetings with the quality assurance officers Formation of other groups by the lecturers for the basic courses, professional skills, coaching, honours programme, and so forth Executive director within the BE faculty knew the background of faculty and university, had knowledge of the politics, formed a team with the director of education and the dean; represented the director of education on the university taskforce Involvement of educational representatives from the units and two quality officers from the educational office; meetings led by the director of education	Preparations made by steering committee, consisting of the two directors and the dean, who selected coordinators for the learning lines and for the modules, and. module team members who represented the relevant disciplines Selections mandated by the steering committee

Preparation – Development of the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Communication	Organisation of faculty-wide Education Day for introduction of TEM to all staff members of the ET faculty Curriculum committee assembled by each of the three directors of education of the faculty Five people on Curriculum committee for Civil Engineering: director of education, 3 teachers of the different disciplinary pillars (transport, construction and water) and the academic skills line coordinator Designation of module coordinators, who met monthly,so every knew what was happening in which module Communication within module teams left up to module teams; mainly informal Regular meetings for some teams; a few meetings for some teams, which communicated mainly by email Informal rounds visiting the teachers made by the director of education during the preparation and the design of the modules	Website developed for general communication. Education Days organised by the faculties Communication of results to faculty mostly by their directors of education Newletters for other communication Invitations for the dean of BC to explain the strategy within different faculties Communications with lecturers within the BE faculty through “floor” meetings, where different units were visited, mostly separately	Mostly informal communication between the coordinators and team members, but also with the wider faculty Work by all involved on their University Teaching Qualification (UTQ), tailored to this specific group Regular discussion of plans, which created alignment between the programme modules

Preparation – Development of the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Resistance	Quite some resistance within the faculty, mostly within the mechanical engineering and industrial design engineering programmes Project-based work already going on in these programmes, felt left out during the design part of TEM Less possibility of project work within the modular system Resistance within Civil Engineering, but much less than within the other programmes High support from new educational model from director of education, who talked a lot with all of the teachers to show the positive side of the model Much freedom and responsibility when designing modules given back to teachers by the director of education Resistance in the past and on going; high variation in resistance from person to person; perception of enough involvement by some teachers, different perceptions by other.	Much resistance in the BE faculty toward the changes within the BC, as seen in an Education Day Greatest resistance experienced by director of education from the Architecture unit Resistance from director of education himself, felt he wanted to execute changes in his own way Lack of positive impression of BC by BE lecturers: what was the need for change, was it an improvement, why making use of time-slots, why so much freedom of choice, and so forth Perception by BE educational representatives of being consulted after most decisions made; top-down process Skeleton of the programme developed, left only to fill in the puzzle Presentation of more than 20 variants of the scheme, with basic courses and USE learning track (courses linked to society with arts and social aspects) taking up large part of the curriculum Division of remaining curriculum over too many courses, combination of 3 EC courses to make 5 EC courses, yielding cacophony of subjects within a course, given by many lecturers Hostile atmosphere sensed within group of educational representatives of BE, conflict between architectural and technical representatives Suggestion of two majors, approved of by dean of the BC, obstructed by director of education, who wanted to keep Bachelor education broad Much resistance within group of quality control officers, who felt most threatened; not positive about new course evaluation forms, which would take more of their time, at the expense of the coaching of students Doubt of added value of greater freedom of choice within people involved with project work; feeling that students already had too much freedom and should learn more basics	Little faculty resistance Some modules harder to design than others, where collaborating departments had different traditions and ideas on how to improve education

Preparation – Development of the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Resources		M€ 2.5 available for realisation of the Bachelor College More room for hiring staff not available Time invested only on BC changes; for example, educational representatives had only 0.05 fte available for their task Appointment within the BC of a dean, a secretary, a policy officer and a quality control officer	Funds available for replacement of responsibilities, allocated by the University Board of Executives Funds not used much in practice; difficult to find replacements for many tasks people were working on
Evaluation and monitoring	Quality monitoring during the design process through showing designs to the educational committee; mostly formal, led to no big adjustments	Involvement of quality control officers in the education commission and also in the evaluation of lectures and courses	Development by the quality control officer and director of education of new procedure and tools for monitoring to go with new curriculum Close collaboration by quality control officer and director of education in collecting information and using it to improve education
Implementation – running the new programme	**UT Civil Engineering**	**TU/e Built Environment**	**TU Delft Architecture and Built Environment**
Implementation strategy	Top-down decision (at the university level) to implement TEM Design of blueprint within the programme by the curriculum committee, including people with a broader view then their own discipline (deliberately few professors), the academic skills coordinator and director of education Following blueprint design by committee, return of autonomy to teachers to create common ground on the new curriculum The module coordinators meet every month (still) to discuss things that are important and keep each other posted. Many informal talks with teachers by director of education, in the past and on-going, to show positive side	Two taskforces introduced at the beginning at the BC level, where commitment of the directors of education was stated to be very important Establishment of 11 Working groups within these taskforces, dealing with time schedules, time slots, and so forth Intended balance in composition of these working groups: proportional distribution of members of different faculties over the groups, to establish some kind of bond between different faculties Initial idea to have some kind of flexible puzzle, where students were free to choose blocks, consisting of 3 courses, in whatever year they wanted Need for some kind of framework, a skeleton for students' curriculum Construction of framework, consisting of basic courses, USE courses, compulsory courses and free electives; same structure developed in principle for all faculties	Elements of quality assurance (QA), organisational development (OD). with hints of complexity leadership (CL) Important role for quality assurance in the change, but focus not just on achieving measurable goals Role for OD, as steering committee formulated the vision and did strategic work to facilitate implementation by the organisation Role for CL, as coordinators had a lot of freedom in making design decisions independently and solving problems

Implementation – running the new programme	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
People involved	People on the curriculum committee (very few professors) Initial selection of professors as module coordinators, considered to be valuable to have professors involved in the BSc curriculum Impractical due to professors' lack of adequate time to be module coordinators Selection of other staff members specifically as module coordinators Not such close involvement by educational advisor, quality assurer and Bachelor coordinator during the design process Greater involvement during programme implementation	Intended balance in composition of the working groups: proportional distribution of members of different faculties over the groups, to establish some kind of bond between different faculties Inclusion of executive director of BC in taskforce 1 Inclusion of educational director for Physics and the secretary of BC in taskforce on 'engineers of the future'	Selection of those involved based on their ideas on education and their capacity to collaborate, to keep the bigger picture of the programme and its disciplines in mind
Catalysts	No teacher training Little extra time for the redesign (some student-assistants or junior employees could be hired for a limited amount of time because some seed money was available) Some teacher resistance Insecurities of staff and first year students (not a good combination) Reality check: what to do with students who failed only a small part of the module, but passed the rest? Would they really fail the whole module?	No extra time for the redesign Some resistance by teachers High workloads due to redesign, intermediate examinations, and so forth No consensus following meetings with the educational representatives, due to different interests represented Chaotic character of meetings; more an arena of forces, where architecture met technique Director of education had his own idea of where to go to with education at BE, and went his own direction most Possibly good idea to introduce 2 majors at BE, Architecture and Technique Director of education favored a broad Bachelor programme; along with BE dean, did not want to split faculty into 2 parts (as 2 majors would do) Students invited by director of education to meeting at home on a Monday evening between 7 and 11 pm, compared the old and new curriculum, asked the students which lectures they felt to be important and filled in the format for the new curriculum Results of meeting sent to the different units; 95% of the new curriculum decided that Monday evening	No real barriers No instances of resistance that obstructed the process as a whole Some cases of the right person not being in the right place, dealt with by replacement of the person

Implementation – running the new programme	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Communication	No change in communication from what was done during preparation for the Bachelor programme innovation	Website developed for general communication. Education Days organised by the faculties Communication of results to faculty mostly by their directors of education Newletters for other communication Invitations for the dean of BC to explain the strategy within different faculties Communications with lecturers within the BE faculty through "floor" meetings, where different units were visited, mostly separately	Meetings of teams as often as necessary, in the setting of their UTQ(university teaching qualification) programmes Heavy involvement of students in discussing plans and in communicating the changes to the student body
Resources	Individuals' own expertise TEM Carousels Help for module teams available from the educational advisor and bachelor coordinator		Funds for replacement of responsibilities
Monitoring	A lot of monitoring during the first year Possibility that the degree of monitoring may have encouraged students to complain, viewed in retrospect by the director of education and teachers Dissemination of university-wide questionnaires for students after the module Teachers' evaluations after every module		Early involvement of quality control and people responsible for scheduling when rudimentary plans were made Guidelines based on the Koersen op Studiesucces report (Tonino et al., 2011) and on an inventory of issues with the old curriculum Professionalisation of teachers for the reform is included in the process of obtaining the University Teaching Qualification by these teachers During the design process, frequent consulting with members of the steering committee Clear goals for coordinators, responsibility theirs for achieving those goals Active quality control from the beginning of the implementation Evaluation of the whole first year

Implementation – running the new programme	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Keeping momentum		Preservation of momentum by introduction of changes within very short time limit, one year	Little effort to preserve momentum Coordinators remain in office and will continue to do so Less communication from the directors of education, frequent consulting among the coordinators continues to be important
After implementation	**UT Civil Engineering**	**TU/e Built Environment**	**TU Delft Architecture and Built Environment**
Staff satisfaction	Variability in level of staff satisfaction Satisfaction for most teachers with pedagogical aspects of TEM, but not the modular system Teacher dissatisfaction not always expressed to programme management team Some going their own way (within the modules), some shifting to the Master programmes	In retrospect, greater recognition of advantage of changes and higher educational quality Much better efficiency and studiability Clear curriculum structure Incoherence of a number of 5 EC courses Inappropriate use of clickers within BE for intermediate exams, rather than to stimulate student activity during lecture Too many decisions made for students, too many rules, the BC a bit too directive Difficulty of judging professional skills.	A number of minor issues remaining In general, satisfaction for those involved
What remains to be done and sustainability	Further integration of the modules Evaluation/research about whether the goals have been met Synchronisation between modules (for instance, on students' level of responsibilities)	Possibility that shift to more than 1 major might have solved a lot of problems within BE Work by a curriculum commission on the final terms of education	Monitoring of the education periods, along with retention data, BSA data, and pass rates for all modules A number of issues in the new situation, including re-sits and staffing Regulations for transition suboptimal, but this will go away by itself

Description of the curriculum change	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
The curriculum change	No change in final qualifications Change of programme organisation fo a modular system: courses in 15 EC blocks (quarters). Strengthening of technical aspects of the programme, greater integration of management part was more integrated in projects More monodisciplinary modules in the first year, more multidisciplinary modules in the second year Inclusion of a project in each module Integration of an academic skills learning track throughout the programme Integration of the courses Joint creation of a blueprint for the whole programme by the curriculum committee set up especially for the redesign of TEM Provision of a global list of subjects and possible idea for the project, for each module Assignment of a module coordinator and module team for each module, based on the subjects that made up the module Selection of additional team members by the module coordinator in some cases Design primarily by module coordinator in some cases, joint design work in other cases Much freedom for each team, resulting in high variation in integration of each module	Educational teaching approaches included lectures, instructions, practicals and design oriented education Development of a skeleton with compulsory and elective courses Large 5 EC courses instead of 1, 2, and 3 EC courses Basic courses USE courses Application of EVO (digital learning environment) in Calculus and Applied Physics. TOP profile in OGO in the first year Introduction of a task on T, O and P Supervisors in the first year including not only architects, but also people from technique and process. Professional skills in the programme	Mostly already stated in previous boxes Full integration of courses Question of inclusion of arts and social sciences

Description of the curriculum change	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
The engineer		Importance of engineer's attributes Fitting of about half of the courses to these attributes Sense in which OGO should become more important in the programme again First conclusion by taskforce in defining profile of future engineer: No such thing as the engineer profile of the future; rather a number of engineers, with certain characteristics: multidisciplinarity (with knowledge of both technical and non-technical disciplines); a 'unique selling point' or specialisation; strong analytical skills; innovative and solution-oriented Engineer important as a link between technology and society who must be able to work in a globalising world (communication and cooperation) Completion of TU/e programme as starting point for career of continuous innovation and development (lifelong learning)	Engineer as expert and connection to other disciplines

Student engagement/ satisfaction with the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Student engagement	Detection of change difficult, according to director of education and most teachers (no graduates yet); any change could also be due to BSA, changes in study finances, and so forth Desire by director of education for research to get a better picture High enthusiasm about the curriculum change from one teacher, who could see greater student engagement	Introduction of tutor groups for Mathematics and Physics Mandatory participation in introductory access examination Rubrics used by some faculties to give students more feedback than just a grade Continuous feedback for students within OGO on their functioning and their professional skills Centering on students seen more in individual choices students can make within their curriculum, possibilities and supervision offered by the institution to make choices possible Getting students to be active as an important aspect within the new BC Introduction of clickers to get feedback during lectures, intermediate examination to get students to work during the semester Important to centre on the student and not the lecturer when educational choices must be made Prompting of students to organise lectures within the project work where 'senior' students talk about their education and impression of it Organisation of excursions to businesses like architectural offices and home corporations or building physics advisory offices, so that students get knowledge about their perspectives and how they fit with their personalities Availability of coaching by lecturers and 'senior' students. Studiability of the programme was increased by having fewer parallel courses and examinations (a maximum of three), as well as a limited number of re-sits. If the students were not successful, despite these measures, they had to start from the beginning with the course and participate in the intermediate exams. Increase in efficiency for some courses from 70% to 90% through introduction of intermediate examination	Not clear what happens exactly in the classrooms, but curriculum includes design projects, lectures and other studio work, such as hand drawing, form studies ,and so forth Teaching and learning activities and assessment aimed at supporting the student to become an engineer of the built environment Student support officers supply additional services for non-education related matters and for matters that cannot be resolved in the classroom context Aim of retaining as many students as possible, having those not suited find that out as soon as possible to enable good transition to another programme First semester as combination of important theoretical components of the field and of a design experience, good representation of what the programme is like Expectation that students will keep up with programme, hard to resit exams; extra pressure on top of the regular programme Not yet a satisfactory solution for resits Scheduling of makeup work for design exercises during the summer, so that practical work does not compete with other courses Question about dealing with delays Stimulation of students to keep up from the start, having to work on assignments, partial exams, and so forth Little room for wasting time in the schedule, activities scheduled for every day of the week

3TU.CEE

Student engagement/ satisfaction with the curriculum	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Student satisfaction	Much monitoring done to ensure that the students would not face consequences from being the first students to confront the Bachelor innovation Regular student panels, invitation by director of education to ask whenever there were uncertainties Many complaints from the students during the first year Restrospective conclusion by director of education and teachers regarding too much monitoring and evaluation, due to some uncertainty about how it would go this first time Shift to current evaluation of module at the middle and end; many fewer complaints	Students feeling more positive about their education than before Greater appreciation by students of the first year project work Introduction of professional skills within the programme. Earlier recognition of delay of studies, due to coaching trajectory Nominal study accepted as more normal by students Early leaving of the faculty occurring during first semester, about 20-30% of students USE courses experienced as useless by some students, others with greater appreciation Different student associations within BE faculty, high student activity and student satisfaction Significant change seen in improved responses to NSE survey question about feeling at home: 37% last year (2014), 67% now; related to more active student coaching Change in overall score from 6 to 7.1; score of 4.7 out of 5 for question about learning a lot	

Studiability	UT Civil Engineering	TU/e Built Environment	TU Delft Architecture and Built Environment
Studiability	Resistance and uncertainty about studiability Disagreement from most teachers about the 15 EC or 0 EC rule (requirement to earn 15 EC each quarter, so students get either the full 15 EC or 0 EC), as creating too much stress for students, preventing deeper learning	Studiability increased by fewer parallel courses and examinations (maximum of three). Having project work end before examinations Studiability of the programme was increased by having fewer parallel courses and examinations (a maximum of three), as well as a limited number of re-sits. If the students were not successful, despite these measures, they had to start from the beginning with the course and participate in the intermediate exams. Different, more positive culture, in which students must keep on working, remain concerned with courses Requirement to obtain 15 EC per quarter, 60 per year. Hope to improve drop-out rate in Built Environment to under 20%, compared to 36% last year (2014) Asking students in evaluation forms about amount of time spent on different courses, intermediate, and final exams (should be about 28 hours per 1 EC), to address common student perception of spending too much time on courses	Innovation focused on studiability Too much time spent on projects in old curriculum, not enough time for other courses; too many parallel courses, too many exams, meaning that many students needed to resit exams Attention to these issues in new curriculum Resitting exams still a problem, makeup work for projects scheduled in the summer Courseload spread out evenly, according to principles of the Koersen op Studiesucces report (Tonino et al., 2011) No lecture free periods: if period ends with exam on Friday, new period starts on Monday Variability in student assessment: exams, essays, other assessment formats; continuous assessment On-going time-tracking research to monitor whether students spend expected amount of time, possibility of peak loads

Appendix C: Case Study of Electrical Engineering at University of Twente

Reasons for change

The University of Twente developed a new concept for all Bachelor programmes at the University of Twente, called the Twente Education Model (TEM). The TEM concept was developed under the umbrella of the Strategy and Policy unit of the university. In April 2011, an initial document on TEM was circulated in the university and the rector organised a meeting for all education directors at the university.

The introduction of TEM coincided with the educational reform of the Electrical Engineering programme in response to the re-accreditation process in 2010. The education director decided to combine these things and applied for a pilot with a new EE curriculum on a TEM footing, starting in September 2012. This request was granted by the rector under the condition that TEM only be applied in the first 3 quarters of the first year Bachelor curriculum; the fourth quarter must remain as is. This decision was made because the education directors from other faculties feared that EE would become too much of a role model for TEM in the rest of the university, and because they wanted to be able to share module 4 with other programmes that started with TEM a year later.

Problems with the old curriculum

The re-accreditation gave a sense of urgency to drastically reforming the EE curriculum. The curriculum was assessed as being of good quality, but there was a big issue concerning its studiability and consequent length of studies. The faculty dean communicated during all meetings that he thought this curriculum innovation was important to improve the studiability of the curriculum.

The need to plan thesis writing together with taking classes and exams was an important barrier delaying completion of studies. In practice, students also spent more time than intended on their thesis project. This was solved by moving subjects to other quarters and requiring detailed planning for the thesis writing that adheres to the set standard.
A second barrier lay in an over-full schedule; many subjects contained too much theory. A review of the study load and content of the whole curriculum was therefore necessary.

A third cause of delay lay in the level of responsibility put on the student. Difficult courses require full-time studying at a rapid pace. Students coming from secondary education had difficulty keeping up with this and ran a high risk of lagging behind quite early in their studies. To prevent this, the students need greater guidance in their studies.

Another cause of delay lay in the students' attitude toward studying. For many EE students, it is important to be active outside their schoolwork.

Characteristics of the EE programme

The EE programme aims to educate broad electrical engineers who are able to develop and improve electrical systems. EE is a small programme (the number of students beginning their studies was 45 in 2011 and 64 in 2014) where all

students know each other and the teachers as well. The atmosphere is easy-going. Much effort is put into helping the students by coaching and taking an individual approach.

Goals of the innovation
A series of sessions were organised by the university to inform staff about the nature and purposes of the educational innovation. The staff members interviewed for this case study felt that these sessions did not make the TEM concept clear. The teachers interviewed felt unsure of the meaning of TEM, even after teaching in it for two years now. They were uncertain of what is considered to be most important in the UT vision: attracting good students, the need for educational innovation, cost reduction, efficiency or good pass rates. The advantage of this uncertainty was that teachers experienced a large degree of freedom in designing TEM modules, which was appreciated and fit well within the academic environment. It does not work to tell people what to do, you need to convince them.

