3TU.

Comparing Bachelor Curriculum Innovations at the Three Technical Universities

An Exploratory Study

TU Delft Delft University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.

3TU. CENTRE FOR ENGINEERING EDUCATION

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'Change in education is easy to propose, hard to implement and extraordinarily difficult to sustain.' [1]

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[1] Hargreaves & Fink (2006)

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1.Introduction

In 2010, a nationwide discussion took place about the profiling of universities in the Netherlands. The discussion was instigated by the report from the committee 'Toekomstbestendig Hoger Onderwijs Stelsel' (Veerman, 2010). Around the same time, the Ministry of Education, Culture and Science (OC&W) was developing plans for making performance agreements with all institutions of Higher Education in the Netherlands, aiming to improve retention, success rates and educational quality. While it is the Mission of the Dutch universities of technology to provide a sufficient amount of highly qualified engineers, up until 2011 they did not succeed in accomplishing this goal.

In this context, the three universities of technology in the Netherlands initiated a redesign of the bachelor curricula. It is thought that the output of high-quality graduates in engineering is enhanced by increasing the attractiveness of engineering education and by eliminating obstacles for successful completion of these programmes. Raised attractiveness would result in increased time spent on tasks. Removing obstacles would result in students spending their time more efficient. In addition, the aim was to modernise common basic subjects in engineering courses (mathematics, mechanics, physical transport phenomena) (3TU, 2011).

The Dutch universities of technology all redesigned their bachelor curricula in the period from 2012 until 2014 in their own way. It appears the three universities have the same goals and commitment in redesigning their curricula, but nevertheless substantial differences exist in focus and scope of the bachelor redesign, as well as in the process of implementation.

In 2014, the 3TU (three Dutch technical universities) Centre for Engineering Education (CEE) was founded as a vehicle to enable the comparison and evaluation of the efforts of each of the universities. The main mission for 3TU.CEE is to jointly inspire, stimulate, support and disseminate effective and high-quality engineering education through research and application of evidence-based innovations. To be able to do this, the first step is to get better insights into the various curricular innovations.

In this preliminary research, we studied the characteristics of the 3TU innovations from the perspective of the intended curriculum (Van den Akker, 2003). It is a comparative study that is aimed at getting more insight into the similarities and differences in the curricula of the three technical universities. The present research is part of a larger bachelor curriculum innovation comparison, initiated by 3TU.CEE. Follow-up research will focus on the implemented and the attained curriculum. The main goal of this follow up research is to gain more understanding of innovation in technical higher education, specifically whether the innovations have contributed to learning outcomes that strengthen the engineering profile.

1.1 Theoretical Framework

Based on the typology of Van den Akker (2003), we chose to focus on the intended curriculum (table 1) as a null analysis of each bachelor curriculum innovation. The intended curriculum consists of the preparatory phase in which drivers for change, vision, process and intended programme/curricular structure are established and communicated.

INTENDED	Ideal	Vision (Rationale or basic philosophy underlying a curriculum)
	Formal/ written	Intentions as specified in curriculum documents and/or materials
IMPLEMENTED	Perceived	Curriculum as interpreted by its users (esp. teachers)
	Operational	Actual process of teaching and learning (also: curriculum-in-action)
ATTAINED	Experiential	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

Table 1: Forms of curriculum (van den Akker, 2003)

Research Questions

In an international study on curricular change and its successes and failures to realise sustainable change, Graham (2012) points out that several key factors of sustainable change are essential in the design process. These are (1) the context of the change (drivers for change), (2) leadership and faculty engagement (both leadership and faculty espouse the benefits of the change), (3) educational design and implementation (vision and commitment, change at the core of the curriculum, unique educational approach, high faculty involvement) and (4) sustained change (Graham, 2012, p. 61). To investigate the intended phase of curricular change we chose to use these key factors to formulate the following main and sub-research questions:

- In what way did the three technical universities address the bachelor curriculum innovation objectives?
  - What were the main drivers for the innovation process at each technical university?
  - In what way is the leadership of the innovation process and implementation structure organised?
  - What are the key design characteristics of the intended curriculum?
  - What is the effect of the key characteristics on elements within the curricular programmes?

In the following paragraph, we will briefly discuss why these questions are relevant to the successful implementation of curriculum change.

External Drivers for Change

According to Graham, successful change is driven by a crisis setting in which the market position of the institution is in question, there are regulations enforced at the national level to reform education and/or the institution has a profile of risk taking and innovation.

Leadership and the Approach towards Curricular Change

Key in the execution of the innovation is the leadership in which the senior management of an institution communicates and defends the principle vision and choices for the innovation to external and internal partners. It is essential, however, that the majority of the faculty (scientific staff and teachers) are supporting and involved in the curricular change. Stolk et al. (2008) propose that there are three major approaches to engineering curriculum renewal processes determined by 'people- product-politics'. Taking one of these 3Ps as a point of departure determines the character of the change process. A product oriented approach starts with a set of requirements (outcomes & constraints) and ends with a set of specifications devised by a small design team. The political approach is a community approach where many members of the faculty are involved in the innovation process to create a shared vision. The advantage is the creation of a larger sense of ownership towards the proposed change. Finally, the people approach is a more value-oriented approach, as the values and experience of the students and teaching staff are taken as the primary point of departure for the design of a new curriculum. This also creates higher levels of acceptance of the proposed programme.

Other indicators of Graham pertain to the educational design and implementation plan. She states that it is necessary that the core of the change is monitored and becomes visible in the designs of the intended programmes at the department level, such that a coherent change will be realised. According to Graham the best changes serve as a benchmark of enlightening good practices in the field.

Not everyone is willing and able to go along in the change process. Graham recommends not to persuade these "resisters" to adopt the change, but rather leave them doing what they do best. Yet ask them to make a small change that will support the bigger change. Note, however, that this strategy is only possible when there is a small amount of people who resist the change.

Key Characteristics for Sustainable Change

For sustainable change, shared ownership is required. This was also indicated by Stolk et al. (2008). Fullan (2011) points out that the changed elements in the educational programme, also called intrinsic drivers stimulating ownership, should meet four criteria for sustained and lasting change. The criteria are:

- To stimulate intrinsic motivation of students and teachers in line with the proposed goals of reform, meaning they contribute to a reform goal that is important to them.
- To engage educators and students in continuous improvement of instruction and learning as a meaningful and preferably personal contribution to others and society.
- To stimulate teamwork to realise capacity building driving permanent quality performance.
- To affect all teachers and students 100 per cent to realise systemic change.

Reform policies should thus include the following intrinsic drivers to realise sustainable change: (1) constructive alignment with student engagement, challenging topics and formative feedback loops to achieve higher order learning, (2) social engagement and learning with peers to improve the system, (3) pedagogy in the driver's seat for technological innovations and (4) a whole- systems approach. At the moment of writing, it is difficult to discuss the level of sustainable change as it seems the bachelor curriculum innovations have only recently been implemented. Yet we can use the criteria and intrinsic drivers of Fullan (2011) to get a grip on the sustainability of the change goals. Each of these intrinsic drivers meets the criteria for sustainable change and can thus be held as key characteristics that will eventually realise the intended curriculum.

1.2 Research Method

The research consisted of two consecutive phases. In the first phase, a short case description was composed of the intended curriculum of each university of technology. These descriptions of the intended curricula were based on available documentation Public and internal policy documents, project plans and other available materials were used to study the innovation process at each university of technology. This desk research methodology was used to prevent a further burden on those involved in the change process. Additionally, the follow up research is an extensive field research that will complement any missing information. Only if necessary, the desk research was supplemented by interviews with involved staff members. This choice at this point in the study limited the possibility for triangulation to validate our findings from different sources. Therefore, we have asked two references at each university to validate the chapters describing each institution. In addition to this, the 3TU.CEE leaders[2] were invited to provide feedback on this research document.