At the start of the TEM process, there was the idea that programmes would share the same module, for reasons of efficiency. This idea of efficiency was seen as invalid by the staff interviewed, because a module with twice as many students will become twice as expensive. There was moral pressure to develop shared modules, but it was not obligatory. It was difficult to share modules when everyone already had a draft curriculum with modules at hand. It was considered an added value to have shared modules, but the process hindered it. If the discussion had been held at a higher conceptual level, there would have been more room for innovative solutions and decisions could have been more radical, going further than making bundles of pre-existing subjects into modules.

Formulated goals
The main purposes of the innovation from the EE perspective were to increase the number of students graduating on time, and also to have students graduating with a pass score, not only with very high marks. To increase the number of students and to better match graduates' field of work, it was decided to move to English as the medium of instruction.

The development of the new curriculum

People involved in the development
The pilot was led by the education director at that time. This education director retired at the end of the first run of the pilot, in 2014. He was succeeded by the current education director of EE. The first education director was a strong advocate of problem-based learning (PBL). He urged teachers to implement this approach, but it was used in only two out of eight modules. The teachers felt that it was their academic freedom to decide what to do in a module; an education director cannot impose it on them. The role of the education director is to guard the coherence of the curriculum as a whole at the level of learning outcomes, student success, and the selection function of the first year. The new curriculum was developed by a "core team", consisting of the education director, the Bachelor coordinator and the study advisor. They exchanged ideas on a daily and weekly basis and produced plans that were discussed with the "committee on curriculum innovation". The education director took the lead in this core team and produced many different ideas within a short time. It was very clear for the core team which modules should be in the first year of the Bachelor: electronics, network analysis, an introduction and fields and waves.

A committee on curriculum innovation was established to think about the educational concept and to protect the quality of the new curriculum. This committee consisted of experienced staff members of the departments involved in the EE programme. They discussed the ideas of the core team.

The new modules were developed by "module teams", led by a module coordinator. The module teams were composed of teachers involved in teaching the module subjects in the old curriculum.

Consultation of documents
The education director collected literature on PBL and put this material in a central place for the module teams to read; he used the material in his presentations to convince staff of his ideas. He also read literature on strategies for educational innovation. He learned from this that a good approach consists of talking to people very frequently and being clear in talking to people who are against the education innovation. He discussed the innovation strategy with an education specialist from the university education service. Together they defined steps to take.

Teachers involved in the pilot got the opportunity to go to Aalborg University to see PBL in action. Most, but not all, teachers participated in this.

For the development of module 4, the PBL approach and problems from a pre-existing course in Advanced Technology (AT) were re-used. These had been tested in practice for many years and were therefore well developed. The current module coordinator of Module 4 had been involved in teaching the pre-existing AT course as a tutor and could bring this experience to the current EE module 4.

Changes in the curriculum
The module development process had a pragmatic nature. It started with a critical look at the "old" subjects that formed the basis for the new module. Decisions were made on what should be in the module and what should be left out. A time reduction of 10% per subject was advocated to allow for a larger project in the module. The teaching methods of the "old" subjects were often re-used in the module. After that, the TEM requirements were taken into account: the math learning track, the project, number of EC. In some cases the strictness of 15 EC was difficult to handle.

Module 4 was copied from the old AT module and was mainly developed by the module coordinator in consultation with the other teachers involved. The new module used the experience with and cases for PBL developed over many years. Because the education director at that time was an advocate of the PBL method, it was not necessary to convince everyone of the usefulness of the PBL method.

Internal communication
The module teams worked quite independently from each other during the pilot phase. There was no time in the pilot phase to share ideas with other module teams. Development was left up to the module team and the education director monitored it from a distance without knowing all the details of the module. The education director attended module meetings if necessary. They monitored the overlap and coverage of the curriculum of the first year as a whole. The current practice was that after each module there was a meeting of all module coordinators and the core team.

To inform the faculty as a whole, half-yearly lunch meetings were organised and the education director visited all the scientific departments involved to talk about the curriculum innovation.

Communication with other programmes
The EE programme currently shares Modules 5 and 7 with Computer Science (CS) and Module 4 with Advanced Technology. There is partial sharing of Module 4 in EE and in AT: they are taught in different parts of the curriculum in the programmes (AT in Q3) and they have slightly different content.

In the first draft of the curriculum, there was large overlap with the curriculum of CS. However, this seemed undesirable because the first year of the curriculum should select students for their suitability for EE study. The scores in the first year should predict how well the student will perform in the rest of the course of study. For this purpose, specific EE topics must be in the first year curriculum; these topics are not relevant for CS students.

Sharing modules is difficult when the modules in the curriculum build on each other. You need to have had certain mathematics to be able to do the work in a module. Teaching a shared module in parallel also leads to capacity problems from the teacher side.

A module on Fields and Waves was at first jointly developed by two faculties (Engineering Technology and Electrical Engineering, Mathematics and Computer Science). During the process it became clear that the approach to this topic differed by faculty. Because of this, there are now two versions of this module, one version for the Applied Mathematics and Technical Physics programmes and another version for EE and Advanced Technology. There have also been discussions with Mechanical Engineering about sharing a module on Control.

Resistance
In a number of modules, the teachers received less time for their topic than before. There were personal talks with these teachers. Two teachers stopped teaching in the programme because of this; TEM was not the only cause for their leaving. They have been given other tasks.

Because of the pilot, the curriculum had to be developed in a very short time. There was some resistance within the faculty concerning the pace of development. A group of 5 to 6 teachers felt they could use an extra year. The argument was that development of student interactive education requires a lot of time.

This time pressure helped to put in place the education director's plans. The low accreditation score also helped. The idea that their job might be in danger because of the threat of a programme shutdown increased the staff's willingness to change. This idea was strengthened by the personnel reorganisation going on at that time at the Faculty because of financial problems. Many teachers had to leave the faculty; the remaining teachers had to work extra hard and do the work of their colleagues. The process of change was supported by visits from the education director to all the scientific departments, in which the necessity and nature of change were discussed.

Education versus research
Most teachers at the university choose research over education. The UT-advocated policy that it is not a problem if you spend more time on education at the cost of your research performance looks different at the workfloor level. At the end of the day, education is something you do on the side. When you have a formal task in education with allocated time it is easier than when you have a scientific job profile. Investing extra time in education is therefore challenging. You must convince teachers that it is worthwhile and that it is not a problem for your career. The Dean played an active role in this regard with the faculty.

Resources
In the pilot phase, all modules received a development budget of €50,000. After the pilot phase this budget was reduced to €15,000. The budget was distributed by the education director out the UT central TEM budget. The money was split among the departments contributing to the modules, and was spent on extra student assistance, and translation of texts to English. The UT central TEM budget was also used to appoint an executive secretary for the committee on curriculum innovation. This person's role was to give a boost to the process. Another part of the budget was used to appoint someone to develop the skills learning trajectory.

Evaluation and monitoring
The development of the curriculum was monitored by the education director and the core team. There was no quality assurance officer involved.

The implementation of the new curriculum

In September 2012, the pilot with the new EE curriculum started. In September 2013, the whole university started implementation of TEM in the first year of the Bachelor programmes.

People involved
The education director and the Bachelor coordinator monitored the execution of the new modules from the sidelines and helped where possible. The module teams executed the modules, managed by the module coordinators. The students were informed about the educational innovation in a lunch meeting organised by the EE programme. The

3TU.CEE

senior students' opinion was that the level of the programme would decrease. This negative attitude carried over to the first year students.

Strategy
The implementation strategy could be placed both within the "policy" and the "reflective practitioner" categories (Borrego & Henderson, 2014). At the UT level, a new policy was defined that had to be implemented in all Bachelor programmes. Within the EE programme, the development of the modules and the preparation of the implementation were done within the module team, where reflective teachers worked together to create a module that was a consistent whole.

Catalysts and barriers
There were a number of things that were not considered in advance and had to be solved during the first run of the new curriculum: part-time students, transitional arrangements, students getting sick, the readiness of the student information system, the new role of module coordinator, and room availability and equipment.

There were some problems with the programming learning track, which in the first run of the curriculum included too much theory and theory that was too difficult. There was also a content-related discussion on programming versus computer coding. For the second run of the module, a different teacher was involved and a whole different setup was developed.

The teachers' workload was high, mainly due to assessment:
- Two groups of students were studying in parallel; old curriculum and new curriculum. The courses were not taught anymore, but the teachers still had to develop and mark the exams. This placed a high workload on the teachers.
- The workload was also high during the modules. EE decided that students had to finish the modules within the planned 10 weeks. Exams were usually in week 9, the re-sits in week 10. This led to a rapid workpace for the teachers who developed and marked the exams.
- To get students on the right pace of studying, weekly exams were scheduled in modules 1 and 2. This involved developing and marking exams on a weekly basis.
- The PBL methodology requires the involvement of a high number of staff to do the tutoring. At the moment this is manageable because of the small number of students in EE. It was questioned how this will work with a larger number of students.

The teachers felt pressure to do everything right to enable the students to receive the 15 EC for the module. A staff meeting was organised at the end of each module to deal with problems of individual students being sick or performing badly in one part of the module. The system is such that students can only obtain 15 EC for the whole module, not for parts of it. Failing a module delays completion of the couse of study. While this system was kept in place, exceptions were being made for individual students. The number of students with exceptional arrangements was kept as low as possible for the EE subjects to keep the system working. If students knew that extra re-sits were being offered, the modular system would go under. For the obligatory university-wide mathematics learning track, extra re-sits are more common across the whole university.

Communication
At the start of the new curriculum, a lunch meeting was organised for students and a letter was sent out. Students were informed by e-mail about matters concerning them, for instance, the transitional arrangements, and they could go to the study advisor to discuss their personal situation and questions. The students felt that communication could be improved and teachers should be better informed about the transitional arrangements.

Currently, the module coordinators meet four times a year at the initiative of the education director to discuss how things are going. The discussions focus on problems of student progress and student performance, not on the content of the modules.

The current education director has put together a management team, consisting of the Bachelor coordinator, the Master coordinators and the study advisor. This management team discusses the education director's areas of concern. The education director visits all the scientific departments involved twice a year to discuss education matters. There is also a professors' dinner at which education matters are discussed.

The education director is member of the "faculty steering group", composed of the five Bachelor education directors of the faculty. They meet weekly to discuss practical educational matters, such as the assessment regulations, or diploma sessions. One member of the steering group represents the EWI Faculty in the University Committee on Education (UCO) where all educational programmes and faculties at UT are represented.

There is a group of people at UT central, coordinated by the university Dean of educational innovation, who are further developing TEM at the UT level. For instance, they defined the new rules and regulations, and rules for keeping partial EC for modules over the years. The education director feels that this is supports the implementation of TEM and that they are open for discussion. Discussions are held at the education director days, which are organised three to four times a year. These days are appreciated; it is nice to meet the other education directors.

Resources
Appreciation of education was an important resource for the implementation. The Dean expressed this appreciation publicly and at the end of the first pilot year, a dinner was organised for staff involved in the pilot.

In the pilot phase, some teachers' existing expertise with PBL, together with the university education service, was used to develop training for inexperienced teachers in module 4. This training was useful because they received feedback on their functioning as a tutor. Now there is no training organised for new teachers, but they learn from observing their peers in action as a tutor.

Monitoring
Quality assurance was coordinated by the Bachelor coordinator and was the responsibility of the module coordinator. Students are involved in the organisation of oral panel evaluations. Quality assurance for all TEM modules is also controlled by the UT central "programme bureau for educational innovation". They have a standard questionnaire for all modules and have evaluation meetings with all module teams from all programmes.

In the new EE curriculum there is supposed to be more emphasis on understanding, instead of having students learn tricks. To check whether this goal was reached, a conceptual test was developed in the pilot phase to assess the students' understanding of concepts addressed in the modules. Understanding means: insight into how things work, analysis, evaluation, and being aware of connections. This test was administered after the first half of the first year of study. The results of this test showed that students understood the concepts more or less, but not at the level that was expected. The results were discussed with the teachers; it was clear that students did not reach the level of "understanding". In module 4 however, teachers had the idea that students reached a higher level of understanding than before.

The new curriculum versus the old curriculum

The curriculum change
The learning outcomes and the content were not changed because the quality of the programme was assessed as Good by the accreditation committee. The content and the organisation of the curriculum were transformed according to the TEM.

There was consensus amongst the teachers and the management on learning outcomes of the programme and the topics to be taught in the curriculum. The topics in the new curriculum were more or less the same as in the old curriculum, the learning goals were unchanged. The general idea was that students need to learn how to learn and

3TU.CEE

that developing academic skills is important. This was done by taking students by the hand in module 1 and releasing that grip in the next modules. The first module contains weekly tests to help students study consistently.
The curriculum was transformed into a modular system; the modules are thematically organised. The student is supposed to have a continuous pace of study. The motto is "active participation means student success". Modules must be passed as a whole. Each module contains a project in which the different module subjects are integrated. There was also a switch to teaching in English.

A framework called the Maturity Model (Berg, Steens, & Oude Alink, 2014) was developed by the "programme bureau for educational innovation" to evaluate whether the developed modules represent the TEM vision and starting points. The Maturity model distinguishes 5 phases, from starting phase through final vision phase. It is not the intention of EE to reach the final phase of the model. They designed the first modules intentionally to be very academic in order to motivate students to work 40 hours per week with weekly assessments. They acknowledge that it should not be like that for three years.

The original TEM idea was that 50% of the module would be dedicated to the project, that it would be project-centred. Teachers did not believe that students would actually learn from a project and therefore the project was mainly used as an illustration.

Some modules of the new curriculum (4 and 7) use the PBL method. Students need to be trained in this method. This would be easier if the method were used more often in the first year curriculum.

Staff satisfaction
The staff was satisfied with the new curriculum. Some teachers from the second year still thought that there was too much content in the second year compared to the official study load, but they did not change that. In general, the teachers were satisfied about the number of students passing for the first study year.. The coherence of the content was increased through the thematic clustering in the modules, which was seen as an advantage of the new curriculum.

In every evaluation of the new curriculum there was attention for the level reached by the students in comparison to the old curriculum. This seemed to be okay, looking at the overall picture. At the module level, however, teachers saw differences with the old curriculum:

The teachers and students saw a decrease in knowledge of mathematical manipulations. This is logical because there were fewer practical sessions in which students practiced solving pure mathematical problems. In that sense, the graduate student in the new curriculum is different.
Some basic skills were only taught through the project. The project could be passed without really mastering that skill. This was a point of continued concern, to make sure that all students master the basic skills.

In the new curriculum the students performed better on understanding and being able to explain how things work. The teachers of the PBL module 4 were satisfied with the PBL method. The main advantage of this method is that good and motivated students can be better served. The PBL method puts the initiative for learning with the student, and this is good for motivated self-directed learners. However, weaker students could suffer with this method, because they would like to be taken more by the hand. There is always a call for more lectures by the students, but the teachers thought this was not effective. It takes some time for the students to understand what they are actually learning using the PBL method. A point of concern that teachers had was over what students actually did. Sometimes the outcomes of the PBL groups were disappointing. That made teachers feel that it might be better to give lectures, because this allows greater teacher control. However, it is not clear that this would lead to better learning results.

What remains to be done
The following issues remain to be addressed:
The modules are continuously evaluated and adjusted. Fine-tuning everything through this process will take a number of years.

Twenty-first century skills were not included in modules 1-3. These modules mainly focus on basic knowledge, leaving too little time for things such as information skills. However, twenty-first century skills were addressed in the later modules.

The mathematics learning track does not harmonise well with the curriculum. Sometimes an irrelevant mathematics topic is taught in a module, where another topic would be very useful. It might be efficient for the university as a whole to have this learning track, but from the perspective of this educational programme it is not

Student engagement and satisfaction

Engagement

Student engagement, or active learning, has different forms in the different modules. There is no standard for it. The most extensive form of student engagement is found in the PBL modules. In the other modules, student active learning occurs in the project.

In the pilot phase, before the official start of TEM, EE was only allowed to use the TEM approach in the first three modules of the first year of studies. The modules that followed kept the original curriculum. This was a strange situation. In the first year the students were active and becoming self-regulated learners. In the second year this was lost, because they returned to the old system of teacher-led education.

Satisfaction

The first cohort of students in the new TEM curriculum felt like guinea pigs. Everything was new and many things went wrong. The implementation was done in a hurry, full of band-aid solutions.

In general, the students were satisfied with the current curriculum within the perspective of TEM. Given the criteria set by TEM, this was the best solution. However, they missed elements of the old curriculum, such as the big multidisciplinary project and some of the content. According to the students, the quality of teaching remained the same because the same high-quality teachers were active in the new curriculum. Recently, the issue of the loss of the multidisciplinary project was solved; the project returned in Module 11.

Students thought that there was less content in the curriculum than before. Most subjects returned in the new curriculum, but they were taught with less depth. Some subjects were more or less removed completely; other topics (like quantum mechanics) were re-introduced.

Students felt that the level decreased in some subjects. The overall level reached by the graduate cannot increas because the length of study has diminished over the years. First the old curriculum had to change from 4 to 3 years. Now, with TEM, the theory was put into two years. The third year of study in the current curriculum consists of only module 11 (a design assignment with some theory on signal processing), a minor and the graduation phase. The third year was considered to be a bit empty by the students because it only consists of a minor and the graduation phase. The minors (30 EC) focus on deepening of the subject. They can be relevant for students if they are connected to the topic of the graduation phase. Students missed a good variety of broadening minors. The third year is still under development.

Students thought that they learned less about social skills in the new curriculum. Electrical engineers are known for their low social skills, and therefore it is important to have these included in the curriculum. In the old curriculum there was more attention for social skills via the big projects.

The evaluations of the modules differed to a great extent. The main factor in this was the teacher's motivation. A motivated teacher who is willing to put time into the development and teaching of the module will produce a good module.

3TU.CEE

Students varied in their evaluations of PBL. The main complaint was that it took so much time to do it. It takes less time when a teacher explains things than that the student has to find them out for him/her self. Less theory is able to be covered per hour with PBL than in traditional teaching. It is not efficient. It forces you to go in-depth into the problems, while you miss the breadth of the subject. It might be the case that you understand the theory dealt with in the problems better in the end.

The students' opinions on the modular system had different angles:

- In the old curriculum, subjects built on each other and topics recurred several times over the years. In the modular system, some topics are dealt with in only one module. Would students still remember at the end of their studies what they learned in the earlier modules?
- An advantage of the modular system is that learning is more efficient. In the old system, where topics recurred several times, much time was spent on retrieving knowledge that had been forgotten. It is questionable whether this extra time is a waste, because repetition of knowledge leads to consolidation of knowledge over a longer period of time.
- The modular system also sets a strict time frame of 11 weeks. Because of the time pressure there is less time to let what has been learned sink in and to consolidate knowledge. Some topics do not re-occur in the curriculum and are therefore soon forgotten.

Studiability of the curriculum

The studiability of the curriculum increased because of better alignment of the subjects with each other and the separation of taking classes and working on the thesis. At the same time, the modular structure forces students to study continually, because otherwise they lose a whole module of 15 EC.

In practice, the system is not so strict. Students are offered multiple options for re-sits within and outside the module. Teachers consider this to be okay because you should not fail a whole module over one small element of minor importance. However, this undermines the TEM starting points. To help students to receive their 15 EC, the students are instructed to report special circumstances to the Bachelor coordinator immediately and they do that often, to be sure that they can get an extra chance or a special arrangement. In the past, they did not report every illness or problem.

To enhance studiability, the programme has become more academic in the first modules. Students are more taken by the hand (through weekly tests and the PBL method), making students less independent. The EE educational philosophy of motivating students to work hard requires much more coaching by the teacher. They feared that if they reduced that support, the number of students passing the modules would drop dramatically. The modules use different teaching methods. This is good for the variety of students who enter the programme. Some students study more independently than others; it is good that some modules are more academic than others.

Students complained about the transitional arrangements for student who were studying in both the new and the old systems. They had to re-sit exams for courses that are not taught anymore and to make individual arrangements with teachers to re-sit a certain practical or exam. According to the education director, the transitional arrangements were clearly stated and communicated. Elements of the old courses are also taught in the new modules. Teachers did not like students to take only parts of the modules, so they asked them to do the whole module, which led to delay in their studies. The (old) 20 EC minors were terminated and were replaced by 15 EC minors. To receive the missing 5 EC, they had to do an extra course of 5 EC to fill in the gap.

Marks

In the old curriculum, students either passed the subjects with high grades, sometimes after 5 attempts, or failed and dropped out. In the new system, there is more room for passing with intermediate scores.

Length of study
The modular system prevents students in their last year of study from still having to complete subjects from their first years. In the old curriculum, students did not think it important to finish everything on time. Students and teachers saw that TEM is very effective for decreasing the length of study. However, they also saw at what cost. Many EE students are active outside their studies and this puts them in a tight corner in the new curriculum. Doing things besides their studies is seen as an advantage for their curriculum vitae.

Success rates
The target success rates were set at 50-60% for the first year of study and at 80-90% for the second year of study. The success rate for the first year of study was much higher than the target (70-75%). There were concerns about the success rates in the second year of the programme. The idea is that if you pass the first year, then you should be able to finish the second year according to schedule. The current success rates in the second year (Module 5: 70%; Module 6: 40-50%) therefore seemed a bit low. The absence of binding study advice in the first year could be a reason for this. Students were not certain that increasing success rates were good because they saw decreasing possibilities of doing things besides their studies.

Dropout rates
Teachers and students thought that reducing the dropout rates should not be a purpose in itself. Reducing the dropout rates would mean that students who do not belong in the programme would stay on-board. The programme should also have a selective function in this respect. Students did not think that the number of students dropping out of the course of study was changing with the new curriculum. The same number of people would have chosen the wrong study as before, although they might now realise this earlier.

Indicators

Table 9: Indicators for the Electrical Engineering programme of the University of Twente

	Before the change: 2011	After the change: 2014
Student numbers	45	64
Student gender	96% male 4% female	93% male 7% female
Staff involvement	49.6 FTE	33.011 FTE
Staff gender	89% male 11% female	82 % male 18 % female
First-year students studying according to the official schedule	49%	53%
Drop-out rate in the first year of study	24%	28%
Proportion of total FTE spent on education at faculty level	40.6%	40%

FTE: Full Time Equivalent

Current Bachelor curriculum overview

This information was taken from the following website: https://www.utwente.nl/en/education/bachelor/programmes/electrical-engineering/study-programme/
The Bachelor's in Electrical Engineering is a three-year programme. Each year consists of four modules of ten weeks.

Table 10: Overview of the current Bachelor Electrical Engineering programme from the University of Twente.

Year	Module
Year 1	*Module 1: Introduction to Electrical Engineering & Electronics* Topics: basics of electronics, electrical networks, signal theory, electronic instrumentation, system design and programming for electronic hardware, the corresponding foundation in mathematics Project: electrical measurements on humans, for example, in sports (e.g., measuring match endurance) or in healthcare (quantifying responses to certain materials, early detection of illnesses)
	Module 2: Electrical circuits Topics: ways to analyse and apply electrical networks comprised of sources, resistors, capacitors and inductors and the mathematics (calculus) necessary to perform the analysis Project: designing a circuit to feed the (energy) output of a solar cell into the power grid, addressing the question of how to use a solar cell efficiently
	Module 3: Electronics Topics: analogue circuits extended to systems with feedback in order to create stable circuits and oscillators and more complex analogue circuits and digital electronics, an introduction to (radio frequency) transmitter systems, solving sets of linear equations Project: understanding and designing a radio transmitter and receiver
	Module 4: Fields and waves Topics: Maxwell theory, which describes electromagnetic fields, the mathematics to describe fields (vector calculus), electrostatics, magnetostatics and electromagnetic waves Project: design and test an electromagnetic antennae with a view to obtaining the best signal

Year 2	*Module 5: Computer systems* Topics: basics for the analysis and design of systems using combinational and sequential logic (e.g., representation of numbers, operations on binary numbers, basic gates, combinatorial and sequential circuits, state machines and programmable logic), basic principles of the components of a processor system and how they interconnect, differential and difference equations Project: working as part of a multidisciplinary team to tackle a real-world problem, discovering how programming (computer science) and interfacing (electrical engineering) are combined in the embedded system
	Module 6: Systems and control Topics: differential and difference equations, state description, convolution and integral transformations, extension to systems functioning in other domains, such as mechanical or thermal systems Project: design and develop a mechatronic system
	Module 7: Device physics or computer networks The student chooses between device physics or computer networks. Topics device physics: quantum mechanics, transducers, accelerometers, solar cells, transistors, elementary optics and solid state devices as used in microelectronics Topics computer networks: communications networks and their applications, computer and component hardware and software; the central theme of this module is the internet Project: Various projects
	Module 8: Signal processing and communications Topics: representing information as a signal to allow transmission, reception and processing, signal properties and how the choice of a suitable signal is influenced by the type of information, properties of the transmission medium, required performance, hardware considerations such as complexity and power consumption, and possible coexistence with other systems
Year 3	*Module 9 and 10: Electives* Students can choose to take modules inside or outside the faculty and/or to go abroad.
	Module 11: Design This module consists of a major design project in which students work together with a large group of fellow students. The problem must be broken down into sub-functions and sub-problems, the preconditions must be discussed, and all the different partial solutions are be merged into a single, total design at the end. In this module, non-technical conditions related to your design, such as user-friendliness and social or ethical aspects are also considered.
	Module 12: Final Bachelor's assignment The final Bachelor's assignment is conducted under the supervision of one of the chairs within the department of Electrical Engineering: microsystems, mechatronics, telecom, integrated circuit design/ architecture or biomedical applications. The choice of topic can be geared towards preparing for a Master's programme. This module concludes with writing a thesis, which has to be defended before a research committee.

Appendix D: Case Study of Electrical Engineering at Eindhoven University of Technology

Short description of the programme

(Werkgroep 180 degrees, 2010)

A. The Bachelor programme was modified in order to achieve better progress statistics while maintaining the level of the final programme. The changes led to a programme that more explicitly exhibits the attractiveness of Electrical Engineering. The programme incorporates more opportunities for students to choose according to their own preferences. Amongst these choices there is an option to specialise in one of the faculty's core topics (*tracks*: Care & Cure, Smart Sustainable Society, and Connected World). There is an extensive excellence programme (STAR). The programme includes opportunities to retake exams with minimal competition with regular courses. The sets of related courses that constitute the programme (learning tracks) are currently being reviewed in order to streamline the content (learning outcomes) of each learning trackwith associated number of EC, and to specify the tracks and the excellence programme. At the same time, the design projects, the technical training and the soft skill programme were redesigned.

B. The Educational Advisory Board and the Promotion Team supervise the re-design process; they report to the Faculty Board. Given the complexity of the process, it is necessary to supervise it carefully and continually. The Evaluation Committee was therefore integrated into the EAB.

C. The faculty started implementing several "best practices". The course schedule was simplified using a "slots" setup. The faculty experimented with education that focuses on what the student needs to learn instead of what teachers want to teach. The faculty implemented an entrance programme that precedes the 1st curricular year and incorporates math training material.
For a number of courses, the faculty introduced "*summer schools*", short intensive full-time training sessions focused on passing the examination that immediately follows.

The EE faculty has taken a comprehensive approach in order to achieve the following goals in 2015:

- The Bachelor student intake will be above 100 (now 70), increasing at 10% a year;
- The 1st year drop-out rate will fall below 30% (now 45%);
- the students who reregister in the 2nd year, 70% will obtain a Bachelor diploma within 4 years (mandated by the Ministry of Education; now 10%); to this end:
- 50% of these students will enter the 2nd year with the propaedeutic (first year) diploma (now 15%);

- The minimum pass-percentage for any course will be 65% (now 65% on average);

- The final Bachelor level will continue to conform to TU/e academic criteria and to the ASIIN-accreditation agency criteria (ASIIN, n.d.).

Faculty culture regarding education

Education in general
According to the director of education for EE, management and lecturers in his faculty have a very positive and engaged attitude regarding education. There is consensus on the topics to be taught in the curriculum.

Attitude regarding objectives
In general, the attitude towards the final objectives of the programme is positive/critical.

Education versus research
For the more technical faculties like EE, the proportion of time spent on education/research/management is about 40/40/20.

Need for changes

Reason for change
The BC dean indicated that it had become clear from the Ministry's plans that studiability and efficiency should be increased; efficiency should be increased from about 40% to 70%. Money would be distributed relative to the programme's market share. A number of faculties had a very limited number of students: The faculties had a total of 250 students.
The director of education reported that the EE faculty had only 60 first year students. Of these students, about 30 left the programme before completing their studies. It seemed to look more like a classroom than a faculty. Only 1 student was able to complete the Bachelor degree within 4 years, and there were hardly any students in the Master programme.
The executive board of the university, as well as the faculty board, realised that there was little reason to continue on with this low number of students. The general idea was that even the faculty would no longer exist within 3 years. Apart from that, the region of Brabant needed more electrotechnical engineers; otherwise thestudents might be forced to leave the region.
The rector magnificus indicated that a minimum of 100 first year students was required in order to continue on with the faculty in the future. Furthermore, the target for efficiency should be about 80%.
Moreover, there was a limited number of female students within the programme and the target audience should be broader: not only science motivated students, but also students interested in humanity and care. There should be more freedom to choose, and the studies should be more directed towards society.

Problems with the old curriculum
According to the director of education, the programme was not doable and it had a very bad image. There were too many students not completing the programme on time, and the drop-out rates were too high. Apart from that, the efficiency was very low and pass rates for courses were too low.
There should be more freedom to choose and the programme should be directed more towards society.

The quality of education regarding final knowledge was ok; only the road towards it was not ok. There were also some issues about education in quarterly periods compared to semesters, but in the past quarters had also been scheduled.

Goals of the innovation

Vision
At the TU/e level, the first taskforce formulated a vision for education (Taskforce Redesign Ba-curriculum, 2001). The taskforce advised leaving money issues out of the decisions. It was more important to consider developments in engineering education and the future engineer and his role in industry. A more differentiated type of engineer was sought: every engineer is multidisciplinary (with knowledge of both technical and non-technical disciplines); has a 'unique selling point' or specialisation; has strong analytical skills and is innovative and solution-oriented; the engineer will become more important as a link between technology and society and must be able to work in a globalising world (communication and cooperation); completion of the TU/e programme is only the starting point for the engineer, preparing him or her for a career of continuous innovation and development (lifelong learning).

Formulated goals
Research for the purpose of orientation was done within taskforce 2 regarding studiability, the degree to which the programme was doable by students. The number of parallel lectures should be decreased and intermediate tests should be used.
The director of education's opinion was that supervision of first year students should be improved. The transition from secondary education to university education should be smoothed. Coherence should be incorporated in the choice of packet. Most students chose a safe, coherent package of courses. The result was that the programme got a kind of academic signature, which should be improved. A more differentiated type of engineer was sought.

Preparation - The development of the new curriculum

Preparation strategy
At the TU/e level, taskforces had a clear structure, and followed different roadmaps. They dealt with problems such as curriculum programmes, teaching schedules, communication, quality assurance, coaching, organisation, as well as professional skills, presentations, websites, and so forth. Some were at the TU/e level, others at the faculty level.

Consultation of documents
KIVI reports (Royal Institute of Engineers) on the engineer of the future, and IEEE (Institute of Electrical and Electronics Engineers) and American research were consulted at EE. Studies were done of models at Boston and MIT.

Universities in Ghent (B) and Utrecht were visited, because these universities had science faculties with very high efficiencies (about 80%). These universities made use of large educational blocks of 7.5 EC, 2 parallel courses, with possibilities of compensation for low marks between courses. Introduction of the practice of intermediate examinations resulted from these visits. Another observed practice was summer schools, which were also introduced at EE.

Produced documents
At the BC level, the first taskforce analysed the current situation and wrote a vision for education for the BC. The EE director of education co-authored the taskforce report. Taskforce 2 did research for the purpose of orientation, with regard to studiability. The lower the number of parallel lectures, the higher the efficiency would be, and intermediate tests should be introduced overall. Research was done regarding education in blocks or in series. Research was conducted on the science orientation of students. An ACQA exercise was done at W, and EE made use of the results.

Changes in the curriculum
The director of education reported that in terms of students' final knowledge, the quality of education was ok; it was only the path towards it that was not ok. In fact, the learning outcomes of the Bachelor programme remained the same. Part of the general skeleton used by the BC was developed at EE, and served as the start of the redesign. The BC chose 3 parallel courses of 5 EC each as the general skeleton.

Educational teaching approaches were lectures, instructions, practices and OGO's. Another practice was summer schools, which were also introduced at Electrical Engineering.

There were some issues about education in quarters rather than semesters, but the schedule had also used quarters in the past.
More opportunities were introduced for students to choose according to their own preferences, as well as opportunities to retake exams with minimal competition with regular courses. The course schedule was simplified using the "slots" setup. An entrance programme was introduced, which preceded the 1st curricular year and incorporated math training material.

People involved in the preparation
At the TU/e level, the rector magnificus asked the student union to establish a focus group made up of students studying according to the schedule and students not studying according to the schedule, to give their opinion of how the programme should look: the student advisory group.

The director of education of EE was involved right from the start of the redesign, and worked together with his fellow directors of education, the rector magnificus and later on, the director of the BC. Within his EE faculty, he worked together with the education committee, students and lecturers. In fact, the educational concepts developed at EE were later introduced in the BC.

The secretaries for several taskforces formed the Programme Management Team. They met each week and coordinated matters of linkage. People from Wsk and Inf., E, W, ID, IE&IS formed a curriculum workgroup. Based on their background with ACQA (Academic Competences Quality Assurance), the Modeling lecturers assisted with programme design from an ACQA perspective; programmes are normally evaluated by ACQA.

Within the BC, a core group was formed consisting of the Dean, a secretary, a policy officer and a student assistant. Later on, a secretary and quality officer joined the team.

A quality assurance group, KWAZO, held peer-supervision meetings with the quality assurance officers. Furthermore, different workgroups were formed, such as 'administrative processes' with the director of DHPZ and a USE workgroup. Lecturers for the basic courses, professional skills, coaching, honours programme, and so forth, formed other groups.

Within the EE faculty, the director of education chaired a core team. A workgroup was also established, consisting of students and lecturers. Later on, 90% of what was introduced by EE was applied in the new BC.

Internal communication
The BC secretary said that in the beginning, the 'what' question was communicated, but not the 'why' question. Lecturers were thinking about the consequences of changing from 3 to 5 EC, not about the need for change. Communication improved later on, with the assistance of the Communication Expertise Centre. The newsletter was one result of this, but also a kind of road show by the BC dean. However, according to the secretary, top-down communication appeared to be difficult, because the lecturers who had to execute the changes were mostly reached only at the end.

Resistance
According to the director of education, there was no real resistance within EE towards change in the organisation. For example, no lecturers were against the change. However, there were critical discussions.
According to a quality officer, however, a lot of resistance was felt within the group of quality control officers. It seemed they felt most threatened. They were not very positive about the new course evaluation forms. The management reports would take up more of their time, at the expense of the coaching of students.

Resources
At the TU/e level, M€ 2.5 were available for the realisation of the Bachelor College. A dean was appointed within the

BC, as well as a secretary, a policy officer and a quality control officer.

EE invested in a larger number of student advisors and introduced a VWO teacher to deal with first year students. More room for hiring staff was not available. People just invested time in the BC changes.

Evaluation and monitoring
Quality assurance is always important. Quality control officers are involved in the education commission (OC) and also in the evaluation of lectures and courses. They are also involved in councils of students from years 1, 2 and 3 to get feedback on education. . If there are serious matters needing direct action, the quality officers take action. They also introduce these matters in their consultation meetings with the director of education.

Implementation – The implementation of the new curriculum

Strategy
At the BC level, two taskforces were introduced at the beginning of the implementation process, where the commitment of the directors of education was stated to be very important. There were 11 workgroups established within these taskforces, dealing with time schedules, time slots, and so forth. The composition of these working groups was intended to be balanced: a proportional distribution of members of different faculties across the groups. The idea behind this was to create some type of bond between different faculties.
The first idea was to have some sort of flexible puzzle, where students were free to choose blocks, consisting of 3 courses, in whatever year they wanted. However, students needed some kind of framework, a skeleton for their curriculum. At that point a framework was constructed, consisting of basic courses, USE courses, compulsory courses and free electives. The same structure was developed for all faculties, in principle.

People involved
The composition of these working groups was intended to be balanced: a proportional distribution of members of different faculties across the groups. The idea behind this was to create some type of bond between different faculties.

The executive director of EE participated in taskforce 1. Another taskforce was 'engineers of the future', joined by the educational director for Physics and the BC secretary.

Catalysts
Faculties had previously been mostly autonomous. One positive effect of the communication within several groups was the bonding of people spread all over the university. The horizontal layer within the BC created bonding. People started learning from each other.

This BC change was the first major change since the introduction of OGO in 1995.

Barriers
There was no extra time reserved for most people involved with the redesign. High workloads arose due to the redesign, for instance, due to the introduction of intermediate examinations, and so forth.

In the beginning the 'what' question was communicated, but not the 'why' question. Lecturers were thinking about the consequences of changing from 3 to 5 EC, not about the need for change.

Communication improved later on, with the assistance of the Communication Expertise Centre. The newsletter was one result of this, but also a kind of road show by the BC dean.
Communication

At the TU/e level, a website was developed for general communication. Results of the processes were mostly communicated to the faculties by their directors of education. Other communication took place through newsletters. Within EE, lecturer lunches were organised, where lecturers dealt with problems and inspired each other to find ways to solve difficulties, for example, by using variation or alternation.

Keeping momentum
Momentum was preserved by introducing the changes over a very short time period of one year. There was a lot of discussion about it, but the rector magnificus required it to be done in this short time. Afterwards, many people thought this was the best way to handle implementation, which otherwise might have been a lingering procedure.

After implementation

Staff satisfaction
According to the director of education, the greatest successes at EE were the number of students entering the program and the improvement in efficiency. The possibility of switching to another faculty in the first semester was experienced as positive.
USE courses were experienced to be substandard. At the moment, the plan is to introduce career policy in the USE courses, together with professional skills. The basic course on Design was a failure and Modeling is going to improve. Applied Physics and Calculus were ok.

The number of first year students grew from about 60 to 250 (2015). Efficiency increased from 2% to 50% (2015).

Monitoring
At the TU/e level, the BC dean must monitor the quality of education. A uniform course evaluation system was developed. The results are presented in a management report and communicated to the BC advisory commission, in which students and lecturers from the faculty education commission participate.

Apart from that, a BC monitoring group, consisting of educational commissioner students from a student association, is consulted twice each quarter by the BC dean and quality control officer. Together with the first year council these sources of information are monitored and reported.

Twice a year these types of evaluation results are communicated with the faculties' directors of education and quality control officers.

No baseline measurements were taken when the BC started. However, there is a database with all kinds of data regarding number of first year students, drop-offs, switchers, number of graduates, number of EC, and so forth. A "BSA report" is produced every year. The database dates back to 2009. Therefore, some comparison with earlier years can be made, but there might be a large number of other factors to take into account, such as the introduction of BSA, the change in examinations, and the like.

Ruth Graham has written an evaluation report about the first 3 years of the BC (Graham, 2015).

There is also a PhD project at Eindhoven School of Education on intermediate exams.

Unforeseen issues
According to the EE director of education, a large problem is the loss of OGO in the compulsory program because of lack of space. It is now an elective and students are choosing it as such.

3TU.CEE

What remains to be done
According to the quality officers, lecturers and students have problems with time-scheduled blocks of 4 hours. No one seems to be interested in or is able to give 4-hour lectures. What to do with these hours? How to deal with this? Within EE, lecturer lunches have been organised, where lecturers deal with these types of problems and inspire each other to find ways to solve difficulties, for example, by using variation or alternation.