The generic design model of Wademan (2005) was used as an inspiration to get a grip on the description of the interventions and design principles used at each institute. This model comprises four phases, namely problem identification, preliminary identification, tentative products and design, redesign and refinement of product and theory. By using this conceptual structure, an accessible and readable structure emerged to confront our three comparative research questions; the last research question, which addresses the effect of the key characteristics, will be addressed in follow-up research. Additionally, the fourth phase of Wademans' model, redesign and refinement of product and theory, is beyond the scope of this study as the investigation is descriptive and comparative in nature. Also, most programmes have not reached the phase for a more elaborate description of a redesign yet.

In the second part of this study, a comparison was made of descriptions of the intended curricula at each university to gain an understanding of leading principles of design, as well as to show what typical interventions were realised in the bachelor curriculum innovation processes. Leading questions in the follow up will be to will be to what extent the proposed changes have been effectively implemented and if they positively influenced the learning outcomes in terms of the desired engineering profile.

[2] Dr. J. T. (Jan) van der Veen (UT, Chair), prof.dr. P.J. (Perry) den Brok (TU/e) and ir. A. (Aldert) Kamp (TUD)

1.3 Reading Guide

Each sub-study at the institutional level (TU-D, TU/e and UT) contains three overarching chapters:

1. Problem Definition; describing the sense of urgency to change and the stakeholders involved
2. Preliminary Investigation; describing the change process and educational leadership
3. Tentative Products; describing the intended characteristics of the proposed curriculum reforms

The study ends with a paragraph on the results, making a cross comparison on key indicators and demonstrating similarities and differences in the approach towards the bachelor curriculum renewal.

Finally, this report is concluded with a discussion of the research questions and the possible implications for learning and exploration at the 3TU level. Shared themes are also identified.

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2. Case Description TUD: Study Success

'Charting a Course for Study Success'

In this chapter, a description is provided of the intended bachelor curriculum innovation at the TU Delft. The description is based on the initial steps to come to a bachelor innovation process, the sense of urgency for different stakeholders, the organisational process for the first steps and an insight into the 'intended' curriculum at the programme level. It is based on the study of relevant internal documents[3] and a limited number of interviews (N=2).

The chapter reflects on the impulse that was given to study success as a result of increased pressure from the Ministry of Education, Culture and Science to settle on a number of 'performance indicators'. The most important parameter is the completion rate of 70% in 4 years for students who gained a positive Binding Recommendation on Continuation of Studies (BSA) in their first year and who entered the second year of their programme.

2.1 Problem Definition

Context—Early Warning Signals: Brakels Committee

In 2009 and 2010, the Brakels Committee (Brakels et al., 2011), as a preparation for the institutional accreditation and a review of the previous accreditation rounds, wrote an advisory memo on measures for study success: 'Towards a bachelor diploma in four years!' The memo explicitly addressed the government-issued report of the Veerman Committee (2010), (fig. 1). [4]

- Additional attention to selecting courses that discriminate between good and poor students. The selection of these courses should be supported by intensive coaching of students.
- Strict criteria for the realisation and production of minors, larger electives and less elective space within the curriculum.
- Minimal enrolment numbers in courses, minors, programmes and tracks.
- A decrease in Joint Degree and Erasmus Mundus programmes.
- Flexibility in rostering class contact timeslots (evenings are an option).

Figure 1: TU Delft, reaction to advisory report on institutional accreditation by the Mouwen Committee (2011)

On top of these, a package of measures is proposed by the Brakels' Committee that have a greater chance of positively influencing student pass rates (fig. 2).

- Modular blocks
- Compensatory assessment within and across courses
- Binding Recommendation on Continuation of Studies of 45 ECTS
- Embedding extra-curricular activities within the programme structure
- Measures to guide failing students to other studies

Figure 2: Proposed measures by the Brakels Committee (2011)

[3] The bibliography contains all consulted documents

[4] The Committee Brakels consisted of a number of internal stakeholder delegates

'Study Success' can be defined by three key characteristics as derived from the document study and the literature study of van den Boogaard (2015). The key characteristics have been a point of discussion and attention at Delft University of Technology for a long time:

- Student retention; students pass with a nominal study duration through the entire programme,
- Students are successful in passing a course
- Persistant student should be able to pass in a well organised educational environment;

Motive: Sense of Urgency

According to the memo 'Charting a Course for Study Success' (Tonino et all, 2011), of all the universities in the Netherlands, TU Delft has the lowest pass rate and retention rate. Only 22% of the students who pass the first year of their studies, succeed to obtain their bachelor degree within four years. Only 60% of TU Delft students are able to pass their course assessments the first time; 40% need to retake the assessment or their courses.

Stakeholder 1: Institutional Level

VSNU (Association of Universities in the Netherlands) and OC&W agreed in 2008 that 70% of the students who gained a positive BSA in the first year should complete the bachelor within four years. According to the steering group 'Study Success' and the Executive Board, this target could only be realised by a major change in study culture and pedagogical approach, including (CvB nota (2012):

- A more balanced study load;
- Educational staff professionalised in didactics, i.e. familiar with new ways of learning;
- Having a University Teaching Qualification (UTQ) certificate or exemption of the UQ on the basis of equivalent experience;
- Higher student engagement;
- Better matching (student–study track/intake procedure).

These educational improvements/innovations were not only intended for the improvement of study success in itself, but also seek to consolidate and improve the 'brand of TU Delft' as a high-quality research and educational institute, aiming for higher positions on international rankings. It is emphasised by the Executive Board that in terms of content, TU Delft is among the top-ranking universities, and there is no intention to question or discuss the content of the educational programmes at TU Delft.

In line with the above, the steering group 'Study Success' and the working group 'Didactics' defined directives and guidelines for programme design such as:

- Increasing the BSA norm in the first year of study from 30 to 45 ECTS from 2012 onward;
- Modular education units;
- More formative assessments and a limited number of summative assessment;
- Study load in congruence with the number of ECTS;
- Better regulations and monitoring of the bachelor/master thesis duration.

Stakeholder 2: Department and Programme Level

The sense of urgency experienced by the eight faculties varies as a result of:
- prior curriculum change. Some of them just finished right before this innovation wave;
- strong ties with external programmes as in the case of Life Sciences taught in conjunction with Leiden University;
- newly founded programmes, such as Nano-biology;
- the feedback from alumni and industry that the graduates are well qualified and the programme is positively assessed[5].

[5] Self Assessment report mid-term review 2014, 22 September 2014

Most faculties, however, took the bachelor education innovation initiative as an impulse to improve their education[6]
- to achieve higher pass rates and consolidate funding for high-quality education;
- to pressure delayed cohorts into finishing their studies more quickly and relieve high pressure on educational and sport facilities and housing;
- to embed more active learning methods;
- to modernise student coaching systems;
- to stimulate assessment for learning;
- to include blended learning as a means to make the roster more flexible for students and staff.

Stakeholder 3: Teaching Staff

Teaching staff felt the sense of urgency to varying degrees[7]. As student numbers increased over the past few years and staff capacity did not always grow accordingly, staff has been under pressure to work with larger groups. They prefer to have intensive contact and quality education with critical students. Organising teaching and learning to maintain the quality and increase the pass rate proves to be an enormous challenge.