The intermediate exams have also introduced a lot of work: 200 exams is a lot for a lecturer to deal with. The problem has mostly been solved by having PhD's help.

A large problem was the loss of OGO in the compulsory programme at EE, because of lack of space. A special group at EE is examining the possibility of getting OGO back into the compulsory programme at EE.

Description of the curriculum change

A skeleton with compulsory and elective courses was developed for the university. A choice of large 5 EC courses instead of 1, 2 or 3 EC courses was made. Some basic courses were introduced, like Calculus, Applied Physics and Design. Apart from that, what are called USE courses were introduced, courses linked to society with arts and social aspects.

Digital learning environment applications were introduced, like EVO (electronically enhanced education) in Calculus and Applied Physics. Physics began by defining the learning objectives in their new basic applied physics course. Within applied physics there was clear alignment between the learning objectives and the actual change in the courses.

The attributes of an engineer were felt to be important in education. About 50% of the courses were fit to those attributes. In that sense, OGO should again become more important in the programs.

The first taskforce began by defining the profile of the future engineer. Its first conclusion was that there is no such thing as *the* engineer profile of the future, but rather a number of types of engineers, with the following characteristics:

- every engineer is multidisciplinary (with knowledge of both technical and non-technical disciplines); has a 'unique selling point' or specialisation; has strong analytical skills and is innovative and solution-oriented;
- the engineer will become more important as a link between technology and society and must be able to work in a globalising world (communication and cooperation);
- completion of the TU/e programme is only the starting point for the engineer, preparing him or her for a career of continuous innovation and development (lifelong learning).

Student engagement and satisfaction

Student engagement
According to a quality officer, centering on the student must be seen more in the individual choices students can make within their curriculum, in terms of the possibilities and supervision the institute offers to make choices possible. Getting students to be active learners was an important aspect within the new BC. Clickers were introduced to get feedback during lectures, and intermediate examinations were introduced to get students to work steadily during the semester.

Student satisfaction
EE is trying to develop a bond with students: in fact, the aim is for students to become enthusiastic about the programme and the social life around it even before they start their course of study. Interactions are very informal. EE even has its own café, the Walhalla, which is open every day. The NSE survey showed EE students to be very satisfied with their environment.

Student support
Students are supported by coaching. Coaches were chosen for their knowledge about the entire curriculum and new coaches were trained to have that knowledge. At the moment, 7 coaches are available. The initiative is with the faculty; students are also invited for individual sessions with matching talks. A pilot was started at EE with alumni coaching. Students welcomed this type of coaching because they have no real idea about the engineering profession. In the 2nd year they have "speed dates" with alumni, mostly by telephone, and reflect on what they got out of that by writing an essay about the engineering profession. In the 3rd year they are coached by professors in preparation for their Master.

Assessment
At some faculties, rubrics are used to give students more feedback than just a grade. Within OGO, students get continuous feedback on their functioning and their professional skills.

Studiability

Studiability of the programme's demands was increased by having fewer parallel courses and examinations. Among other results, this has led to a different, more positive, culture. Students must keep working and stay on top of courses. Tutor groups have been introduced for Mathematics and Physics.

All students must participate in an introductory access examination. Prior to this examination, students can practice the mathematics needed for this test in an "experienced mathness" programme. If students did not pass the examination a remedial programme is available. The results of the introductory examination also indicate the likelihood of successful graduation.

EE quality officers reported that most students choose safe, coherent packets. The result is that the programme has gotten a kind of academic signature. There are a lot of rules, for example, to register for USE courses, to take intermediate exams, and so forth. For students coming right from secondary education it is important to treat them in the type of way they are used to. However, some lecturers, mostly the older ones, think that the students should develop a more academic attitude, right from their start at the university.

Studiability of the programme was increased by having fewer parallel courses and examinations (a maximum of three), as well as a limited number of re-sits. If the students were not successful, despite these measures, they had to start from the beginning with the course and participate in the intermediate exams.The result of these changes is a different, more positive culture. Students are forced to keep working and stay on top of courses.
Faculty and course programme characteristics

Student numbers:
- 2011: 77
- 2014: 110

Student gender:
- 2011: 95% male; 5% female
- 2014: 94% male; 6% female

3TU.CEE

First-year students following the official schedule:
- 2011: Not known
- 2014: 8%.

Drop-out rate in the first year of study:
- 2011: 28%
- 2014: 16%

Switch rate in the first year of study:
- 2011: 3%
- 2014: 11%

Bachelor efficiency:
- 2011: 38%
- 2014: 44%

Appendix E: Case Study of Electrical Engineering at Delft University of Technology

Context

Electrical Engineering (EE) offers a broad Bachelor programme in which all the major elements of EE are addressed. It also offers four Master programmes: Electrical Sustainable Energy; Microelectronics; Signals and Systems; and Telecommunications and Sensing Systems. Additionally, EE participates in a 3TU (3 engineering universities in the Netherlands) Master programme on Embedded Systems. The EE Bachelor diploma also grants access to many other Delft Master courses, such as Mechanical Engineering and Aerospace Engineering. The Bachelor programme attracted approximately 150 first year students in 2013. About 15 percent of the students in EEMCS (Electrical Engineering, Mathematics and Computer Science) are female. The aim of the EE Bachelor programme is to train students towards the final goals of the course of studies as represented in the programme and exam regulation document and to give access to a Master programme offered by the faculty. The final goals of the programme cover the seven academic criteria stated by 3TU, and include an eighth goal: reflection, indicating critical reflection and the ability to study independently. This goal is an extension of goal four, the development of a scientific approach, which represents a scientific attitude and the capacity to be a life-long learner.

The Board of Executives of Delft University of Technology observed university-wide issues with retention rates. It appointed a committee to advise on these issues and to increase the retention rates of the programmes. This committee issued a report titled “Koersen op Studiesucces” (KOS) (Tonino et al., 2011), in English, “Charting the course for student success ”. The faculties were required to implement the committee’s recommendations to increase retention rates and the ‘studiability’ of the programmes. The KOS recommendations covered 4 main topics: a modular curriculum, effective use of class time, assessment and feedback, and the spread of course load. The Board supported this operation by making funds available for teachers involved in the change process so that they could be temporarily relieved of their regular duties. The new curricula were to be implemented in the academic year 2013/2014.

At Delft University of Technology all programmes must adhere to a uniform structure. All Bachelor programmes take three years and offer a minor in the first semester of the third year. This minor can be broadening or deepening, but programmes cannot offer any courses during this semester that are conditional for obtaining the Bachelor diploma. This semester is not available for the programmes to offer their own courses.

The EE programme struggled with declining enrolment numbers at the start of the millennium and started a process for changing the curriculum to attract more students to EE. This new curriculum went into effect in September 2010, a year before the KOS report was published and programmes were required to implement its recommendations. In this case study report we describe both processes, the process for the “first new curriculum” and for the “second new curriculum”, because the innovation process based on KOS was closely related to the previous overhaul.

3TU.CEE

Vision and innovation

Enrolment in EE had been declining since the start of the new millennium, with only 54 students enrolled in the academic year 2005/2006. The programme’s retention rates were relatively low, but the low influx of students was considered the most pressing issue at the time. It was decided that the curriculum needed an overhaul to create a programme that would attract more students. Between 2006 and 2008 a number of initiatives took place, including a study of the attractiveness of the programme, a think tank on renewal of the Bachelor curriculum, and work by the VBO-committee (Federation of Enterprises in Belgium)on new learning goals for the new curriculum. The VBO-committee made some recommendations for the new curriculum. These were:

1. To create projects aimed at integrating knowledge representing the various disciplines of EE;
2. To create a broad programme in which all the disciplines constituting EE are clearly represented; and
3. To improve the alignment between communication about the programme and the actual profile of the programme.

In this process it was decided early on that the programme should continue to focus on the technical and analytical side of electrical engineering. A curriculum committee was appointed and set to work. They identified eight continuing ‘learning lines’ of related courses over the three years of the curriculum that would constitute the programme. These were: mathematics, physics, circuits, signals and systems, computer engineering, telecommunications, electrical energy and projects. They chose to incorporate project-based education as the backbone of the curriculum and the projects were designed to integrate knowledge of the theoretical courses in relevant designs.

The regular courses were left unchanged in format for two reasons: (1) the committee wanted to continue the use of existing high-quality learning materials that were tried, tested and complete, and (2) it was felt to be important to maintain the visibility of the independent elements that together constitute the field of EE. These courses offered knowledge that would be applied in the projects that ran throughout the semester. The committee had put a lot of effort into looking at the order in which topics needed to be offered and at the increasing levels of difficulty and complexity of courses and projects over the duration of the programme. The new curriculum was implemented in 2010/2011 and proved to be successful in attracting more students. Retention rates went up with approximately 10 per cent in that academic year.

When the KOS report was published in late 2011 and the Board of Executives communicated that all programmes needed to comply with the KOS recommendations to increase retention, the staff at EE was initially not amused, as the curriculum overhaul and implementation had been a long and intense process. The curriculum committee was reactivated and they decided the curriculum would be left intact where possible and the objectives and standards of the programme would remain unchanged, but that the KOS report would be taken as an opportunity to fine-tune the curriculum. This was a challenge, because the KOS recommendations did not readily match the structure of the “first new curriculum”.

In EE, first year retention had traditionally been around 50%. Not all the staff in EE considered this a problem and shared the same sense of urgency to try to do something about this issue. The push to increase retention creates a number of dilemmas: some students get off to a bad start or have trouble keeping up with the fast-paced programme, but it is not possible to offer additional activities or to slow down the pace for students who need more time, because students need to finish on time. Lowering standards is not an option, because then students would no longer be eligible for the faculty’s Master programmes. It was felt that the most promising strategy was to help students create realistic expectations for the programme in terms of its content and level and the impact it could have on their lives.

One of the requirements arising from the KOS report was that courses would be scheduled in modules that would take 5 or 10 weeks and that no more than 3 courses could be scheduled in parallel. Within the EE curriculum, this was achieved by reassigning EC to courses and projects and in so doing, creating shorter and more intensive courses and

projects. The projects no longer spanned a semester, but were scheduled in the second half of each semester. That way students could spend more time on their regular courses in the first half of their semesters and had more relevant knowledge for getting started on their projects immediately.

Another goal of the KOS renewal was to create a faculty culture that was more supportive of Bachelor education. There had been a strong focus within the faculty on the graduate level of education, which meant, among other things, that few full professors were involved in the undergraduate programme. It was felt that the full professors should be more engaged and visible in the Bachelor programme, but so far very few professors had taken an active interest in it. According to one of the interviewees, this was partly due to the fact that the Bachelor was in Dutch and most of the professors are not native Dutch speakers. In general, though, professors tended to focus on students who could contribute to their research programmes.

Electrical engineering and engineering education

In this project we identified three attributes specific to engineering education:

1. The inclusion of design activities
2. The use of authentic engineering problems
3. Cross-disciplinarity within and across courses

In Electrical Engineering, design activities are an integral part of the curriculum. There is a team-based design project in each semester and these projects build on the courses that were taught prior to or in parallel with the project. The designs students work on in their projects pertain to authentic electrical engineering problems. The first design students work on, for instance, is the 'booming bass' project. In this project students design a sound system that needs to produce the loudest possible bass sound. The second project is the Smart Robot challenge, in which students work on digital control electronics, sensor technology and design of analogue interface electronics. In the second and third year of the programme teams of students work on the design of a chip and of a self-driving car. These projects incorporate many authentic engineering problems. Most of these projects end in a competition between the teams' prototypes.

All courses in Delft train "T-shaped engineers", which refers to engineers with a broad knowledge base of the basics of their field and a specialisation. Many relevant disciplines and topics are covered in the Electrical Engineering Bachelor programme, including the business and ethical aspects of electrical engineering, which are integrated with the Bachelor capstone project.

Process and strategy

The first new curriculum was the outcome of a long process in which a number of committees were involved. First, a study was conducted to find out why enrolment had declined and what could be done about it. The researchers concluded that students in EE appreciated the programme better as they progressed through it, which is uncommon for many programmes. The outcomes of this study served as input for the Bachelor curriculum renewal committee that calibrated the learning goals of the Bachelor programme and made recommendations for the new programme. They also designed the contours of the new programme and the learning lines. The course design work that followed was taken up by a newly installed curriculum committee. The director of studies shortlisted a number of potential members for this committee and conferred with the director of education and the dean of the faculty on who would be asked to serve on this committee. There were no other formal procedures for selecting or appointing people for these positions. The considerations for selection were whether people had a strong affinity with Bachelor education, were experts in their respective fields and would be able to muster support in their departments for the new curriculum. The committee consisted of senior staff of the EE programme and two full professors of applied computer science and mathematics. All members of this committee were in charge of a learning line, which made the meetings effective in terms of keeping everyone informed and aligned.

3TU.CEE

Within EE all staff have appointments to spend time on research and on teaching, without a clear demarcation of how much time should be spent on which activity. There is no full-time teaching staff. There is no direct relation between time spent on teaching and remuneration of the department. Education-related tasks are financed through the lump sum financial structure of the departments. The director of studies can request people to teach, but it is up to the departments to deliver. This made it quite hard to find the right people to prepare and teach the courses. People in EE are highly committed to education, but over the years it has become less of a priority next to research, at least in part as a result of the financial system in which departments receive relatively little money for their educational activities. This gives research and grant writing precedence over teaching activities.

All members of the curriculum committee adopted a learning line and created learning line committees: teams of teachers who worked on the development of the courses that were part of that particular learning line. These processes were largely decentralised: the members of the curriculum committee had much freedom to work with their teams. These learning lines included complex topics; few people can oversee these topics in the way necessary for designing courses that incorporate all the important elements and span multiple years. This complexity could be addressed effectively within the learning line committees.

The learning line teams reported to the director of studies, who functioned as the information nexus of the overhaul: this person maintained oversight of all related activities and the development of the learning lines, and he coordinated logistics of information, scheduling, and so forth. The plans were pitched and presented regularly on various occasions, such as the faculty's annual Education Day and at some designated lunch meetings, but also to the extended education management team.

When the first new curriculum was implemented in September 2010, the curriculum committee was disbanded. It was reassembled when the KOS report was published a year later. At that time some members stayed on, while others were no longer available and were replaced, including the student members. The committee started its work in early 2012 and operated the same way they had done in the first new curriculum. It turned out to be quite difficult to tweak the old curriculum to fit the KOS requirements, given the logistic constraints and content of the EE programme. The committee proposed the outlines of a new curriculum in May 2012. This plan was far from perfect, but it was the best the committee could come up with at the time. The plan was not approved by the Board of the university, because it did not comply with all the recommendations of the KOS report. The committee decided not to push the plan, but to continue to improve it so they could be sure that the new curriculum would address the issues pertaining to retention effectively enough. In practice, this meant that the new curriculum would not be implemented in September 2013, as required by the Board of Executives, but in September 2014.

With the support of the dean, the curriculum committee looked for an external expert for advice, and found this person in prof. Albert Pilot. He made an analysis of the first new curriculum with regard to studiability and retention in the autumn of 2012. The outcomes of his analysis changed the game, as the curriculum committee started to re-evaluate the educational logistics under which they were operating. At that point it all just fell into place: some of the lab sessions that were part of the projects would become part of the courses that fed into the projects. That way, students could gain hands-on experience in the lab in the first education period in a more structured way than before, as the link with the courses was more clear. Students could get a head start on the project, because they would have mastered the necessary basic skills and knowledge. As soon as the new structure fell into place, the other matters followed quickly. Suddenly it was clear how the courses needed to be redesigned, what mathematics should be offered when, that all intermediate exams would be voluntary, and that there would be a universal rule as to how the results for these exams would contribute to the final grades, for subjects where students could sit partial exams during the term rather than a final exam at the end of the term.

One consequence of postponing the implementation of the new programme was that the schedule became tighter. The director of studies and the curriculum committee were confident that everything would be finished in time, but the

faculty's education management team, consisting of the dean and the faculty's director of education, were getting doubtful at some point. Everything needed to be ready by late 2013 or early 2014 at the latest for the new curriculum to be implemented in September of that year. This tight schedulerequired the director of studies to develop a plan for how to move forward and to report on short-term goals while the new curriculum was being developed. This generated extra work for the director of studies, which at the time was a nuisance, but in the end did not create any problems.

The curriculum committee decided to implement some recommendations of the KOS report in September 2013 as "quick wins". They implemented a new schedule for resitting exams: resits were scheduled as soon after the exam as possible.I It was quickly found that this schedule created problems. It created a lot of tension for students who had to do a resit, as studying took away time from the courses in the new term. In the "new new curriculum" that went into effect in September 2014, the resit exams for the first term were scheduled in the week after the Christmas break. The resits for all other courses were scheduled over the summer break. This way, the resits would not compete for the students' attention during the terms, as they had in the previous situation. A major change was also that students would have time one day a week for independent study. In the previous situation, students had complained about the fragmentation of their time for independent study due to the large number of contact hours. In the new curriculum there would not be any teaching activities on Wednesdays.

One member of the curriculum committee also chaired the faculty's 'opleidingscommissie', or 'programme committee', which represents the body of teachers and students and has an important advisory role in curriculum matters. At the time, the opleidingscommissie was not functioning effectively as an advisory board for curriculum matters. The curriculum committee received almost no feedback on its plans from the programme committee. At the end of 2013, the committee was revitalised by the appointment of a new chair. Around that time, the curriculum design had been completed, and input from the revitalised opleidingscommissie could no longer be processed. The opleidingscommissie was charged, however, to give advice on the implementation of this new curriculum about which they had had little to say. The way things went was regretted by both sides, but it was a consequence of how things played out at the time.

One of the goals of the process was to change the faculty's culture regarding their engagement in the Bachelor programme. The second curriculum committee included two full professors, but few professors were involved in the Bachelor programme. One of the interviewees said that it was uncommon for professors to discuss Bachelor education matters; if they discussed education, it would usually be about the Master programme. The full professors tended to be selected for their positions based on their research merits, and Master students contribute through research and are potential PhD-candidates. When the blueprint of the new curriculum was finalised, the learning lines and courses needed to be redeveloped. The director of studies and the dean asked a number of full professors in the field of each learning line to coordinate and oversee this process. This was not an easy process, partly because the professors had not had very active involvement in the development of the curriculum, partly because this kind of responsibility was new to some and because such responsibilities do not fit well within the professors' portfolios of research-related activities. Some of the professors were not very happy with the new programme. One of the interviewees stated that he worried that the overall level was too low and that students had too few opportunities to gain in-depth knowledge of the field, especially when compared to undergraduate programmes at other top universities in the world. It took time for this set-up to work; in some cases it worked out, in others it did not. After the courses and learning lines were designed, the position of learning line coordinator was not continued.

Quality control

The education and student affairs office was understaffed during the process of curriculum redesign. As a result, this office had only little involvement in the process. The quality control officer within EEMCS was not explicitly involved in the development of the new curriculum, but the quality control procedures for all programmes in the faculty were overhauled during the same period of time, to go full circle. An online tool, Eva-Tool, was developed to manage the quality control processes within the faculty and to create more transparency. The tool enables officers to manage

3TU.CEE

evaluation outcomes and reports, to send results to teachers and to log their response and improvement plans. The quality control officer and director of education of a particular programme go through the teacher responses and advise the teacher on further improvement if necessary. The course evaluations are posted online so students have access to them. Courses are evaluated independently, but the officer organises 'college responsie groepen' or CRGs, student meetings where each education period is discussed as a whole. Those who taught courses during that period are invited to attend. The reports of these meetings are also sent to those who taught during that particular period.

Quality control was involved in monitoring the implementation phase of the new curriculum. All EE students were asked to fill out a small number of surveys anonymously during the academic year. The outcomes were discussed in a CRG, but only very motivated students tend to participate in those kinds of meetings. Overall the students were positive about their programme and the courses.

Documentation and communication

There was a lot of documentation of the curriculum change process, but not everything was shared outside the curriculum committee. There are few channels for communication in the faculty; for instance, there is no digital newsletter on current education issues in the faculty. The curriculum committee was organised such that members conferred with their departments and colleagues to get input and to muster support. There were presentations at 'town hall meetings' that were organised during lunch a few times and at the faculty's Education Day. The director of studies tried to use the opportunities for communication present in the faculty as much as possible, but also looked for ways to get feedback on milestones or deliverables.

Members of the curriculum committee communicated informally with the colleagues in their departments about the plans and to ask for input. Most communication about the curriculum change was done by the director of education, who conferred with the dean and management and support services about the plans and their implementation.
The idea behind this was that if more people were involved in communication, it would lead to fragmentation. Additionally, the committee members could focus all their attention on the content of the programme and the courses.

Implementation, monitoring and points of special interest

Another issue pertained to the implementation of the new curriculum for the older students. The second-year students were given the transition rules in advance and had conversations with staff about how they would fit into the new programme, but they still ran into all kinds of problems with the setup of the new curriculum. One pressing issue had to do with the fact that participation in a lab was an entry requirement for a project, and that in the new curriculum the lab could be done without taking the class that was offered in conjunction with it. Students could not do anything meaningful in the lab as a result, but still technically qualified for the project. Obviously they did not gain the knowledge and skills necessary for successful completion of the project. These relatively small issues had major implications for the current student body.

In Electrical Engineering, the curriculum committee chose to stick with disciplinary courses rather than fully integrated modules for the reasons stated above. Ensuring cross-disciplinarity and interdisciplinarity in the courses, however, requires work on the teachers' side. One of the interviewees stated that while this was important, it was not always easy to continue to focus on cross-disciplinarity and interdisciplinarity while preparing lectures and assignments. Active collaboration with fellow teachers takes time and planning, and this added to an already full workload. This was considered to pose a risk to the connections between subjects and the coherence of the curriculum by the interviewee. A related issue was the position of full professors acting as learning line coordinators: at first these were temporary positions. After the learning lines and courses had been developed, there was no one who protected the range of ideas and collective notions behind the learning lines. In practice, this meant that the learning lines started disintegrating after implementation. This issue was recognised by the education management, and the learning line coordinatorships are being reinstated to ensure coherence and continuity within the learning lines.

Results

Student satisfaction

As part of the overall monitoring of the implementation, a study was done during this year to monitor the implementation from the students' perspective. Participation was on a voluntary basis and it was anonymous, so it is unknown whether the data are representative. A survey was held after the first four weeks of the first year. The participants were enthusiastic about the programme: 60% gave the programme an 8 out of 10. They found their courses relevant, interesting and stimulating. They appreciated the learning environment and the atmosphere in the faculty; however, students observed that the pressure of the courses was very high and the pace was very rapid. In a group interview that was organised to discuss the survey outcomes, at least 25% of the participating students admitted that they were already behind and had trouble catching up. They attributed this to their own lack of discipline: most of these students had had an easy time at pre-university education and were not used to having to keep up with their coursework. Not all courses were paced similarly, with some progressing much faster than others. The lab work required for some of the courses was not taught in tandem with the topics covered in the labs. This needed fine-tuning.

Students informed the staff that more information on how tough the programme is would not have helped them. They felt they knew it would be tough and more information on this topic would have been counterproductive. According to the National Student Survey (NSE) (Studiekeuze123, n.d.), overall satisfaction with the programme is high: students gave 4.1 out of 5 on average for the programme as a whole. Atmosphere, group size, rostering and study environment scored high, while availability of information and course load scored relatively low, but still above average.

Student success

In 2014/2015 many changes were made in the curriculum, but the rules and regulations of the university also changed. Since 2013/2014, Dutch universities are allowed to require more from incoming students in addition to the pre-university diploma. Delft University of Technology implemented an online questionnaire that students must complete. Their answers are used to give them personalised feedback on their choice of study. This requirement is not binding and currently universities cannot refuse students based on participation or on the estimation of how well students will do; however, initial results are promising all the same. A major part of the personalised feedback is based on the grades students obtained for mathematics and physics in pre-university education. In the first year it turned out that of the students who had obtained a 6 out of 10 for mathematics, only 30% received a positive BSA recommendation for continuation after the first year, which is binding. Of the students with a 7 out of 10 for mathematics or higher, 60% obtained positive BSA recommendations. Of the students who did not participate in the survey or who enrolled after the official due date, 65% left the programme in the first semester. To take this personalised feedback a little further, the programme ran a pilot to support students in making their decision to study electrical engineering. All students who enrolled in the programme received an invitation for a day with the faculty, for which they prepared homework. On the day itself, students heard lectures and participated in a work group on topics on electrical engineering and mathematics. At the end of the day they took a small test and had a 10-minute interview with a staff member regarding their experiences and their beliefs about what it would take for them to study at EE. Staff and students were quite happy with these faculty days: the feedback was positive and they found that students were willing to reflect on what studying at EE would mean for them at the end of the day. Teachers who are involved in the organisation of these days believe that the combination of having to do homework, participating in a mathematics working group and taking a test shows whether students are willing and able to 'do the mathematics', that is, if students are willing to grapple with calculations. This is considered to be important for students in EE, as the teachers view it as an effective behaviour for student success. Initial results for student progress were promising. Students who participated in these faculty days obtained more EC in their first year than the students who had not attended.

3TU.CEE

Pass rates in the first semester were very favourable. For example, the pass rate in the first education periods of the linear circuit course was higher than in previous years, while the course load increased. In the first education period, the pass rates for mathematics were also slightly higher. The big change is seen in the second term: the pass rates nearly doubled, and the percentage of students who passed all their courses in one go also increased slightly. Further, it showed that students who pass the first project tend to do very well in the first year. Another sign of success was that almost all drop-out took place in the first semester. This is positive, as students who leave early on are more successful in transferring into other programmes compared to students who postpone the decision to leave even if they are not doing well. Overall, however, the pass rates for the learning tracks, such as the mathematics track and the circuit track, and the rates for positive BSA were comparable to previous years. What changed was a decrease in the number of students with between 25 and 44 EC. A large number of students obtained very few or no EC. At the same time, an increased proportion of the students passed their exams on the first try and the number of students who obtained their propaedeutic (first year) diploma in a year increased to 36%, while the proportion of students passing their exams in a second or third try decreased. Still, out of 21 students who had not yet fulfilled the BSA requirement before the summer, 14 obtained at least 45 EC. This is interpreted to indicate that the studiability of the programme is quite high: students who put in the required effort and pass in one go, continue to be successful. One of the interviewees said that he observed that students who had at least moderate capability and who were motivated to work hard and do the mathematics, usually did well in the programme. Of the students who stuck around, many seemed to be able to make up their failed exams in the summer. This is most likely an indicator that students realise early on that the content or level are not for them and that they are not going to hang around to try, but also that students who do well, continue to do well. In addition it is a sign that the first year is selective, as there are very few students in the EC bracket at just under 45 EC. The average number of EC obtained in the first year of EE is given in Table 13, but these numbers include the students who switched away from the programme in their first year. The next challenge is to make sure that students continue to do well and to find out what the programme can do to stimulate the students who are not off to a good start and help them become successful students in EE, too.

Table 11: Binding recommendations for continuation of studies at TU Delft overall, and in the faculties of Electrical Engineering, Mathematics, Computer Science and Electrical Engineering

	TU Delft	Electrical Engineering, Mathematics, Computer Science (EWI)	Electrical Engineering (EE)
2013-2014			
Positive	60.5%	54.4%	49.1%
Total negative + on hold + stopped	39.5%	45.6%	50.9%
Negative	19.7%	21.4%	18.8%
On hold	4.1%	1.0%	0.6%
Stopped	15.6%	23.3%	31.5%
	100.0%	100.0%	100.0%
2012-2013	**TU Delft**	**EWI**	**EE**
Positive	63.9%	53.5%	50.0%
Total negative + on hold + stopped	36.1%	46.5%	50.0%
Negative	18.7%	22.5%	22.6%
On hold	3.5%	4.9%	1.4%
Stopped	14.0%	19.1%	26.0%
	100.0%	100.0%	100.0%
2011-2012	**TU Delft**	**EWI**	**EE**
Positive	69.2%	59.3%	52.1%
Total negative + on hold + stopped	30.8%	40.7%	47.9%
Negative	18.7%	25.9%	29.2%
On hold	1.5%	1.5%	2.1%
Stopped	10.5%	13.3%	16.7%
	100.0%	100.0%	100.0%
2010-2011	**TU Delft**	**EWI**	**EE**
Positive	68.4%	63.7%	61.5%
Total negative + on hold + stopped	31.6%	36.2%	38.5%
Negative	18.3%	23.2%	26.0%
On hold	3.4%	3.5%	2.1%
Stopped	9.9%	9.5%	10.4%
	100.0%	99.9%	100.0%

[1] This was a financial penalty for students taking longer than the standard duration of their programme to graduate.

Table 12: Average number of EC obtained by first year students in EE at TU Delft

Year	# students	Education period				
		1	2	3	4	resits
2010	88	3	10	21	34	36
2011	91	3	9	20	31	32
2012	137	3	11	20	32	34
2013	140	4	10	18	27	31
2014	140	5	16	NA	NA	NA

These numbers include students who switched out of the programme.

Appendix F: Case Study of Architecture and the Built Environment at Delft University of Technology

Context: attributes of the faculty

The faculty of Architecture and the Built Environment offers a broad Bachelor programme and a Master programme in Architecture, Urbanism & Building Sciences (consisting of five separate tracks: Architecture, Urbanism, Real Estate & Housing, Building Technology and Landscape Architecture), and a Master programme on Geomatics for the Built Environment. There has traditionally been a strong emphasis on education in the faculty. There is an annual enrolment of approximately 300 BSc students and 500 MSc students. Between 2011 and 2013 a restriction to the number of students was in place in the Bachelor programme. Approximately 40% of the Bachelor students are female. The Bachelor programme of Architecture and the Built Environment trains all-around building engineers who fulfil the 3TU academic criteria and meet the 23 programme-specific final learning goals that are described in the education and exam regulations document of the programme.

The TU Delft Board of Executives observed high university-wide attrition rates and appointed a special committee to advise on measures to improve this situation. The committee issued a report titled "Koersen op Studiesucces", in English "Charting a course for student success" in late 2011. The university faculties were given the task of implementing the advice of the committee in their own programmes and in so doing, increasing the studiability of these programmes for students. The advice from the "Koersen op Studiesucces" (KOS) report included four main topics: a modular curriculum, more effective use of contact hours, feedback and assessment, and a better spread of the course load. The Board of Executives supported this operation by making funds available for hiring temporary staff to perform the regular duties of teachers who were involved in overhauling the curriculum, so they could focus on the renewal process.

There is a uniform structure within TU Delft for the three-year Bachelor curricula, which all offer minor programmes in the first semester of the third year. These can be focused on broadening students' training, or helping students specialise within their programmes. This means that programmes 'lose' this term, as they cannot offer instruction that is required for graduation during this term.

Vision and renewal: reasons for change

By 2005, the Bachelor programme in Architecture and the Built Environment came in last in terms of retention. Teachers regularly felt the consequences of the low studiability of the programme, such as students procrastinating and large numbers of students resitting the exams. A new dean was installed in 2011; she attached importance to improving retention rates and identified three focal points: professionalisation of the staff, assessment policy, and improving the studiability of the Bachelor programme by removing barriers within the programme.

3TU.CEE

The most pressing issues

The curriculum at the time had a number of issues: the design projects were set up in such a way that students spent too much time on them and this took away time they should have been spending on other courses. The programme was fragmented: there were many courses with a small number of EC that were taught in parallel. As a result, there were many exams and resits scheduled in the same timeframe. In general, there was a student culture in which procrastination was very common. The programme also had a number of strengths: there was a lot of attention to designing and the staff was engaged with Bachelor education, from adjuncts to full professors.

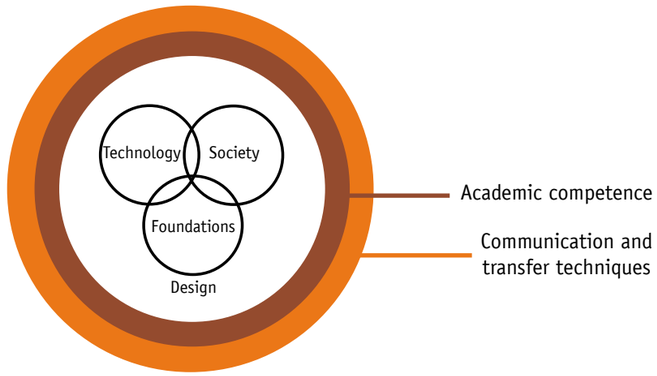
Description of the new programme

Early on in the renewal process, the decision was made to leave the final programme objectives intact. The structure of the programme was overhauled: the backbone of the new programme was formed by six 'learning lines' within which courses would be offered in a fully integrated manner. Learning to design was the main focus of all other learning lines. Additionally the decision was made that there should be a variety of formats for education and assessment. To facilitate and support this change process, a tailored programme for obtaining the university teaching qualification (UTQ) was offered to the staff. Another decision that had a lot of impact was to change the entire three-year curriculum in one go, so that the new curriculum would be in force on September 1st, 2013. Early in the process, a set of transitional measures was drawn up in close collaboration with the student representatives in the faculty: the student association and the student group in the faculty council. These transitional measures were communicated to the students even before the new programme was designed. This created urgency for the management team; having communicated these arrangements there was no way to back out, and the new curriculum had to be implemented on September 1st. The train had left the station and the entire faculty had to join in on the action.

Besides improving the programme's studiability the faculty had a number of content related goals: [1] to update the programme, such as addressing current and future design challenges in the area of redevelopment and transformation; [2] to increase the academic level of the programme ('learning line' on academic competence); [3] to remove overlap between courses, such as the overlap between foundations of architecture, foundations of urban development and history of architecture.

Early in the development of the new curriculum, the director of education came up with a rationale for the new programme: six content-based 'learning lines' that were comprised of related courses over the three years of the Bachelor programme. This rationale is represented in Figure 2. The core competency in this curriculum is design (60 EC, comprising 6 design projects). Achievement of a good design requires a strong background in building technology (25 EC), society (20 EC) and foundations of architecture and the built environment (15 EC). Academic and research competences (15 EC) are skills required for designing, and a building engineer also needs to be able to communicate his or her designs to others (15 EC).

Figure 2: Curriculum concept for BSc Architecture and the Built Environment: six 'learning lines' at TU Delft.



The learning lines consist of modules in which relevant topics are offered in an integrated manner. A number of starting points were defined: students need to work on integral assignments that combine knowledge from courses (from the old curriculum) that feed into the design project, there would be fewer partial grades awarded, and all relevant topics should be addressed during the terms in which a module is offered. That means that the foundations module would not consist of three weeks of history, three weeks of foundations of urban development and three weeks of something else, but that the topics would be addressed in combination every week. Every semester contained a design project and the topic of the design project led the choice of modules in that semester. The topics range from the design of a small house in an environment to the design of a metropolis.

The academic year is divided into four terms. The uneven numbered terms consist of 5-credit modules that take 5 or 10 weeks. There are always two modules scheduled in parallel: one module of 10 weeks and two modules of 5 weeks are offered in every uneven numbered term. The 10-credit design projects are scheduled in the even numbered terms. These are organised slightly differently so the students have plenty of time at the end of the semester to work on their projects. In practice, the students had spent most of their time and energy on their design projects, which competed with the other courses. This is taken care of in the new curriculum.

Architecture and the Build Environment and Engineering Education

The programme's design fits well with the starting points of engineering education. Design plays a pivotal role in the programme, with the second half of each semester devoted to design. The focus of the initial design projects is on small-scale design projects such as a simple house in a certain environment, and develops into complex design challenges with a strong focus on integration of a multitude of aspects of building engineering, such as the redevelopment plan for an area in the third year project. These projects consist of authentic building engineering projects, because all the relevant elements of the design process come into play: as integrated technical issues in a societal context in which economic, judicial and political aspects need to be considered as part of the design. The other modules adhere to this principle too. Many modules draw on the canon of 200 designs that was compiled by the faculty, which also included failed designs. The module coordinators and education management stress the importance of integrated assignments that incorporate knowledge and skills from the disciplines that feed into a module in a balanced way. Some coordinators also make sure that exam questions are integrated and draw on knowledge from multiple supplying disciplines. It is felt that this creates and ensures the authenticity of the questions students are confronted with. The final objectives of the programme were left unchanged in this process of overhaul and the programme still supports the training of broad T-shaped engineers who can specialise after obtaining their Bachelor degree.

Process and strategy

The problem owners and staff involved in the process

The new dean who was installed in 2011 was sensitive to the issues related to retention and graduation. With her consent, the director of education and the head of the education and student affairs office laid the foundations for the new programme in the academic year of 2011/2012. It was clear that the programme was difficult for students to manage and this had a negative influence on students' rates of progress in the programme. When the new dean was appointed there was an opportunity to get these issues on the agenda of the highest level of management in the faculty. The head of the education and student affairs office was part of the committee that eventually published the 'Koersen op Studiesucces' report. The input from this committee generated a lot for him to consider. In addition to the inventory of known issues, a survey of the teaching staff was done to find out what other issues people experienced with the curriculum. Next, a small committee was appointed to formulate the starting points for the new curriculum. This committee came up with the outline presented in Figure 2. The higher level of management approved the plans. Through a change in personnel a new director of education and programme coordinator took on their responsibilities in 2012 and they continued to design the new programme and the process of its implementation.

In the continuation of this process, the learning lines were further construed under supervision of an external advisor who worked for the education support office of TU Delft. This advisor collaborated closely with the head of the education and student affairs office and the new Bachelor programme coordinator. The outlines of the learning lines were laid out in a document that, in turn, served as the basis for the learning line coordinators and the module coordinators. In some cases, the same person fulfilled both of these roles.

The module and learning line coordinators were carefully selected based on interviews. Attention was paid to their ideas on education and innovation, their ability for teamwork and which departments they represented. The integration of courses that were strongly related to single disciplines into new interdisciplinary modules implied that many decisions needed to be made regarding the content, and the management team deemed it of utmost importance that team members would be able to be one another's critical friends, but also to compromise if necessary. All coordinators were appointed by the dean, who gave them a mandate to act according to what they believed was necessary, without having to ask permission from the dean or wider community. They were accountable only to the Bachelor Education Steering Committee, which consisted of the dean, the director of education, the Bachelor programme coordinator and the head of the education and student affairs office. This steering committee supported the module and learning line coordinators whenever and wherever requested.

A number of the coordinators were preparing to obtain their university teaching qualifications (UTQ) in the same timeframe. They were offered a tailor-made programme in which the plans and curricula they were developing served as the backbone of their UTQ portfolios. In practice this had several advantages: all of the meetings were prepared by an education specialist who gave feedback on the quality of the plans, and the coordinators were well informed about the work others were doing. This made it much easier to harmonise their plans. Most teams collaborated well, although some teams had some issues with putting together a curriculum. This mainly occurred when team members represented departments and disciplines that had little or no experience in collaboration or if the number of EC for a subject had changed a lot. People within some learning lines had a history of working together, for instance, if they had collaborated previously or because they were part of the same department. In other learning lines people represented different departments and traditions in teaching and learning, and relationships needed to be established before they could sit down together and work on the learning line or module. Eventually these teams managed to come up with thorough plans for internally consistent units of education, in spite of tensions and internal differences.