Performance pressure in education/research and valorisation has stretched the workload for scientific teaching staff to the limits of their capacities. Another bachelor innovation was not exactly what they were hoping for.

Stakeholder 4: Students

Students were not averse to measures of study success and were in particular pleased with guidance and planning measures to support student learning, especially in the first two years of their studies. They were also in favour of education in smaller groups and bachelor thesis projects, which are doable within the nominal study duration (ORAS, 2011).

Many of them questioned the added value of replacing mono-disciplinary courses by larger integrated modules. The directives given by the project group Study Success to reduce the number of parallel courses to two or three at the same time was based on arguments of increased transparency, better cohesion and more focus for the students. Students, however, feared that it would cause even more delay in their studies because of the bigger impact of failing one large module. Similarly, they were concerned about the prescriptive nature of a BSA and the emphasis on exit strategy for students who already had a hard time adapting to a new life in the first year of their studies. Another concern that was expressed by the students was about the compensatory assessment, which in their belief might lead to a drop in quality of the TU Delft engineer when the study result of courses with engineering rigour can be compensated with results achieved in 'softer', less fundamental courses. Finally, students wondered about the didactic qualities of the lecturers (also expressed in relatively low appreciations in the annual National Student Surveys), as they too often have to listen on a mandatory basis to lecturers with bad didactic performance, who add little to their learning and do not challenge their critical attitudes.

Surprisingly, the students did not discuss any impact that the emphasis in the bachelor innovation process on pass rates and study duration could have, in a positive or negative way, on their own study behaviour, personal development or the qualification of the graduate. They assume that a TU Delft engineer has a thorough foundation in knowledge, is involved in society and societal problems, is independent and has an academic attitude.

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[6] Faculty blueprints have been studied to obtain an overall impression. Two thirds of the available blueprints (n=12) literally stated that they used the change to implement additional changes. These blueprints have not been included in the reference list.

[7] Informal conversations dir. of education and review report of Mouwen Committee

2.2 Preliminary Investigation

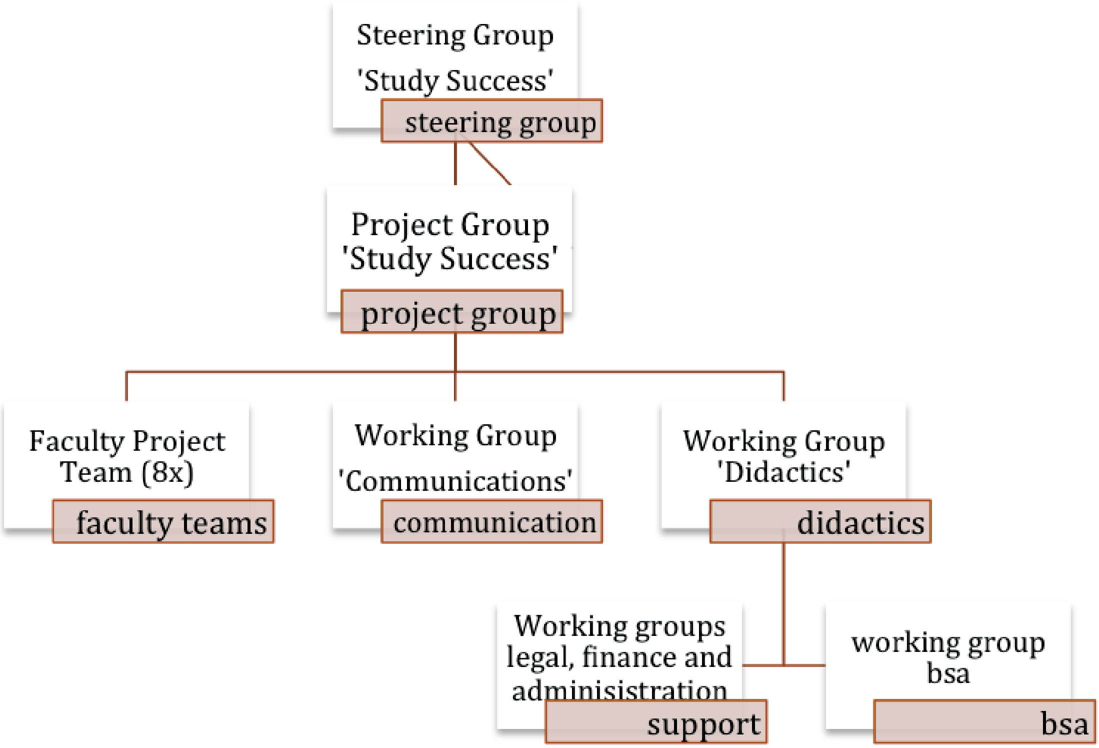

Figure 3: organisation of bachelor curriculum innovation process

Initiative and Process at Institutional Level

Initiative

In 2011, the Vice President of the Board of Education gave the assignment to the Director of Education and appointed a project leader to come up with a project plan. This plan included the organisational set-up and roll-out of the bachelor innovation process based on the advisory memo of the Brakels Committee.
Beside the steering group 'Study Success' and working group 'Didactics'[8] already mentioned in the above, a project group 'Study Success' was established, together with a number of other support groups.

Decision-making

The steering group 'Study Success' had a member of the Executive Board, the Head of Education & Student Affairs, and two senior full professors gave advice to the project group. The Vice President for Education & Operations of the Executive Board chaired the steering group. The group gave advice to the project group 'Study Success' and was the interface with the Executive Board. The steering group took care of the leadership and structure for the complex of measures to be taken.

The project group 'Study Success' was responsible for the realisation and operationalization of the project results on content, process and planning. The project group reported to the steering group and was also responsible for the communication between other working groups and the steering group. The departmental project teams had to report periodically on implementation progress, improvement of pass rates, etc.

[8] The working group didactics is in formal English working group pedagogy. However, to remain close to the original documents the term "didactics" has been kept despite the implications of the terminology.

The working group 'Didactics' was the sparring partner for the project teams at the faculties. The working group established the boundary conditions for modular education, assessment and study load. The group provided guidelines and hints on how to improve the curricula in the best possible way, by providing evidence-based information on, for example, efficient in-class contact time, student motivation, etc. The group consisted of Directors of Education, lecturers, educational advisors and staff and students.

'Pilot'

Prior to the bachelor curriculum innovation of the entire university, the department of industrial design had redesigned its bachelor programme in modules of 7.5 ECTS with integrated disciplines across the bachelor programme. Student pass rates increased dramatically during the first year. The structure of the industrial design programme was, therefore, an example and showcase. Additionally, the literature review confirmed the benefits of modular programme structure on student pass rates.

Initiative and Process at Programme Level

The departmental project teams were responsible for the implementation of the project within the agreed-upon deadline and ultimately decided the quality and feasibility of implementing the curricular conceptual plan. Its Dean appointed each departmental project team. Most departmental project teams consisted of supporting staff on education (Programme Director, educational advisors and occasionally an academic counsellor), scientific staff with an active role in the educational organisation (e.g. in the Board of Studies) and student representatives.

Participation, Organisation and Support Base

The working group 'Communications' was involved in timely communication on behalf of the project towards all project teams and stakeholders within the community of TU Delft. It organised lunch meetings to inspire the department staff with good practices and information to support the curricula reconstructions and improve their design. If desired, the department staff could get support from the educational support unit or money to hire an external advisor and education support experts from outside the university.
Deans and educational directors were informed via the regular staff meetings. Occasionally, a session that elaborated upon the state of the art with respect to the implementation was held to realise reciprocal feedback. Faculties had and have regular meetings to discuss their progress on the prescribed framework and student pass rates.