The setup for the exams posed an extra challenge. One of the guidelines from the steering committee was that there should be more variety in how students would be assessed, partial grades should be avoided and that subjects taught in the modules should be tested integrally. The topics representing different disciplines were to be addressed in a connected way in exam papers, so the teams needed to come up with exam questions with plenty of depth to test whether students had sufficient knowledge of all of the separate disciplines, but were also able to transcend the boundaries of these disciplines. For all the non-design modules the TU Delft-wide guideline was to organise 1 summative test per 2.5 EC awarded, be it an exam, test, paper or assignment.

The order in which subjects were offered was a major topic of discussion, partly because there were some strong ideas on what the preferred order should be and partly because the design modules led the curriculum design. For the first year, this meant that statics and mechanics of materials had to be offered early on in the first semester, as students would draw from this knowledge in their first design assignment in the second term of the year, when they would design load-bearing constructions and climate installations. In the end, it was decided to teach the rudimentary building blocks of mechanics in the first term and to teach these concepts again, but in more depth, in the third term of the first year.

The learning line coordinator for design had been given an additional assignment: in the old curriculum there was no standard form for assessing the design assignments. As a result, the assessment criteria were unclear, creating a lot of insecurity and stress for the students. A uniform assessment procedure and criteria were badly needed. The

coordinator for design collaborated closely with the design module coordinators and was able to come up with criteria and a procedure in a short time. One design module coordinator did not want to work with the criteria because it was felt that they did not fully apply to that specific module, but this will change in due time, so that all the design modules are assessed in the same way. This will also help students to take note of their own development and growth as designers.

Quality control: evaluation and monitoring

The quality control department was involved in the project early on. One of the problems with the old curriculum was that it was organised in such way that it was hard to hold teachers accountable if course evaluations showed disappointing results. The course evaluation system also needed to be reviewed in the new curriculum. This concerned how data were collected, how results were communicated to teachers and students and how teachers were expected to deal with the information. It was decided that in the new situation, terms would be evaluated as a whole, rather than the individual modules. Students would have to complete fewer surveys and it would be easier to identify peaks in overall courseload. The quality control officer drew up a procedure for what was expected from teachers based on the evaluation outcomes: the evaluation would be the topic of term meetings with the module and learning line coordinators involved in the term, the Bachelor programme coordinator, the head of the education and student affairs office and the quality control officer. Based on the meeting, the coordinators work on action plans for improvement, which are published so that students and staff can follow up on what happened with their feedback. Additionally, students are asked to participate in timesheet research, to find out if students are spending enough time on their studies and if there are still peaks in courseload during the terms.

Documentation and communication

There has been no specific plan for communication, but the management organised all types of activities for communication with the wider community at strategic points during the change process. When the first outline of the programme was developed in the autumn of 2011, the director of education presented the plans to the staff. After that, a number of documents were drawn up that played an important role in the process later on. Halfway through 2012, the document with the sketches of the learning lines was presented. This served as the starting point and guiding document for the module teams. This document contained a lot of information on how the modules and learning lines would be organised. In the spring of 2013, the vision for the Bachelor programme was published by the Bachelor programme coordinator. This document contained an elaboration of the educational philosophy and its meaning for the new curriculum, which roles were identified for whom, and which bodies and councils would exist to confer and decide on education issues. During this entire process there was a lot of email exchange and discussion between the Bachelor programme coordinator, the head of the education and student affairs office and the module and learning line coordinators.

In general, the staff interviewed for this study was satisfied with the entire overhaul operation. This is partly because they had relatively great freedom in acting as they deemed fit, because they could confer with their colleagues informally, for example, within the UTQ programme, and because those involved had existing networks and could meet other stakeholders in a natural way on a regular basis, for instance, because their office space was nearby. The head of the education and student affairs office attributed a large part of the success to human resource management within the faculty: “If you want to do something complex, you have to keep it simple and you have to make sure you have the right people in the right positions. You have to make decisions that help make things simple, such as by creating a clear framework and by giving mandates that facilitate the decision-making processes.”

None of the staff interviewed used the option of hiring additional staff to take over their regular duties and responsibilities. The problem with this policy was that it is hard to have someone else do your work, because there are very few people who could actually do that without needing a lot of instruction or supervision. Helping

new colleagues find their feet in this line of work takes a disproportionate amount of time. For all involved in the overhaul, the process took a lot of extra work.

Implementation, monitoring and areas of concern

The implementation of the new programme went down well. In the early stages of the new programme, staff, coordinators and officers from quality control and rostering conferred together a lot. A module coordinator for a module that had presented some difficulties attended all of the lectures the first time the module was taught. This took an enormous amount of time, but proved to be very valuable. For all the teachers involved, this was their first experience of collaborating so closely within a team of fellow teachers. The coordinator could ensure that the agreements were honoured and that alignment between the different elements of the module was maintained. This created many possibilities for continuing the conversation with the teachers of the module.

The transitional measures had been communicated in an early stage of the overhaul and the individual exam programmes for students had already been set up long before the change went into effect. Unfortunately, this failed to make the transition painless for the second year students, who encountered a lot of trouble with the new programme. In some cases they did not have the necessary prior knowledge to participate effectively in the new modules and some of the modules still had bugs. The steering group recognised in retrospect that there was a lot of room for improvement in the transitional measures. The transition for the first and third year students was quite smooth and went according to plan.

Another issue that was not given enough consideration in the preparatory stage of the process was the policy on resitting exams. No guidelines had been given for the resits, so the coordinators took it upon themselves to schedule resit exams. However, coordinators did not consult with the coordinators for the next term, and eventually some of the resit exams competed with deadlines from the new modules. Teachers were unhappy with this situation, but so were the students who had to retake exams, because it created a large peak in courseload. The schedule is such that terms are back to back: the exam is scheduled in the final week of a term and after the weekend the new term starts. Students have only a very brief breathing space. The solution for the makeup work worked well for the design modules. Students who need to do additional work on their design assignments must turn this in before some date in August. During the summer break they can participate in design workshops where there is space, support and supervision to finish the work. The education and student affairs office has concerned itself with finding a solution for the resitting exams situation and is looking for real solutions that do not compete with the regular programme.

A final area of concern that was mentioned in the interviews was issues pertaining to the extent to which the programme can be organised and taught. These two topics were not a concern in the framework of the new curriculum. These were issues to be addressed by the coordinators; however, within the faculty of Architecture and the Built Environment there is a fairly large group of staff with an appointment as ‘teacher’, which means that they should be involved in teaching every term. In the current curriculum this is a challenge, as the topics of the design modules lead the content of what is taught. The availability of teachers was never taken as a design specification, and some teachers have too little to do in some of the terms. The contrary goes for adjunct teachers: if everything needs to happen at the same time, there is no time to train adjuncts or for them to supervise all the groups of students effectively.

Results

Student satisfaction

Monitoring by the quality control officer has gone according to plan and it has generally been found satisfactory. There is a simple system to find out what is going right and what is going wrong. The point of departure is that all modules should score at least 7 out of 10. In the first year this did not happen for all the modules, because some

of them simply did not work out according to plan. In general, the modules tended to score high in the course evaluations: on average, the new modules scored half to a full point more than the courses in the old curriculum. Even a computer-supported module that used to score very low was given over 7 out of 10 in the new situation. This is considered to be an incredible achievement by the teachers involved. So far, where there are disappointing evaluation results, there are clear underlying reasons that can be worked on and resolved.

A group of students participated in timesheet research. The initial results of that research effort show that the students spend approximately 40 hours a week on their studies. That is exceedingly more than in the old curriculum. The pass rates for the modules are quite high and the staff interviewed observed that the students in general have responded very well to the way the programme is organised. One of the interviewees mentioned that he is wondering if the connections between the subjects covered in the new curriculum are clearer now than they used to be.

Student success

Overall, the retention rates in the Architecture and the Built Environment Bachelor programme are improving. The retention rates were the starting point for the overhaul, but shortly into the design process for the new curriculum, no one mentioned retention rates any more. What needs to be reported here is that the binding study advice (BSA) threshold was raised from 30 (50%) to 45 (75%) EC in the first year in 2012. There was a restriction to the number of students in place in the academic years of 2011/2012 and 2012/2013, and decentralised selection was chosen as the means to select which students were admitted and which were not. In 2012 there was a brief period in which the 'langstudeer boete[1]' was in place, which led to a national political debate on the future (or lack thereof) of the student loan system. These measures undoubtedly influenced the students' retention rates and study pace. As a result, it is difficult to attribute the improvements in retention to the curriculum change. However, the first results for important indicators of success, such as the BSA pass rates and the Bachelor-in-4 graduation rates are more than promising, as is shown below in Tables 14 and 15.

Table 13: BSA pass rates at TU Delft overall and for the Faculty of Architecture and the Built Environment

	TU Delft	Architecture and Built environment (A)
2013-2014		
Positive	60.5%	78.1%
Total negative + on hold + stopped	39.5%	21.9%
Negative	19.7%	9.0%
On hold	4.1%	5.1%
Stopped	15.6%	7.8%
	100.0%	100.0%
2012-2013	**TU Delft**	**A**
Positive	63.9%	73.4%
Total negative + on hold + stopped	36.1%	26.6%
Negative	18.7%	12.9%
On hold	3.5%	2.8%
Stopped	14.0%	10.8%
	100.0%	100.0%
2011-2012	**TU Delft**	**A**
Positive	69.2%	85.1%
Total negative + on hold + stopped	30.8%	14.9%
Negative	18.7%	5.9%
On hold	1.5%	0.7%
Stopped	10.5%	8.3%
	100.0%	100.0%
2010-2011	**TU Delft**	**A**
Positive	68.4%	69.7%
Total negative + on hold + stopped	31.6%	30.2%
Negative	18.3%	14.1%
On hold	3.4%	3.3%
Stopped	9.9%	12.8%
	100.0%	99.9%

Table 14: Average number of EC obtained by Bachelor students in Architecture and the Built Environment at TU Delft.

	Number of students	Exam period				
		1	2	3	4	resit
2009	582	8	21	29	40	41
2010	501	6	20	29	39	41
2011	399	7	21	34	42	47
2012	273	5	21	33	43	48
2013	246	4	25	32	42	48
2014	271	7	23	NA	NA	NA

These numbers include students who switched their studies.

3TU.CEE

Appendix G: Case Study of Built Environment at Eindhoven University of Technology

Short description of the programme

(Taskforce Redesign Ba-curriculum, 2001; Meijers & Brok, 2013)
The redesign took the form of an integrated set of measures that would contribute to getting this change in mentality underway:

A. ***Structure:*** the TU/e Bachelor's programme offers a structure in which each student can follow his own unique path.
   a. A path of 180 EC is made up of four overlapping components: (i) a common general component (30 EC); (ii) a major (90 EC); (iii) elective subjects (60 EC); and throughout the path, (iv) a substantial component of social sciences and humanities (25 EC).
   b. Differentiation of levels: Three different levels will be distinguished for performance in all components of the course of study, and a minimum number of components will need to be passed at the highest level in order to achieve the BSc diploma.

B. ***Coaching:*** Bachelor's students will receive coaching, starting from their preliminary registration (intake) and continuing up until their choice of a Master's. Besides academic counseling, they will also receive personal development (and planning) counseling and supervision in the development of a personal identity as a Bachelor of Science.

C. The ***studiability*** of the programme of study was increased by:
   a. clearly structured blocks with a maximum of 3 parallel subjects (of which only one can be a project or design based learningsubject), thus providing more extensive modules that are all the same size;
   b. more independent study, fewer contact hours and more assignments per subject, facilitated by providing more on-campus workspaces;
   c. limiting the opportunities for resits;
   d. spreading tests and exams evenly to prevent competition between the subjects and to spread the workload;
   e. applying compensatory assessment strategies within and between components of the course of studies;
   f. experiments with innovative teaching methods and information technology enhanced teaching support in order to stimulate the students.

Faculty culture regarding education

Education in general
In general, the attitude towards the final objectives of the programme was critically positive. The attitude of management and lecturers at TU/e regarding education is very positive and engaged.

Education versus research
For the more technical units of the faculty, the proportion spent on education/research/management is about 40/40/20. At Architecture the research portion is clearly less and the education portion more.

Need for changes

Reason for change
The BC dean indicated that it had become clear from the Ministry's plans that studiability and efficiency should be increased; efficiency should be increased from about 40% to 70%. Money would be distributed relative to the programme's market share. A number of faculties had a very limited number of students: the faculties of Electrical Engineering, Physics, Mathematics, Technics and Informatics had a total of 250 students.

The rector magnificus had contact with the board of directors of education and also with a delegation of students on a regular basis. However, the sense of urgency was not felt within the BE faculty. The BE faculty already had many students coming from a broad field of interests. The demands of the Ministry regarding efficiency and studiability were communicated with the directors of education, but were not well communicated within the faculties. Because there was little time, the need for changes and the executive board's vision were not well communicated within the educational field. The interviews made it clear that many people had the idea the executive board imposed the changes to deal with, and maintain, the small faculties with few students.

On the other hand, however, one teacher mentioned that for some people it was clear that changes were necessary: the programme consisted of a large number of lectures, was redundant, inefficient and needed to be updated because it had not been changed for years and was partly incoherent. A number of lectures might have been interesting 10 years ago, but were no longer interesting, such as computer-related lectures, which address what is now common knowledge even for students in secondary education. Moreover, the number of contact hours at BE was very high: about 40 hours a week. Apart from that, it was hard for students to study the programme according to the schedule. Some projects took so much time that students were not even able to go to the lectures. This could have been a good opportunity to re-do some lectures from scratch, and also to think about 1 major or the possibility of more.

According to the teachers, students were not very satisfied. The NSE survey made it clear and these indications reached the executive board as well; this was discussed in the bilateral consultation between the executive board and the faculty board.

Problems with the old curriculum
According to the director of education, too many students were delayed in their studies and drop-out rates were too high. Efficiency was low and pass rates for courses were too low. The programme included too many lectures, was redundant, inefficient and needed to be updated because it had not been changed for years and was partly incoherent. A number of lectures were not even interesting anymore, such as ICT lectures, which is knowledge students already had when they entered the university. The number of contact hours at BE was very high, about 40 hours a week, and it was hard for students to study the programme according to the schedule. Some projects took so much time that students were not even able to go to the lectures. The full programme meant that there were too few choices.

Goals of the innovation

Vision
The first taskforce wrote a vision for education (Taskforce redesign Ba-curriculum, 2011). The taskforce advised leaving money issues out of the decisions. It was more important to consider developments in engineering education and the future engineer and his role in industry. Every engineer should be multidisciplinary (with knowledge of both technical and non-technical disciplines); have a 'unique selling point' or specialisation; have strong analytical skills and be innovative and solution-oriented; the engineer will become more important as a link between technology and society and must be able to work in a globalising world (communication and cooperation); completion of the TU/e programme is only the starting point for the engineer, preparing him or her for a career of continuous innovation and development (lifelong learning).

An educational representative indicated that some of his colleagues argued the faculty should focus more on technology: they were thinking about having more than 1 major. One major question was a change from the 4 corners of urban planning, technique, architecture and management to 3 corners (TOP): technique, design and process. In fact, people from Architecture even argued for the process part to be included within USE and the choice of 2 majors, T and A. However, the director of education and the dean of the faculty argued the Bachelor education should remain broad and the idea of 2 majors was dropped.

One teacher indicated that the faculty of BE clearly saw that the project work needed to change, especially in the first year. It should have a more introductory and orientational character, introducing more basic knowledge and skills.

Formulated goals
The outcome of the taskforces was that studiability should be improved: the number of parallel lectures should be decreased and intermediate tests should be used. The programme should be more efficient with less redundancy, fewer contact hours and more coaching. There should be more choices, and every student should be able to follow his own unique path. Different levels of performance should be specified for all components of the course of study. Three different levels for performance will be distinguished, and a minimum number of components will need to be passed at the highest level in order to achieve the BSc diploma.

Preparation - The development of the new curriculum

Preparation strategy
There was a clear structure of taskforces, with different roadmaps to be followed. They dealt with problems such as curriculum programs, teaching schedules, communication, quality assurance, coaching, and organisation, as well as professional skills, presentations, websites, and so forth. Some occurred at the TU/e level, others at the faculty level.

Consultation of documents
Within the Bachelor College, the Dublin descriptors (learning outcomes defined by the European Union)were consulted and MIT was also often mentioned.

From the interviews, however, it seems that scientific literature was not consulted within the BE faculty for the redesign. Within the BC, a more solid analysis was made by several taskforces, but it did not seem to reach the decision-makers. Many, possibly most, people from BE had no knowledge of the documents drawn up during the planning phase. It seems that there was no solid analysis of the current programme, no analysis of strengths, weaknesses, opportunities and threats.

Produced documents
At the BC level, the first taskforce analysed the current situation and wrote a vision for education. Taskforce 2 did research for the purpose of orientation, with regard to studiability. The lower the number of parallel lectures, the higher the efficiency would be, and intermediate tests should be introduced overall. Research was done regarding education scheduled in blocks or in series. Research was conducted on the science orientation of students. An ACQA (Aged Care Quality Association) exercise was done at W, and EE made use of the results.

Changes in the curriculum
The redesign started from the BC's general skeleton. The old programme's content was the starting point for the new curriculum. Courses of 1, 2, and 3 EC were combined to make 5 EC courses. Some courses were completely rewritten, such as Building Technology and Real Estate.

Within BE education, a number of types of active work were common practice, such as project work, instructions, practices, work lectures. This way the education is more applied, and the application makes conceptual matters

clearer. This has traditionally been included in BE education. First year project work was completely redesigned, with a more important role for technology.

People involved in the preparation
At the TU/e level, the rector magnificus asked the student union to establish a focus group made up of students studying according to the schedule and students not studying according to the schedule, to give their opinion of how the programme should look: the student advisory group.

The secretaries for several taskforces formed the Programme Management Team. They met each week and coordinated matters of linkage. A curriculum work group was formed, including people from the different disciplines. Based on their background with ACQA (Academic Competences Quality Assurance), the Modeling lecturers assisted with programme design from an ACQA perspective.

Within the BC, a core group was formed, chaired by the BC director.

A quality assurance group, KWAZO, held peer-supervision meetings with the quality assurance officers. Lecturers for the basic courses, professional skills, coaching, honours programme, and so forth, formed other groups.

At the BE level, the director of education for BE was involved right from the start of the redesign, and worked together with his fellow directors of education, the rector magnificus and later on, the director of the BC. Within the BE faculty, the executive director knew the background of the faculty and university, had knowledge of the politics and formed a team with the director education and the dean. The executive director represented the director of education in the university taskforce.

The educational representatives from the units were involved in the process; two quality officers from the BE educational office were also involved. The director of education led the BE meetings on redesign.

Internal communication
The BC secretary said that in the beginning, the 'what' question was communicated, but not the 'why' question. Lecturers were thinking about the consequences of changing from 3 to 5 EC, not about the need for change. Communication improved later on, with the assistance of the Communication Expertise Centre. The newsletter was one result of this, but also a kind of road show. However, according to the secretary, top-down communication appeared to be difficult, because the lecturers who had to execute the changes were mostly reached only at the end.

Resistance
The director of education from Electrical Engineering visited an Education Day at BE, which made it clear to him that there was a lot of resistance within BE towards the changes in the BC. The director of education of BE indicated he experienced the largest resistance from the Architecture unit. Furthermore, an educational representative experienced resistance towards the director of education of BE; it was felt that he wanted to execute changes in his own way.

The lecturers at BE did not have a positive impression about the BC: what was the need for change, was it an improvement, why the use of time-slots, why so much freedom of choice, and so forth.

The BE educational representatives thought that they were consulted after most decisions had been made. It felt like a top-down process. The skeleton for the programme had already been developed and they could only fill in the puzzle. More than 20 variants of the scheme were presented. The Basic courses and the USE line took up a large part of the curriculum, which meant that the rest of the curriculum had to be divided over too many courses. Courses with 3 EC were combined to make 5 EC courses. The result was a cacophony of subjects within a course that was given by many lecturers.