The working group 'Legal, finance and administration' was responsible for the matching of financial, judicial and administrative areas within the project and the realisation of the proposal of the legal department of the educational reforms. Last but not least, the working group 'BSA' was responsible for information to students and faculties on the binding recommendations on continuation of studies (BSA). It prepared the policy and implementation measures to increase the BSA from 30 to 45 ECTS and initiated discussions on department policies for students who were 'at the edge' of achieving the BSA of 45 ECTS.

Objectives

The objective of the bachelor innovation is clearly stated in the memo 'Charting a course for study success' and is aimed at increase in study success: 85% of the students who passed the BSA (binding study advise) of 45 EC pass the bachelor in 4 years.
The objectives at the department level depend on the vision explicated in the blueprint and in general have not been defined in a SMART way.

2.3 Tentative Products and Approach

Initiative & Timeline/Phases in the Innovation Process

The initial project document of the project group 'Study Success' to start the bachelor innovation process was issued in August 2011[9]. It included the activities listed in table 2 below.

The initial document 'Charting a course for study success' defined the development planning to be met by each department. It concerned the introduction of the new modular bachelor curriculum, including minors, within the time span 2013 – 2014. More specifically, the faculties were advised to have the full three-year programmes up and running on September 1, 2013 or by September 2014 at the very latest. Time to prepare the new curricula was only a little more than one year. Students and administration had to be informed one year ahead of the implementation with respect to the changes in the programme. These changes could for example be the learning objectives, content, working methods, assessment methods, transition procedures for students from the old to the new programmes and administrative cues to run a logistically smooth organisation.
The project was supported by Education and Student Affairs staff and partially financed by 3TU budgets.

Activity	***Finalisation/ Implementation***
- *Project document Start up*	- *August 2011*
- *Kick off project Study Success*	- *September 2011*
- *Advise working group 'Didactics'*	- *July 2011*
- *Advise working group 'Legal Finance Administration'*	- *July 2011*
- *1st activity plan faculties*	- *July 2011*
- *Definite activity plan faculties*	- *November 2011*
Implementation:	- *Between 2011–September 2015*
- *Re-evaluation programmes*	- *September 2013*
- *Modular education/compensatory assessment*	- *September 2013*
- *Binding Recommendation on Continuation of Studies 45 ECTS*	- *September 2012*
- *Extra-curricular activities*	- *Per direct*
- *Determination of master thesis procedure*	- *September 2011*

Table 2: Timeline of the innovation process

[9] This is based on the date on the project initiation document

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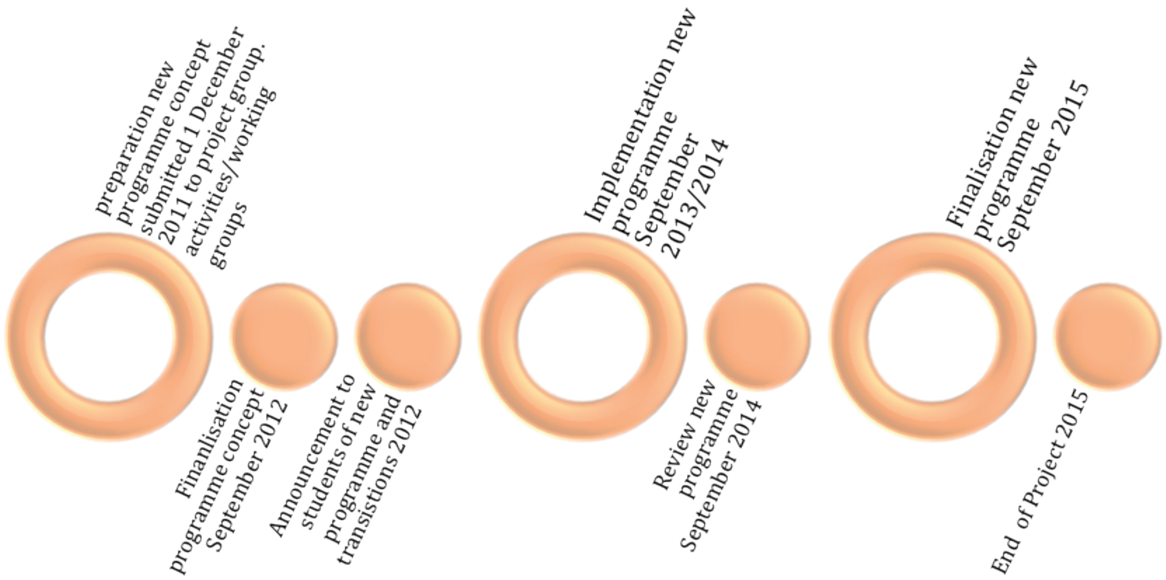

Figure 4: Overview timeline project Study Success

Intended Curriculum

The requirements on the new bachelor curricula were based on the assumption that: (1) only justified didactic changes had to be made to realise greater pass rates and (2) the contents of the programmes were 'good'. As we have already seen in the chapter about the Sense of Urgency in Section Stakeholder 1: Institutional Level, the didactic changes focussed on the following requirements, laid down in the document 'Charting a course for study success':

- Modular courses of min. 5 and max. 10 ECTS with efficient use of class contact time
- Max. two to three courses at the same time of which the duration is max. 10 weeks
- Constructively aligned modules which are to some extent independent of other courses
- Didactic concept determined at course level
- Team teaching and cooperation across modules to stimulate coherence in the programme if necessary
- Contact time is approximately 12 hours, in general, with activating teaching methods
- Compensatory assessment within modules
- Only two summative assessments per 2.5 EC
- limited re-sits and assessment early in the programme
- BSA of 45 ECTS
- Rebalanced curricula in which study load is representative for the number of ECTS
- Study Planning rosters available for students

Figure 5: Requirements for the didactic changes

Structure
Each semester has four periods of five weeks, which can be clustered to a maximum of 10 weeks per module. Depending on the programme structure of two or three parallel courses, the size of a modular course is 5 to 10 ECTS. The bachelor thesis is an exception to this rule. The number of summative tests and re-sits is one summative test per 2.5 ECTS and not more than two summative tests per week.

Educational Model
The document 'Charting a course for study success' does not only comprise 'Requirements', but also makes a number of additional recommendations with respect to the possible ideal design of the courses. One of these is that modules are supposed to be partly or completely integrated, which proposes that the replacement of a mono-disciplinary approach should be by thematic organisation of content within a course. Systemic cross-disciplinary perspectives are used to integrate different course materials, which are constructively aligned in learning objectives, working methods and assessment. Active learning and self-study are more or less obligatory parts of the planned study time. The contact time amounts to 12 hours, and the remainder is spent on self-study and project work/practicals/guided assignments, etc. Formative feedback loops are essential to optimise the learning process, and therefore lecturers are asked to include a formative assessment in each module. Finally, compensatory assessment is stimulated within a module to realise optimal participation in the learning process and a limited or conditional re-sits.

Design of capstone courses, electives in the programme, honours programmes and blended learning as a part of the curriculum are essentially decided by the department or in cooperation with central projects on these topics. They are, however, not a primary part of the curriculum innovation process.

Assessment & Re-sits
The assessment is limited per quarter (10 weeks), including one summative assessment per 2.5 ECTS and not more than two summative tests per week. Considering that there are 15 ECTS per semester, the maximum number of summative tests is six, allowing for compensatory assessment within a course. Re-sits are typically limited to one immediately after a module (five weeks in the next semester) and/or at the end of the year. The re-sit at the end of the year (August) allows for a maximum of three to four summative assessments for each student. The intention is that students are stimulated to study regularly and receive an incentive to realise 'on task' behaviour. Formative assessment should take care of regular feedback to students on their progress with or without bonus points to realise intended behaviour. Other student support measures to monitor student progress, like tutor/mentor programmes, extra study advisor meetings and pre-structured planning to help students are stimulated.