The atmosphere was felt to be hostile within the group of educational representatives from BE. It looked like a fight between architectural and technical representatives. Two majors were suggested, and even the dean of the BC liked the idea. However, the director of education wanted to keep a broad Bachelor education and obstructed the suggestion for 2 majors.

According to a quality officer, a lot of resistance was felt within the group of quality control officers. It seemed they felt most threatened. They were not very positive about the new course evaluation forms. The management reports would take up more of their time, at the expense of the coaching of students.

Those involved with project work doubted the added value of greater freedom of choice. It was felt that the students already had too much freedom and that they should learn more basics.

Resources
At the TU/e level, M€ 2.5 were available for the realisation of the Bachelor College. More room for hiring staff was not available. People just invested time in the BC changes. For example, the educational representatives had only 0.05 fte available for their task.

A dean was appointed within the BC, as well as a secretary, a policy officer and a quality control officer.

Evaluation and monitoring
Quality control officers are involved in the education commission and also in the evaluation of lectures and courses.

Implementation – The implementation of the new curriculum

Strategy
At the BC level, two taskforces were introduced at the beginning of the implementation process, where the commitment of the directors of education was stated to be very important.

There were 11 workgroups established within these taskforces, dealing with time schedules, time slots, and so forth. The composition of these working groups was intended to be balanced: a proportional distribution of members of different faculties across the groups. The idea behind this was to create some type of bond between different faculties.

The first idea was to have some sort of flexible puzzle, where students were free to choose blocks, consisting of 3 courses, in whatever year they wanted. However, students needed some kind of framework, a skeleton for their curriculum. At that point a framework was constructed, consisting of basic courses, USE courses, compulsory courses and free electives. The same structure was developed for all faculties, in principle.

Persons involved
The composition of these working groups was intended to be balanced: a proportional distribution of members of different faculties across the groups. The idea behind this was to create some type of bond between different faculties.

Catalysts
Faculties had previously been mostly autonomous. One positive effect of the communication within several groups was the bonding of people spread all over the university. The horizontal layer within the BC created bonding. People started learning from each other. In fact, this BC change was the first major change since the introduction of OGO in 1995.

Barriers
There was no extra time for the redesign. There was a lot of resistance from most of the teachers. The redesign created high workloads due to intermediate examinations, and so forth.

The meetings with the educational representatives did not lead to any consensus because of the different interest groups represented. According to an educational representative, the meetings had a chaotic character. It was more an arena of forces, where architecture met technique. The director of education had his own idea where to go to with the education at BE, and he tended to go his own direction most. In the discussions among the educational representatives, the introduction of 2 majors at B, Architecture and Technique, was felt to be a good idea. However, the director of education wanted to keep a broad Bachelor education; he and the BE dean felt that 2 majors would split the faculty into 2 parts.

The director of education himself confessed that he therefore invited a number of students to his home on a Monday evening between 7 and 11 pm, compared the old and new curriculum, asked the students which lectures they felt to be important and filled in the format for the new curriculum. This proposal was sent to the different units, and 95% of the new curriculum was decided that Monday evening.

Communication
At the TU/e level, a website was developed for general communication. The faculties organised Education Days, while the directors of education mostly communicated results of the processes with their faculty. Other communication took place through newsletters.
The dean was often invited to explain the strategy within different faculties. Education Days, study days, start-up meetings, and so forth, were organised. The dean's opinion was that the sense of urgency should be clear within the group of lecturers. Within the BE faculty, communication with the lecturers took place in what were called floor meetings, led by the director of education, where different units were visited separately.

Keeping momentum
Momentum was preserved by introducing the changes over a very short time period of one year. There was a lot of discussion about it, but the rector magnificus required it to be done in this short time. Afterwards, many people thought this was the best way to handle implementation, which otherwise might have been a lingering procedure.

After implementation

Staff satisfaction
One of the teachers indicated that afterwards more people saw the advantage of the changes and the improvement in educational quality. Efficiency and studiability were much better than before. The curriculum structure was quite clear. However, a number of 5 EC courses were still not coherent.

Monitoring
The dean must monitor the quality of education. A uniform course evaluation system was developed. The results are presented in a management report and communicated to the BC advisory commission, in which students and lecturers from the faculty education commission participate.

Apart from that a BC monitoring group, consisting of educational commissioner students from a student association, is consulted twice each quarter by the BC dean and quality control officer. Together with the first year-council and students these sources of information are monitored and reported.

Twice a year these types of evaluation results are communicated with the faculties' directors of education and quality control officers.

No baseline measurements were taken when the BC started. However, there is a database with all kinds of data regarding number of first year students, drop-offs, switchers, number of graduates, number of EC, and so forth. A “BSA report” (binding study advice) is produced every year. The database dates back to 2009. Therefore, some comparison with earlier years can be made, but there might be a large number of other factors, such as the introduction of BSA, the change in examinations, and the like.

Ruth Graham has written an evaluation report about the first 3 years of the BC (Graham, 2015). There is also a PhD project at Eindhoven School of Education on intermediate exams.

Unforeseen issues
An educational representative reported that the use of clickers went wrong within B: they were used for intermediate exams, for which they are not designed. They should be used to keep students active in the lecture room.

One teacher felt that it was wrong to decide too much for the students, with too many rules: the BC was a bit too directive. Judging professional skills also turned out to be difficult.

What remains to be done
Having more than 1 major might have solved a lot of problems within BE. A curriculum commission is still working on the final terms of education.

Description of the curriculum change

A skeleton with compulsory and elective courses was developed for the university. A choice of large 5 EC courses instead of 1, 2 or 3 EC courses was made. Some basic courses were introduced, like Calculus, Applied Physics and Design. Apart from that, what are called USE courses were introduced, courses linked to society with arts and social aspects.

Educational teaching approaches were lectures, instructions, practices and OGO’s. Application of EVO (digital learning environment) was introduced in Calculus and Applied Physics.

A TOP profile in OGO was developed in BE for the first year, introducing a task on T, O and P. Supervisors in the first year included not only architects, but also people from technique and process. Professional skills were introduced in the programme.

Student engagement and satisfaction

Student engagement
Tutor groups were introduced at the BC level for Mathematics and Physics. All students must participate in an introductory access examination. At some faculties, rubrics are used to give students more feedback than just a grade. The current director of education at BE is working on this. Within OGO, students get continuous feedback on their functioning and their professional skills.

Centering on students must be seen in the individual choices students can make within their curriculum, and the possibilities and supervision the institution offers to make choices possible.

Active learning by students was an important aspect within the new BC. Clickers were introduced to get feedback during lectures, and intermediate examination were introduced to get students to work steadily during the semester.

Within BC, it is importants to centre on the student and not the lecturer when educational choices must be made.

3TU.CEE

Student satisfaction
The current director of education reported that within BE, students are more positive about their education than they were before. Students appreciate the first year project work more than before. Professional skills have been introduced within the programme.

Delay in studies is recognised earlier because of the coaching trajectory. Students accept it as more normal to study according to the schedule. Between 20-30% of students leave the programme early, and they leave during the first semester.

Some students experience USE courses to be useless, while others appreciate them more.

The BE faculty has different student groups, where students are very active and where they seem to be satisfied.

One question in the NSE survey is about feeling at home: last year (2014) this was the case for 37% of the participants, now it is 67%. That seems to be a significant change. Among other things, this depends on the more active way students are coached. In fact, the overall score on the NSE survey improved from 6 to 7.1. The question about ‘learning a lot’ scored 4.7 out of 5.

Student support
Within the project work, students are now encouraged to organise lectures where ‘senior’ students talk about their education and impression of it. Excursions to businesses such as architectural offices and home corporations or building physics advisory offices are organised. In this way, students gain knowledge about their perspectives and how they fit with their personalities. There is now coaching available by lecturers and ‘senior’ students.

Assessment
A limited number of resits is allowed and students following whole courses again, together with intermediate exams.

The introduction of intermediate examination increased the efficiency for some courses from 70% to 90%.

Studiability

Studiability of the programme’s demands was increased by having fewer parallel courses and fewer examinations (a maximum of three). Project work needs to end before the examinations.

Studiability of the programme was increased by having fewer parallel courses and examinations (a maximum of three), as well as a limited number of re-sits. If the students were not successful, despite these measures, they had to start from the beginning with the course and participate in the intermediate exams. The result is a different, more positive culture. Students are forced to keep working and stay on top of their courses.

Faculty and course programme characteristics

(TU/e facts and figures (2011-2015))

Student numbers:
2011: 244
2014: 129

Student gender:
2011: 74% male; 26% female
2014: 60% male; 40% female

First-year students studying according to the official schedule:
2014 33%.

Drop-out rate in the first year of study:
2011: 28%
2014: 10%

Switch rate in the first year of study:
2011: 3%
2014: 4%

Bachelor efficiency:
2011: 57%
2014: 86%

Appendix H: Case Study of Civil Engineering at University of Twente

Context: attributes of the faculty

The faculty of Engineering Technology offers three Bachelor programmes and a number of Master programmes. The Bachelor programmes are:
- Civil Engineering
- Industrial Design
- Mechanical Engineering

Each Bachelor programme has its own Master programme(s). For Civil Engineering the Master programmes are Civil Engineering & Management and Construct Management & Engineering. Industrial Design has a Master programme called Industrial Design Engineeringwhich has three different tracks: Design & Styling, Management of Product Development and Emerging Technology Design. After the Bachelor programme in Mechanical Engineering students can proceed to the two Master programmes, Mechanical Engineering and Sustainable Energy Technology. Engineering Technology has a total annual enrolment of around 300 BSc students per year. Total enrolment of new students in Civil Engineering has been 71 (2012), 75 (2013), 78 (2014) and 65 (2015).

Vision and renewal

Reasons for change and goals of the innovation

The University of Twente decided to redesign all of the Bachelor programmes, implementing the Twente educational Model (TEM). The implementation of TEM was done for several reasons, such as increasing the number of students graduating on time, and educating T-shaped professionals who can go in depth in their own discipline and can connect their knowledge to other disciplines and societal issues. Three roles were introduced to describe the future typical 'Twente' graduate: the researcher, designer and entrepreneur. These goals were not programme-specific.

Along with the implementation of TEM in all of the Bachelor programmes, binding study advice (BSA) was introduced. Students must obtain 45 EC's to receive a positive recommendation. If the students fail to obtain these EC's, the programme could force the students to leave.

The programme itself had some additional reasons for change.

Over the years, the management aspect of Civil Engineering had been more and more filled in with standard courses, offered by a different faculty. There was a desire on the part of both students and staff to strengthen the technical side of the programme. This was also mentioned to the programme committee during the last accreditation. In addition, students mentioned during their exit interviews that the programme was too easy. So another goal was to make the programme more challenging and to concentrate student drop-out early in the programme.

Faculty vision

In April 2013, a group of faculty members developed the document 'Strategie faculteit CTW (ET)' in which the goals for the faculty were described.

The aim of the faculty is to educate engineers who have a science-based engineering background and an entrepreneurial attitude, who can do both interdisciplinary and multidisciplinary work, and who have a view of societal issues.

The development of the new programme

Planning
In 2010, a UT-broad committee was put together to design what would become TEM. The director of education of Civil Engineering was a member of this committee. One of the final product of this committee was a document describing the vision of TEM.

In 2011, the director of education of Civil Engineering invited several people to form a programme committee. Together they designed a blueprint for the curriculum of Civil Engineering.

In the summer of 2012, the blueprint was complete and the director of education selected some teachers to become module coordinators. They formed module teams and started designing the specific modules. These designs were discussed with the curriculum committee in January 2013.

The new Civil Engineering curriculum was first implemented in September 2013.

Description of the new programme
As mentioned before, all of the Bachelor programmes at the University of Twente were redesigned according to TEM. The structure of all programmes changed. Each Bachelor programme consists of 12 modules, of 15 EC each. These modules take up a quarter and can only be passed as a whole; so students receive 15 EC or 0 EC at the end of the module.

Within TEM, the pedagogy focuses on project-based learning; modules are thematic and student-centred. The idea is to teach students to be critical thinkers who can take more responsibility for their own work. So the focus is not only on content, but also strongly on academic skills.

The Bachelor programme of Civil Engineering was redesigned based on this vision. The decision was made to leave the final objectives intact, while the content of the old curriculum was the starting point for the new curriculum.

Courses were reshuffled and critically looked at to create new integrated modules. An academic skills line was also set up, to make sure students would gather all of the academic skills they needed during the Bachelor programme. This skills line was integrated into the different modules.

There are three different pillars within Civil Engineering: Water, Construction and Transport. The first year of the Bachelor has a monodisciplinary setup: module 1 is an introduction to the whole programme and the three other modules are centred on one of the three pillars: water, traffic and building. The second year is set up in a multidisciplinary way, where two or more pillars are involved in each module. The third year has two minors (modules 9 and 10), while module 11 prepares for the final project that is module 12.

Technical aspects were reintroduced in the programme to make it more challenging. An example of trying to concentrate student dropout at the beginning of the programme is that Mechanics 1 and 2 are taught in the first year. Details on the Civil Engineering curriculum can be found at the University of Twente website (University of Twente, n.d.)

3TU.CEE

Process and strategy

Before the staff of Civil Engineering started redesigning their programme, another whole process had already taken place. That process, the design of TEM, played out at a university-wide level. A small group of people were involved in this design, one of whom was the director of education of Civil Engineering.

The problem owners and staff involved in the process
Within the faculty, a lunch meeting was organised to communicate TEM to the staff. The directors of education invited small groups of people to think of a blueprint for their own programmes. In the case of the Civil Engineering, the curriculum committee was made up of five people; the director of education, the academic skills teacher and one teacher representing each of the three pillars of Civil Engineering. The Bachelor coordinator and educational advisor occasionally joined them to give advice.
When the blueprint was completed, the director of education involved the module coordinators.

A module coordinator was assigned for each module, and staff members were assigned to form the module team, based on the subjects that were going to be part of the module. Sometimes additional team members were selected by the module coordinator.

At that point, the director of education stepped back. She did this very deliberately, because she stated that the teachers were all professionals, and that when they (re)designed a course prior to TEM, she also did not monitor them intensively.

A deliberate decision was made regarding who got invited to be on the curriculum committee. The initial intention was not to invite professors. However, one of the members ended up being a professor. At first, professors were selected as module coordinators because it was considered valuable to have professors involved in the BSc curriculum. However, it turned out that this was not practical because professors had too little time to be module coordinators. Therefore other staff member were specifically selected as module coordinators.

The strategy of the module coordinators was mostly bottom-up, but how the design process occurred differed very much by team. Some of the teams made it a team effort and had regular meetings to synchronise their design and different parts within the module. Some coordinators did the opposite, because they said the workload was high already and they did not want to increase it even more. So they mostly had contact via email, and the module coordinator developed a plan based on the input from the others.

These different strategies had an effect on the designs; some were more integrated and included more new pedagogies than others.

Quality was monitoring during the design process insofar as the teams had to show their designs to the educational committee. This was mostly a formal process that led to no major adjustments.

Resources and documents
Documents were generated at a UT-wide level describing TEM and the university's vision. Teachers knew that these were available and used them to develop an understanding of the vision. Besides the documents about TEM that were available, lunch meetings were organised (TEM carousels). Within the Civil Engineering programme, teachers were encouraged to go to these meetings, and many of the module coordinators did go.

The module teams used the blueprint that was designed by the curriculum committee specifically for the Civil Engineering programme. A set of subjects and a project idea for each module was distributed. This blueprint was given to all of the module coordinators, who then could select their own team. Besides the blueprint for the whole

programme, there was also a blueprint for the academic skills line.
The programme coordinator and educational advisor were available for help during the design process (and also during the implementation process).

Comparing the old and the new curriculum
When comparing the old and the new curriculum, the new curriculum changed in its organisation and its pedagogical perspectives. The old curriculum was set up with multiple courses within a quarter that could be taken separately and did not necessarily relate to each other. The new curriculum is organised in thematic modules where each quarter is an integrated entity. Students pass the total module.

In the new curriculum, the pedagogical approach is project-based education. The new curriculum has more projects, one in each module.

The content of the old curriculum was used as the basis for the new curriculum; hence, the final qualifications of the programme did not change. The order of the content changed in the new curriculum. The technical aspects of the programme were strengthened and the management part was more integrated within the projects. The first year gives an overview of the different pillars and has a monodisciplinary character, while the second year has a more multidisciplinary character. Another change is that more difficult subjects are taught earlier in the curriculum.

Communication
A faculty wide education day was organised, where TEM was introduced to all staff members of the ET faculty.

The three directors of education of the faculty each assembled a curriculum committee, who were invited via email. The curriculum committee for Civil Engineering consisted of five people: the director of education, three teachers of the different disciplinary pillars (transport, construction and water) and the academic skills line coordinator. Module coordinators were chosen and monthly meetings with all of the module coordinators were set up, so everyone knew what was happened in which module.

Communication within the module teams was left up to the module teams. This varied; some team came together regularly and some teams came together a few times and communicated mainly via email. The communication was mainly informal.

The director of education made a lot of informal rounds visiting the teachers during the preparation and designing of the modules.

Resistance
There was quite some resistance within the faculty, mostly in the Mechanical Engineering and Industrial Design Engineering programmes. Those programmes were already using project-based work, and they felt left out during the design part of TEM. They felt that they would not be able to do as much project work within the modular system.

There also was resistance within Civil Engineering, but much less than within the other programmes. The director of education was very supportive of the new educational model and talked a lot with all of the teachers to show the positive side of the model. She also gave a lot of freedom and responsibility back to the teachers when designing the modules.

Among the staff who were interviewed for this study, resistance was mostly felt regarding the top-down approach used at the university level. Many concerns and questions had to do with teachers' workload, studiability for the students and personal resources. Some felt that the pedagogy was not appropriate for a university, and that the basics should be taught in a more traditional manner. Some mentioned the concern that the modular structure would be too

3TU.CEE

stressful for the students.
Another reason for resistance that was mentioned by multiple staff members was that they felt they were not well enough prepared. They were used to designing and teaching in a traditional manner, and they should have had more training to be able to design education according to the TEM vision.

The implementation of the new programme

People involved
The module coordinators were responsible for the modules during the implementation of the new curriculum. They taught the different modules together with their teams. The coordinator of the academic skills line joined the different modules.

Teachers could ask the educational advisor and the Bachelor coordinator for help during the implementation process. The employee for quality assurance set up panel discussions with students to evaluate the implementation.

Catalysts
The director of education of Civil Engineering was part of the team who designed the TEM vision. Therefore she was very supportive of the whole new Bachelor innovation. This had a positive effect on the staff.

Quality control: evaluation and monitoring
A new student questionnaire was developed to evaluate all modules. This questionnaire was used UT-wide and evaluated the module as a whole at the end of each module.

After the module, most of the module teams came together to evaluate their own module. At the beginning the separate parts of the module were also evaluated, but most of the staff interviewed agreed that this was too much. Students got tired of all of the evaluations.

The first time the module was implemented, panel discussions were held with the students every other week. This was done to make sure that no big errors would accrue. In hindsight, this may also have stirred things up, because students started to complain about everything and many ad hoc solutions were created. The second year the staff was more secure, monitored a bit less and became stricter for the students. This led to fewer complaints and problems than the first year.

Implementation was also monitored at a UT-wide level. After each module, module teams were interviewed about their experiences and directors of education were asked to complete a questionnaire.

The UT-wide questionnaire for the students is now still in use. The interviews with the module teams have changed to a questionnaire for the module coordinators and the questionnaires for the directors of education have ended.

The programme itself still has panel discussions with students in the middle and at the end of the module.

Communication
Communication is the same as during preparation for the Bachelor innovation. The monthly meetings with all of the module coordinators are still intact and have a high level of information sharing.

Module teams each communicate differently, hence different people are involved.