Blueprints at Programme Level
The blueprints for the reformed curricula were based on the project plan and initiated by the department's educational management staff and elaborated in further detail by Department project teams and or task forces within each department, taking 'Charting a course for study success' as the guiding and imposing principles. The freedom to optimise the structure and content of each programme was high. It created a bottom-up approach to the curricular reconstruction and realisation of the improvements with open design criteria.
Most departments stated the innovation process was a chance to upgrade the structure and didactics in the curriculum:

- Optimising the fundamental lines of advancement and cohesion and some embedding of a thematic structure
- Stimulating regular study behaviour, by structured guidance in scheduled activities
- Realising active education in and outside the lecture hall (balanced class contact time, variation in working formats, etc.)
- Prevention of procrastination (coaching on self-study and planning in case of exam failure)

- Increasing student and lecturer engagement and motivation
- Some sharpening of the Final Qualifications of the programme in relationship to the demands of the labour market

Some faculties used it for:

- Increasing the integration of authentic problems and case studies
- Increasing the flexibility of education by offering time or location-independent (online) education, thus also trying to decrease the workload for the lecturers, via blended learning

Examples of Intended Curriculum at Department Level

Not all blueprints showed compliance with the directive of large integrated modular blocks of 5-7.5 or 10 ECTS. There was a wide range of modular block size in the intended programmes, from 3 to 14 ECTS, which resulted in educational period build-ups of 3+6+6 ECTS or 3+4+8 ECTS. Often the argument not to comply with the large integrated modular blocks was:

- loss of discipline visibility
- co-operation with other universities/programmes
- recent reform of the bachelor curriculum just completed
- newly established bachelor curricula with other universities incompatible with the new requirements in Delft

As the TU Delft 'Charting a course for study success' curricular reform focused on enhancing study success by primarily 'technocratic' modifications, the reform has not resulted in a joint reconsideration or update of the qualifications of the bachelor graduate or an updated profile of each programme. For example, the differentiation between fundamental sciences, applied sciences and engineering sciences very much depends on the profile of the study and vision of the engineering graduate in each programme. It shows, for example, that applied sciences considers its students fundamental scientists and addresses research skills at an early moment in the programme. On the contrary, mathematics provides a fundamental core, but leaves some room for electives to provide students freedom in the way they want to develop, and technology policy and management (TPM) focuses on an engineer who should be able to address engineering problems in a societal context and therefore pays a lot of attention to authentic problem-solving and applied sciences. The pie charts reflect these particular visions in the time (EC) spent on, for example, fundamental science in applied physics, which is much larger compared to TPM, where the applied sciences and skills receive a much more prominent place in the programme.

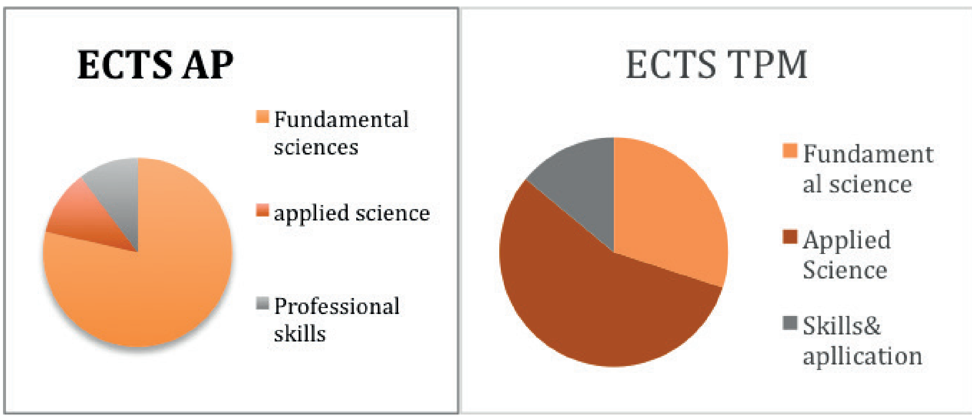

Figure 6: relative ECTS division

Summary TU Delft

The directives and guidelines that were issued by the project group 'Study Success' were based on a literature review of didactical measures, which were researched in an evidence-based way in educational sciences. One of the prime recommendations to enhance study success in a collaborative effort has been the argument that singular measures do not yield the desired results. This led to the strategy to initiate a package of measures to increase the synergy between separate initiatives (van Berkel et al., 2012).

In the TU Delft bachelor curriculum innovation process, the approach has been collaborative. All the working groups and activities were logically and pragmatically realised to maximize the efficiency and effectiveness of the implementation of the proposed measures. Each of the measures was addressed in each bachelor programme, irrespective of its profile. As agreed upon with the Board of Directors, the intervention focused on technocratic changes and has not or negligibly affected the content, vision of the engineer and disciplinary expertise in each programme. Each programme thus had the liberty to reform the curriculum within the set of predefined constraints to best fit their needs and educational context. The 'bottom down' approach allowed the faculties to embrace the change process and remain the co-owners of their programme and avoided an un-surmountable resistance against the changes in curricular structure and other didactical measures. Whether the intervention will yield the target of '70% of students completing their bachelor in 4 years' is still an open question. Most students who started the new programme still need to finish. The first prognoses indicate a positive trend.

3. Case description TU/e: Bachelor College

'Design your own future'

In September 2012, the TU/e Bachelor College was launched. The main goals of this innovated bachelor are to educate engineers for the future, to attract a larger and more varied student population with more female students and to increase success rates.

In this chapter we provide a short overview of the creation, development and implementation of this new bachelor curriculum. The following description is based on existing documents of the executive board, the taskforce bachelor innovation, the Bachelor College Project Management Team and the existing Programme and Examination Regulations. The references of the consulted documents are available in the bibliography.

3.1 Problem Definition

Context

Within the Eindhoven University three issues were motive to initiate the bachelor curriculum innovation. First of all the university had problems in the area of student intake. Secondly the success rates (i.e. Graduation rates) were below the universities own target and much lower compared to others Dutch universities. Third, Political and social expectations were not met (Veerman, 2010).

Only 35% of students who re-enrolled after the first year achieved a diploma within four years after starting their programme. The TU/e has the ambition to double this percentage to 70% in 2020 (TU/e 2020, 2011).

The university wants to build an attractive bachelor programme in which students who take their study seriously can obtain their bachelor's degree in three years. The programme has to meet the increasingly differentiated educational demands of prospective students and the increasingly differentiated demands placed on engineers in the labour market and in society in general. Incremental measures to increase student intake and success rates had not led to improvements before.

To create a curriculum that fits a wider range of science students and educates future engineers, a more fundamental and cohesive approach was chosen to approach the problem.

Motive: Sense of Urgency

Stakeholder Level 1. Institutional–Executive Board

The bachelor innovation was thus originally initiated to attract more students and a more varied student population. Every student with a suitable science profile should, with hard work, be able to successfully complete the bachelor programme at the TU/e.

The TU/e had several ambitions for the bachelor education (Taskforce redesign Bachelor College, 2011):

- Educating engineers for the future
- A larger and more varied student population (+50%)
- Higher success rates (70%)
- More female students (at least 35%)

Stakeholder Level 2. Department and Programme

At programme level, especially the small programmes were threatened in their existence. A decreasing student population, disappointing success rates and, for some programmes, low scores on the National Student Questionnaire (NSE) were reasons to invest in an institution-wide curriculum reform. (Taskforce redesign Bachelor College, 2011).