Resistance
Some teachers changed their attitude once they experienced TEM, and became positive. Some teachers felt that the

basics still needed be addressed in a more traditional way, and have not fully implemented project-based education because they did not agree with that pedagogical perspective.

So there still was (and is) resistance, which varies very much by person. Some of the teachers felt that they were involved enough and others felt differently. The resistant teachers deal differently with TEM; some of them still use traditional methods in their teaching and have adjusted only to the organisational part (modular structure), some shifted to the Master programme and some just deal with it.

Results

Student satisfaction
There were no students among those interviewed. When looking at the National Student Survey (NSE) outcomes, the students gave somewhat lower scores than last year. Points of improvement were schedule, information and communication, for instance, about quality management.

Student success
This is the first year there will be graduates who have followed the new curriculum. So the number of Bachelor graduates finishing in three years cannot be compared.

The number of students obtaining 60 EC in the first year and the dropout rates in the first year have increased (see Table 16).

The number of students obtaining 60 EC in the first year had already increased a little before the implementation. According to the director of education, this had to do with students wanting to finish everything before the new curriculum was implemented.

Table 15: Rate of obtaining 60 EC after B1 and dropout rate in B1 for Civil Engineering at the University of Twente

Obtained 60 EC after B1		Dropout rate in B1	
Year	Percentage of students	Year	Percentage of students
2009	17%	2010	22%
2013	54%	2011	10%
		2012	8%
		2013	27%
		2014	38%

During the interviews with the staff, some of the teachers said that they were positively surprised by the knowledge and skills the students gained in the modules. Other teacher were more sceptical. It is difficult to state what led to the change because so many things have changed, like the situation with governmental study financing, implementation of the binding study advice, and so forth.

Still to be done
The Bachelor innovation is not yet 100% complete. Several aspects remain to be addressed in the time to come. For example, module coordinators should have responsibility for the academic skills line, instead of the skills line coordinator. Due to workload and priorities this is something that has not yet been done.

Another aspect that still needs to be handled is synchronisation of students' responsibilities in the different modules. It currently fluctuates between modules instead of a steady increase (with slight fluctuations).

With regard to evaluation and monitoring, a proper evaluation of whether the goals have been met is being set up for the near future.

Appendix I: Interview protocol

Algemene inleiding

Dit interview vindt plaats in het kader van het 3TU.Centre for Engineering Education, een initiatief vanuit de 3TU om meer systematisch te gaan kijken naar de manier waarop we binnen de technische universiteiten onderwijs geven en te leren over hoe we onderwijs aan ingenieurs kunnen verbeteren.

We proberen bij een aantal opleidingen in Twente, Eindhoven en Delft in kaart te brengen hoe de voorbereiding en implementatie van de vernieuwingen zijn verlopen en dat doen we op zo'n manier dat we de uitkomsten ook kunnen vergelijken. We willen op die manier meer leren over de verschillende manieren om een verandering in te steken en over wat het oplevert.

Het is de bedoeling dat er een rapport wordt geschreven voor dit rapport, maar we zullen zo rapporteren dat uitspraken niet herleidbaar zijn tot een persoon. Als we een citaat van je willen gebruiken, doen we dat in overleg. Dit gesprek duurt ongeveer een uur. Ik wil het graag opnemen, zodat ik niet mee hoef te schrijven. De opname wordt alleen afgeluisterd door mij en mogelijk door een andere onderzoeker in dit project. Heb je nog vragen?

Onderwijskwaliteitszorgmedewerker

Terugblik

Hoe kijk je terug op de vernieuwing: is de vernieuwing geslaagd wat jou betreft?

Waar ben je het meest positief over en wat kan nog beter?

Procesbeschrijving

NB: We proberen hier een chronologisch overzicht te krijgen van het proces. Vanaf de aanleiding tot aan hoe met er nu op terug kijkt. De onderstaande vragen kunnen betrekking hebben op alle fasen van de vernieuwing.

1	Wanneer werd je betrokken bij de vernieuwing?	Achtergrond
2	Was de vernieuwing toen nog in voorbereiding of werd je betrokken toen de vernieuwing geïmplementeerd werd?	Achtergrond
3	Waarom werd je betrokken? Hoe zag je jouw rol/ de rol van kwaliteitszorg in het project?	6.4/ 7.2 Actoren
4	Was de noodzaak tot vernieuwing helder voor jou?	4 Noodzaak
5	Waren er problemen wat betreft studeerbaarheid, rendement, switchen, afbreken studie, kwaliteit onderwijs, tevredenheid studenten, werklast, ...?	4 Noodzaak/ 1 schets oude curriculum
6	Waren de doelen van de vernieuwing helder voor je?	5 doelen van de vernieuwing
7	Welke afspraken lagen er op het moment dat je betrokken werd al vast? Welke documenten waren er toen al geschreven en wat was de status ervan? Waren die documenten gebaseerd op wetenschappelijke bronnen?	5 doelen van vernieuwing, procesbeschrijving 6.1 t/m 6.3
8	Was er een strategie uitgezet over hoe men te werk zou gaan, met het ontwerpen van het curriculum, wie op welke manier betrokken zou worden, hoe er gecommuniceerd zou worden?	6/7 Voorbereiding/ implementatie
9	Met welke personen werkte je samen? Waarom waren juist deze personen betrokken bij de vernieuwing en wat was hun rol?	6/7 Voorbereiding/ implementatie
10	Weet je hoeveel formatie deze personen hadden voor hun taken? Hoeveel formatie kreeg jij voor je werk? Was dat voldoende om het te doen?	6/7 Voorbereiding/ implementatie
11	Kun je het gevolgde proces beschrijven? Was er een strategie die gekozen en gevolgd werd?	6/7 Voorbereiding/ implementatie
12	Ben je weerstand tegengekomen in het proces? Hoe is daarmee omgegaan?	

Bijdrage van kwaliteitszorg

13	Wat is je input in het proces geweest?
14	Heb je bijgedragen aan documenten? Zoja, hoe ging dat?
15	Is er een analyse gemaakt van de bestaande toestand? Is bij de onderwijsvernieuwing expliciet wetenschappelijke literatuur geraadpleegd?
16	Op welke wijze is er gekeken naar de eigenheid van een ingenieursstudie?
17	Welke harde kentallen kunnen we gebruiken om de oude en de nieuwe toestand te vergelijken?
18	Wie kunnen we daar het beste voor benaderen?
19	Was er oog voor kwaliteitszorg in de nieuwe organisatie?
20	Hoe kijk je terug op het proces en de uitkomsten? Vind je dat kwaliteitszorg voldoende geborgd is?
21	Waar zou het beter kunnen?
22	Zijn er nog andere zaken die relevant zijn voor de vernieuwing, die nog niet ter sprake zijn gekomen?

3TU.CEE

Onderwijsdirecteur of een persoon in vergelijkbare positie

Aanleiding vernieuwing
Kun je de aanleiding van de vernieuwing beschrijven?

Waren er vooral externe krachten? Waren er vooral interne krachten? Kun je deze toelichten?

Zag je zelf de noodzaak tot vernieuwing? Waren er problemen wat betreft studeerbaarheid, rendement, switchen, afbreken studie, kwaliteit onderwijs, tevredenheid studenten, werklast.

Strategie
Zijn er wetenschappelijke bronnen gebruikt? Zo ja, welke?

Is er een duidelijke strategie gekozen voor de vernieuwing?

Waar is de vernieuwing op gericht?

Waren er concrete doelen vastgesteld?

Wie zijn er in het voorbereidingsstadium en de implementatie van de vernieuwing betrokken? Waren dat dezelfde personen? Welke gedachtegang zat daar achter?

Hoeveel formatie hadden deze personen?

Is kwaliteitszorg bij de voorbereiding en implementatie betrokken geweest? Waarom wel of niet?

Welke experts zijn geraadpleegd met welke specifieke kennis?

Welke harde kentallen kunnen we gebruiken om de oude en de nieuwe toestand te vergelijken?

Wie kunnen we daar het beste voor benaderen?

Communicatie
Welke documenten zijn er opgesteld tijdens het vernieuwingsproces?

Is er een strategie gekozen om te communiceren met direct betrokkenen en met de docenten?

Ben je weerstanden tegengekomen in het proces? Was dat verwacht? Hoe ben je daarmee om gegaan?

lke data wordt er gemonitord? Beslaat deze data alle doelen van de verandering?

Hoe houdt men de focus op onderwijs? Is dat afdoende?

Hoe gaat men om met onvoorziene problemen die het gevolg zijn van de verandering?

Zijn de doelen behaald? Waar blijkt dat uit? Waar en wat kan er beter?

Hoe kijk je terug op het vernieuwingsproces als geheel? Waar zijn dingen niet goed gegaan en wat zou je volgende keer anders doen?

3TU.CEE

Inhoudelijk
Is er gekozen voor een brede of meer gespecialiseerde ingenieur of een combinatie?

Zijn er nieuwe leerdoelen en eindtermen geformuleerd?

Contacten
Welke mensen kunnen we het beste benaderen voor interviews binnen jouw faculteit: ow medewerkers, docenten, coordinatoren, overig?

Zijn er nog andere zaken waar we het over moeten hebben?

Coördinator

NB: dit kan een leerlijn, module of andere coordinator betreffen. Het gaat om personen die nieuwe onderdelen van het curriculum heft gecoordineerd en/of georganiseerd.

Procesbeschrijving
NB: We proberen hier een chronologisch overzicht te krijgen van het proces. Vanaf de aanleiding tot aan hoe met er nu op terug kijkt. De onderstaande vragen kunnen betrekking hebben op alle fasen van de vernieuwing.

1	Wanneer werd je betrokken bij de vernieuwing?	Achtergrond
2	Was de vernieuwing toen nog in voorbereiding of werd je betrokken toen de vernieuwing geïmplementeerd werd?	Achtergrond
3	Waarom werd je betrokken? Hoe zag je jouw rol/ de rol van kwaliteitszorg in het project?	6.4/ 7.2 Actoren
4	Was de noodzaak tot vernieuwing helder voor jou?	4 Noodzaak
5	Waren er problemen wat betreft studeerbaarheid, rendement, switchen, afbreken studie, kwaliteit onderwijs, tevredenheid studenten, werklast, ...?	4 Noodzaak/ 1 schets oude curriculum
6	Waren de doelen van de vernieuwing helder voor je?	5 doelen van de vernieuwing
7	Welke afspraken lagen er op het moment dat je betrokken werd al vast? Welke documenten waren er toen al geschreven en wat was de status ervan? Waren die documenten gebaseerd op wetenschappelijke bronnen?	5 doelen van vernieuwing, procesbeschrijving 6.1 t/m 6.3

8	Was er een strategie uitgezet over hoe men te werk zou gaan, met het ontwerpen van het curriculum, wie op welke manier betrokken zou worden, hoe er gecommuniceerd zou worden?	6/7 Voorbereiding/ implementatie
9	Met welke personen werkte je samen? Waarom waren juist deze personen betrokken bij de vernieuwing en wat was hun rol?	6/7 Voorbereiding/ implementatie
10	Weet je hoeveel formatie deze personen hadden voor hun taken? Hoeveel formatie kreeg jij voor je werk? Was dat voldoende om het te doen?	6/7 Voorbereiding/ implementatie
11	Kun je het gevolgde proces beschrijven? Was er een strategie die gekozen en gevolgd werd?	6/7 Voorbereiding/ implementatie
12	Ben je weerstand tegengekomen in het proces? Kun je deze weerstanden omschrijven? Hoe is daarmee omgegaan?	

Docent

Zag je zelf de noodzaak tot vernieuwing? Waren er problemen wat betreft studeerbaarheid, rendement, switchen, afbreken studie, kwaliteit onderwijs, tevredenheid studenten, werklast.

Hoe kijk je terug op de vernieuwing: is de vernieuwing geslaagd wat jou betreft?

Waar ben je het meest positief over en wat kan/moet nog beter?

Procesbeschrijving
Wanneer werd je betrokken bij de vernieuwing? Waarom werd je betrokken? Kreeg je een opdracht mee?

Welke afspraken lagen er op het moment dat je betrokken werd al vast?

Welke documenten waren er toen al geschreven en wat was de status ervan?

Hoe zag je jouw rol/ de rol van de docent in het project?

Met welke personen werkte je samen?

Kun je het gevolgde proces beschrijven?

Was er een strategie die gevolgd werd?

Ben je weerstand tegengekomen in het proces, bij jezelf of anderen?

Hoe is daarmee omgegaan?

Bijdrage van docenten
Wat is je input in het proces geweest?

Heb je bijgedragen aan documenten? Zo ja, welke en hoe ging dat?

Was er oog voor docenten in de nieuwe organisatie?

Vind je dat de onderwijskwaliteit voldoende geborgd is?

List of Abbreviations

A&BE:	Architecture and the Built Environment
BC:	Bachelor college at TU/e
BE:	Built Environment
BSA:	Binding study advice
CE:	Civil Engineering
CEE:	3TU.Centre for Engineering Education
EC:	European credits
EE:	Electrical Engineering
NSE:	National student survey
OGO:	Design-oriented education
KOS:	Charting for student success
PBL:	Problem-based learning
STEM:	Science, Technology, Engineering and Mathematics
TEM:	Twente Education Model
TOP:	Technique, design and process subjects at the Bachelor college of TU/e
TU Delft:	Delft University of Technology
TU/e:	Eindhoven University of Technology
USE:	Courses linked to society with arts and social aspects at TU/e
UT:	University of Twente

References

3TU.Centre for Engineering Education. (n.d.). 3TU. Centre for Engineering Education. Retrieved February 5, 2016, from http://www.3tu.nl/cee/en/

ASIIN. (n.d.). Programme Accreditation. Retrieved January 14, 2016, from http://www.asiin-ev.de/pages/en/asiin e.-v/programme-accreditation.php

Berg, H. van den, Steens, I., & Oude Alink, C. (2014). Als eenmaal het kwartje valt. De invoering van het Twentse Onderwijsmodel. *Thema, 5*(14), 38–46.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education, 32*(3), 347–364. http://doi org/10.1007/BF00138871

Bogaard, M. E. D. van den. (2015). *Towards an action-oriented model for first year engineering student success - A mixed methods approach.* Delft University of Technology.

Borrego, M., & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of Engineering Education, 103*(2), 220–252. http://doi. org/10.1002/jee.20040

Chen, X. (2009). Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. *Education, 6(*July), 1–25. http://doi.org/10.1187/cbe.10

Commissie Toekomstbestendig Hoger Onderwijsstelsel. (2010). *Differentieren in drievoud omwille van kwaliteit en verscheidenheid in het onderwijs. Advies van de Commissie Toekomstbestendig Hoger Onderwijs Stelsel.* Retrieved from https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2010/04/13/advies-van-de-commissie-toekomstbestendig-hoger-onderwi/rapport-differenti-ren-in-drievoud-commissie-veerman.pdf

Frederiks, P., & de Bie, D. (2004). *Waren we maar eerder begonnen, over de aanpak van onderwijsvernieuwing*. Houten: Bohn Stafleu Van Loghum.

Fullan, M. (2007). *The New Meaning of Educational Change* (Fourth). Routledge.

Godfrey, E., & Parker, L. (2010). Mapping the cultural landscape in engineering education. *Journal of Engineering Education, 69*(1), 5–22. http://doi.org/10.1002/j.2168-9830.2010.tb01038.x

Goldberg, D., & Somerville, M. (2014). *A Whole New Engineer.* ThreeJoy Associates.

Gommer, E. M., Klaassen, R. G., & Brans, C. H. T. A. (2015). *Comparing Bachelor Curriculum Innovations at the Three Technical Universities - an exploratory study*.

Graham, R. (2012). *Achieving excellence in engineering education: the ingredients of successful change. The Royal Academy of Engineering*. Retrieved from http://epc.ac.uk/wp-content/uploads/2012/08/Ruth-Graham.pdf

Graham, R. (2015). *Overall evaluation impact Bachelor College reform and next steps.* Eindhoven.

Hulst, M. van der, & Jansen, E. (2002). Effects of curriculum organisation on study progress in engineering studies. *Higher Education, 43*(4), 489–506. http://doi.org/10.1023/A:1015207706917

Jagersma, J., & Parsons, J. (2011). Empowering Students as Active Participants in Curriculum Design and Implementation. *New Zealand Journal of Teachers ' Work, 8(*2), 114–121. Retrieved from http://files.eric.ed.gov/fulltext/ED514196.pdf

Kezar, A. J. (2001). *Understanding and facilitating organizational change in the 21st century: Recent research and conceptualizations: ASHE-ERIC Higher Education Report* (Vol. 28).

Lattuca, L. R., Terenzini, P. T., Harper, B. J., & Yin, A. C. (2009). Academic environments in detail: Holland's theory at the subdiscipline level. *Research in Higher Education, 51*(1), 21–39. http://doi.org/10.1007/s11162-009-9144-9

Meijers, A., & Brok, P. den. (2013). *Engineers for the future. An essay on education at TU/e in 2030*. Eindhoven. Retrieved from https://www.tue.nl/uploads/media/TUE_Vision_of_Education_2013.pdf

Merton, P., Froyd, J. E., Clark, M. C., & Richardson, J. (2009). A case study of relationships between organizational culture and curricular change in engineering education. *Innovative Higher Education, 34*, 219–233. http://doi.org/10.1007/s10755-009-9114-3

Rijksoverheid. (n.d.). Prestatieafspraken met universiteiten en hogescholen. Retrieved February 5, 2016, from https://www.rijksoverheid.nl/onderwerpen/hoger-onderwijs/inhoud/prestatieafspraken-met-universiteiten-en-hogescholen

Sheppard, S. D., Macatangay, K., Colby, A., Sullivan, W. S., & Shulman, L. S. . (2008). *Educating Engineers: Designing for the Future of the Field* -. Jossey-Bass. Retrieved from http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0787977438.html

Stolk, J., Somerville, M., & Chachra, D. (2008). Drowning in method, thirsty for values: A call for cultural inquiry. In *Proceedings - Frontiers in Education Conference, FIE* (pp. 3–7). http://doi.org/10.1109/FIE.2008.4720360

Studiekeuze123. (n.d.). Nationale Student Enquete. Retrieved from http://www.studiekeuzeinformatie.nl/nse

Taskforce Redesign Ba-curriculum. (2001). *Toekomstbestendig en Studentgericht Bacheloronderwijs van de TU/e. Eindrapportage van de taskforce Redesign Ba-curriculum en standpunt College van Bestuur. Intern.* Eindhoven. Retrieved from https://www.tue.nl/uploads/media/Eindrapportage_taskforce_Redesign_Ba-curriculum_en_Standpunt_CvB.pdf

Tonino, H., Andernach, T., Bos, E., Bouwmans, I., Drunen, T. van, Lugten, M., … Peppen, A. van. (2011). *Koersen op Studiesucces.*

University of Twente. (n.d.). BSc Civil Engineering. Retrieved December 11, 2015, from https://www.utwente.nl/en/education/bachelor/programmes/civil-engineering/

Van den Akker, J. (2010). Building bridges: how research may improve curriculum policies and classroom practices. In S. M. Stoney (Ed.), *Beyond Lisbon 2010: perspectives from research and development of education policy in Europe* (pp. 177–195).

Werkgroep 180 degrees. (2010). *Bacheloropleiding Electrical Engineering. Op weg naar een studeerbare opleiding.* Eindhoven.

Woodcock, A., Graziano, W. G., Branch, S. E., Habashi, M. M., Ngambeki, I., & Evangelou, D. (2013). Person and Thing Orientations: Psychological Correlates and Predictive Utility. *Social Psychological and Personality Science, 4*(1), 116–123. http://doi.org/10.1177/1948550612444320

3TU.CEE

Figures and Tables

Figures

Tables

3TU.CEE

3TU. CENTRE FOR ENGINEERING EDUCATION

TU Delft Delft University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.