Stakeholder Level 3. Teaching Staff

The consulted documents did not provide evidence for a sense of urgency for the teaching staff.

3.2 Preliminary Investigation

Initiative and Process at Institutional Level

Initiative

The bachelor curriculum innovation was initiated by the executive board in 2011. with the assignment of a taskforce 'Redesign Ba-curriculum'. The taskforce consisted of five professors, four students and two educational directors and was chaired by an independent external expert. An educational policy advisor was appointed as secretary of the taskforce. The taskforce had the mission to devise with a redesign to reverse the negative trends mentioned earlier.

The following elements were starting points for the reform:

- The TU/e offers bachelor programmes that appeal to different types of beta students. (fig. 7)
- The TU/e offers student-centered education.
- Every student with a proper pre-university science diploma (NT/NG-profile) has to be able to complete the bachelor in four years with reasonable effort.

The taskforce was asked to give advice and recommendations for a redesign and to report them to the Executive board.

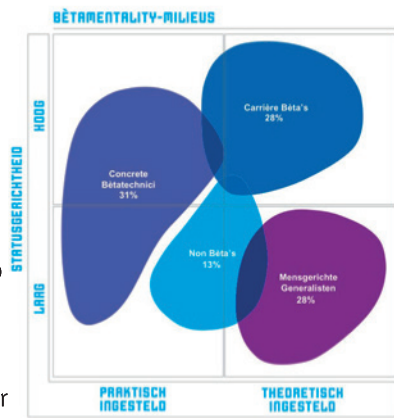

Figure 7: Beta Mentality Model

Taskforce 1: Redesign Ba-curriculum

The taskforce started with a problem description and a brief literature review. After this, market research and research within the TU/e population was conducted. Good practices of other universities such as MIT (Boston, MA, USA), Syracuse University (Syracuse, NY, USA), Utrecht University and Leiden University were also used as an inspiration.

The taskforce concluded that the TU/e could and should broaden its market by making the curriculum more attractive to the 'career betas' and the 'people-oriented generalist betas' too (Motivaction & YoungWorks, 2010) because future engineers are more than mere scientists (Meijers & den Brok, 2013).

- Every engineer is multidisciplinary; has a 'unique selling point' or specialism; 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.
- The completed TU/e program is only the starting point for the engineer, preparing him or her for a career of continuous innovation and development.

Figure 8: Profile of Future Engineers (Taskforce Redesign Bachelor College, 2011)

Decision-making

In June 2011, the taskforce Redesign Bachelor College delivered its advice in the final report 'A future-proof and student-oriented Bachelor's phase for Eindhoven University of Technology' (Taskforce redesign Bachelor College, 2011). This advice was adopted by the Executive Board and served as a basis for the implementation of the Bachelor College. The intended Dean, Prof. Dr Ing. A.M.C. (Lex) Lemmens, was assigned by the Executive Board. The Dean's mission was to lead the intended bachelor innovation and to build an organisational structure for the TU/e Bachelor College. Within this trajectory, quality assurance and programme standards were focal points.

The dean performs his tasks as a programme manager in close consultation with (and supported by) a Reform Implementation Taskforce of bachelor programmes.

Objectives

As stated earlier, the main goals of the bachelor innovation are (1) to educate the engineer of the future, (2) to attract a larger and more varied student population with more female students (35% at least) and (3) to realise higher succes rates (70%). A diversification of the educational programmes is necessary to realise this.
The main points for the implementation of the bachelor innovation for 2013-2016 were (Bachelor College, 2012):

- Successful implementation of the reformed programmes;
- Maintaining the high level of student satisfaction, as evidenced from student evaluations for each programme in the NSE and course evaluations;
- Increase the student intake into the bachelor programmes from 1190 in 2011 to 1540 in 2016 (and to 1700 in 2020);
- Strong improvement of student success rates (more than 55% of re-registering after the first year of completing the programme within four years after the start (and 70% in 2020);
- At least 10% of students stand out as excellent through various challenging programmes;
- Strategic Areas (Energy, Health and Smart Mobility) are well anchored in the bachelor programmes through coherent packages and/or certificate programmes.

Initiative and Process at Programme Level

The Bachelor College Programme is based on design rules (see also appendix 1). These design rules, established by the Executive Board, differ slightly from the advice made by the Taskforce Ba-redesign. The differences are, for example, the distribution of the credit points per element of the curriculum (figure 9), 5 EC reduction of USE education and adding 5 EC to the major by embedding the professional skills in the major.

The 'Programme Plan Reform Bachelors' of September 29, 2011, consisted of the guidelines for the implementation process. This was the basis for the implementation plan, the roadmap to realising the Bachelor College. Seven tracks were defined within this roadmap, and every track consisted of multiple projects. The assignment for this project was the release of specific and concrete advice for the implementation of the reform, but aimed for creating commitment within the organisation as well. The project teams consisted of a project leader (programme director/director of a service department), secretary (was a member of the Programme Management Team, linking pin), employees and students.

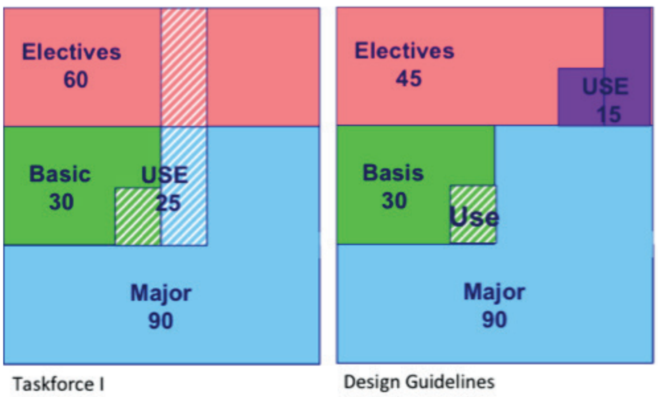

Figure 9: difference between initial taskforce design and design rules

Participation, Organisation and Support Base

Creating a firm support base was important during the entire innovation process. TU/e employees had the opportunity to inspire the taskforce by e-mail. Next to this, students and employees were asked to participate in every step of the process. The taskforces kept working on this support base in several ways:

- By consulting a Student Think Tank, which gave ideas about improving the studiability of the TU/e-programmes.
- During the implementation process, lecturers, students and policy makers participated in all the projects.
- The first taskforce transformed into the Advisory Board Bachelor College for taskforce II (Implementation).
- The dean of the Bachelor College consulted students formally once a month through the SAO (Student Advisory Board) and informally through so-called 'krokettenlunches'.

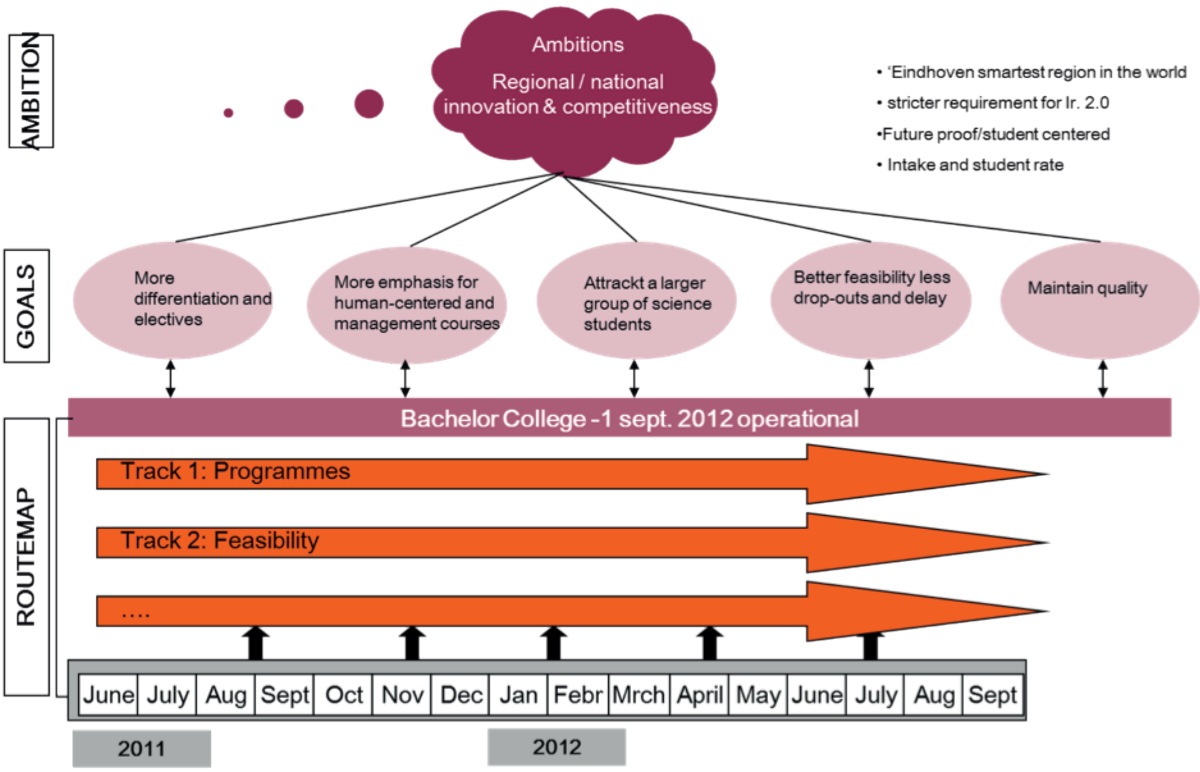

Figure 10: illustration of the redesign process (presentation Twynstra & Gudde, 29-6-2011)

Role	***Task/Responsibility***	***Phase***
Executive Board	Initiation and client	All
Taskforce Redesign Bachelor Curriculum	Contractor in initial phase	Initiation/proposal
Advisory Board Bachelor College	Advisory board	Implementation and beyond
Taskforce II (Implementation)	Expert panel for the programme management team and create support	Implementation and beyond
Student Think Tank	Advisory student body	Initiation
Programme Management Team	Management of the innovation	Implementation and beyond
Dean Bachelor College	Manager bachelor innovation programme and organizational implementation of TU/e Bachelor College	Implementation and beyond
Programme Director Council (OO)	Feedback on the project recommendations	Implementation
University Consultative Council (BO)	Feedback on the project recommendations (depending on topic)	Implementation
Managing Director and Director Council (WOB)	Feedback on the project recommendations (depending on topic)	Implementation
Student Advisory Body (SAO)	Feedback on the project recommendations	Implementation and beyond

Table 3: overview of different types of stakeholders

3.3 Tentative Products & Approach

Timeline: Phases in the Innovation Process

The executive board started the innovation process in January 2011, with the assignment of the first taskforce. At this moment (February 2015), the entire bachelor curriculum has been redesigned. The first students will graduate this academic year. The scheme below illustrates the different steps in the development of the new bachelor college.

	2011	2012	2013	2014	2015
Initiation phase	Task-force 1				
Design & development phase	Taskforce 2				
Implementation		Start Y1	Start Y2	Start Y3	
Evaluation & redesign			Y1	Y2	Y3
Evaluation / Embedding					Entire Bachelor

Table 4: Timeline innovation process

Intended Curriculum

Focus & Principles

As stated in the objectives, the main focus of the bachelor curriculum innovation at the TU/e is a differentiation of the educational programmes in order to attract a more varied student population and to deliver more varied and future-proof bachelor graduates.

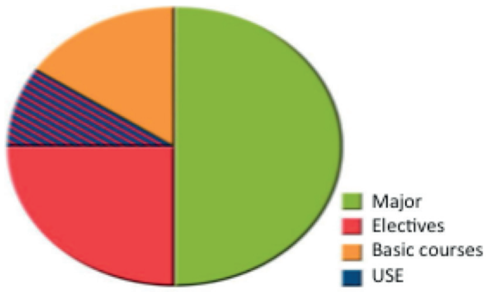

Figure 11: Visual of TU/e bachelor curriculum

The TU/e redesign focused on the structure of the bachelor programmes, coaching the students and feasibility of the programmes. The TU/e Bachelor College offers a structure in which every student can follow his/her own course. Bachelor students receive coaching from registration to master's choice. Not only will attention be given to academic counselling but also to the guidance of personal development and the development of a personal identity as an engineer. A programme is considered feasible by Taskforce I if a student with a suitable science profile, with hard work, is able to successfully complete the bachelor programme at the TU/e (Taskforce redesign Bachelor College, 2011).

Structure

Every student follows a unique path (Bachelor) of at least 180 EC. The bachelor curriculum consists of four elements:

1. Basic Courses (30 EC) – a joint base for every 'TU/e engineer'

The TU/e curriculum has a joint base that consists of six courses reflecting the various dimensions of 'TU/e engineers': These basic courses are mathematics, applied natural sciences, modelling, design, USE basic and professional skills. With the exception of professional skills, every basic course has three different variations at the most. All bachelor students take a basic courses at the same time.
The USE-base contains a number of generic elements that every engineer should know. The professional skills course is not an actual course, but is embedded in the major programme and visible as a separate administrative unit.

2. Major (90 EC)

The major of 90 EC is the core of the bachelor curriculum. Every major has to provide access to at least one master without the requirement of other courses. In the innovation process all majors were redesigned because of the new structure. The major used to encompass a larger part of the entire bachelor programme and a standard course size of 5 EC was introduced. In the old bachelor, most courses had a size of two or three credit points whereas in the Bachelor College, every course has a size of five credits[10].

3. Free Electives (45 EC)

Twenty-five per cent of the bachelor curriculum consists of electives. Students can freely select courses from the university or beyond. Students receive support from their coach with the process of choosing courses. This makes the bachelor programme flexible and gives the different types of students the opportunity to create their own path.

4. Restricted Electives: USE (15 EC) (balance between technology and society)

The underlying philosophy of USE (User, Society, Enterprice) is that the TU/e educates future engineers. These engineers will operate within a multidisciplinary environment. The overall learning objectives of USE are:
- Knowledge of ways of thinking in areas of social sciences, management and humanities
- To be able to apply this knowledge in a relevant technology area
- Be able to work with the broad definition of technology in at least one of the three distinct USE perspectives

[10] This is a student workload of 140 hours

Every USE learning pathway is based on a USE-topic, in which the interaction between technology and environment is clear. A learning pathway consists of three sequential courses: exploration, deepening and application. Students need to select one USE learning pathway out of ten. This selection also implies a choice of a topic and a USE perspective (U, S or E).

Educational model

The Bachelor College TU/e focuses on all young people with beta talent, including the so-called 'career betas' and 'generalist betas'. The TU/e does so by making its education more attractive, more challenging and more promising for different types of pre-university beta students (Bachelor College, 2012).

The reformed bachelor programmes include a major of 90 credits, a basic component of 30 credits and an elective element of 60 EC for restricted electives (a USE-component; 15 EC) and free electives (45 EC).

The elective coherent packages of 15 credits are disciplinary as well as interdisciplinary, offered around challenging topics such as the strategic areas, areas the TU/e focuses on in its education and research. Students may use electives to deepen their own disciplinary knowlegde, to explore other disciplines or to get acquainted with a multi-disciplinary approach. They can steer their own professional development. New majors are offered to attract existing and new audiences. Teachers provide adequate coaching so that informed choices and coherent study paths occur.

Professional and Academic Skills

In an ever-changing work environment, five professional skills are relevant for every engineer of the future, namely:

- Communicating (verbally and in writing)
- Cooperating
- Reflecting
- Planning and organising, and
- Searching and working with (scientific) information.

The student's academic discipline (the major) is the context for the development of these professional skills. Skills are therefore linked to the content of the major but remain recognisable. The professional skills have a total workload of 140 hours (5 EC). The assessment of professional skills is part of the assessment of the course, Design Based Learning (DBL) or project. This implies that students do not receive separate credits for professional skills. The written reflections of the student and a progress overview, are in a digital file (e-file), which can be seen by the student and authorised coaches.

Coaching

Counselling and coaching is a very important part of the curriculum innovation. To realise student centered education students should be challenged to think about their own decision making process, motivation and attitude. This requires coaching and tutoring. A call once every six months is not enough to bring about this awareness. The goal of the coaching process is to facilitate students in the development of their own personal identity as a future engineer. The coaching focuses on the decision making process in relation to the students' personal goals. Several types of counselling and guidance are available during students' academic careers:

- Coach: During the entire bachelor, a student has a coach. This coach is a teacher from his own major and has four coach sessions with the student during the first year.
- Student mentor: in the first semester of the first year students are mentored by a student from their own major.
- Student advisors and counsellors are available for students whenever they need specific guidance.

To enable the coaches to perform their task, workshops and guidelines were made by the project team involved.

Excellence & Differentiation

The new honours programme for bachelor students is accommodated in the TU/e Honors Academy. The objective of the Honors Academy is to prepare students for personal as well as professional leadership. The programme has two phases, each with a size of 15 EC. The programme is an addition to the students' regular bachelor programme.

The TU/e vision on excellence is that every employee and student should be stimulated to develop talent and act on this talent. Excellence means the will and the capability to rise above yourself and to push your own limits. The honours tracks offer an inspiring environment for talented students, with projects that put the students in the driver's seat, with room for students to follow their own interests, develop their talents and make their ambitions come true.

Based on this vision, six honours tracks were specified by the three strategic areas and three multidisciplinary research institutes: Empowerment for Health & Wellbeing, Energy Transition, Smart Mobility, Multiscale Science and Engineering (EMI), The Scientific Debate (ICMS) and Light Force (ILI) (Bachelor College, 2012).

Assessment & Resits

To improve the feasibility of the bachelor programmes, a couple of measures were taken with respect to assessments (design framework, 2011):

- Limited resits; one second chance and then redo the entire course. To limit the participation in re-sits, an admission requirement for the re-sit exam is that the student must have at least a 4 for the first try. This prevents insufficiently prepared students to come to the first exam or to postpone the exam to the re-sit period. When a student doesn't pass the re-sit exam, they must take the entire course again in the subsequent year (including assignments and intermediate tests).
- Compensatoir testing within courses is introduced. A maximum of 70% of the end result is defined by the final exam. The introduction of this measure is to get students started right at the beginning of a course and to distribute student workload.
- Compensatory testing between alligned courses is stimulated to improve the studiability of the major.

Other

Interdisciplinary and Multidisciplinary Education

In the free electives component, coherent packages of 15 credits are offered, disciplinary as well as interdisciplinary, around challenging topics such as the strategic areas. Students may use electives to deepen their disciplinary knowledge or even in order to broaden. They can give direction to their training and development to a unique professional self.

In September 2011, the Bachelor College Innovation fund set out a specific call[11] to stimulate the development of interdisciplinary packages. With this, the first interdisciplinary packages were developed, for example, in the areas of Game Design and Energy.

Programme to stimulate ICT in education

To stimulate the use of ICT in education a programme on ICT in Education (PICTO) is launched. Goal of the programme is to lower the barrier for lecturers on using ICT in their education. The programme is a collaboration of services with expertise and budget for this cause. This element is connected to the redesign of the Bachelor Curriculum, but not a part of the redesign.

Scheduling and Timeslots

The Bachelor College works with a new time table skeleton, a uniform academic calendar in which the different types of courses (major, basic, electives and USE) have a fixed place. This reduces possible overlap in time between subjects and ensures freedom of choice for students. Timeslots consist of two times four reserved hours per week that teachers can use as contact hours for their course (Fig. 12).

[11] http://w3.tue.nl/nl/onderwijs/tue_bachelor_college/informatie_voor_docenten/innovatiefonds_bc/projectdefinitie_innovatiecall_2011_2012/

Uur	Tijd	Maandag	Dinsdag	Woensdag	Donderdag	Vrijdag
1+2	08.45-10.30	A	C	B	E	D
3+4	10.45-12.30	A	C	B	E	D
pauze						
5+6	13.45-15.30	B	E	D	A	C
7+8	15.45-17.30	B	E	D	A	C
pauze						
9+10	18.45-20.30	D	A	C	B	E

Figure 12: illustration of timeslots (Bachelor College, 2013)

Intended Curriculum at the Programme Level

Within the general design guidelines for the Bachelor College (appendix 1), the departments were asked to (re)design their own major and major courses within these guidelines. This had to fit within the timeslots dedicated to the major courses and has a size of 90 EC (95 including the professional skills).

Every major first handed in a short description of the major courses, and after this a more elaborate version. The elaborate version also included learning objectives for the bachelor as a whole, a specification of the first year major components, a plan for embedding of the professional skills and an overview of the electives and coherent packages a major was going to offer.

This resulted in 15 majors in the Bachelor College, including two new ones (psychology & technology, IE&IS department, and medical sciences and technology, BMT department). The charcoal sketches of every major are included in appendix 2.

4. Case Description UT: Modular Project Education

'The T-shaped professional'

In this chapter, the bachelor innovation of the University of Twente is described. The description made below is mainly based on existing documents from the Executive Board, the bachelor innovation taskforce, the bachelor innovation Programme Office and the University Council.
Supplementary information was obtained by interviewing several people directly involved in the bachelor innovation and conversations with department staff members.

4.1 Problem Definition

Context

Several measures and events possibly influenced the design and implementation of the bachelor innovation and its effects. One event that had a large influence at the University of Twente was the appointment of a new Rector Magnificus (Prof. Dr H. Brinksma) at January 1st, 2009. At his appointment, he announced his plans for a strong focus on innovation and improvement of education at the University of Twente.

About a year later, the Veerman committee (2010) presented their report to the State Secretary of Education. As a result of this, discussions about profiling universities were held nationwide.

At a later moment, several government measures related to education and success rates were added to this. The Ministry of Education, Culture and Science (OC&W) established performance agreements (University of Twente, 2012) with all institutions for higher education in the Netherlands. For the University of Twente, this agreement comprises several indicators relevant for the bachelor innovation. As from 2020:

- at least 10% of the UT students participate in an excellence programme.
- the drop-out rate in year one is 20% or less.
- the bachelor study 4-year completion rate of the remaining group is 70% or higher.
- the number of contact hours in every education week is 20.

Other measures that might have an influence are the implementation of the binding recommendation on continuation of studies (BSA) in academic year 2012–2013 and the implementation of the 'bachelor before master' rule in the same year. The 'long-term student fine' (academic year 2011–2012) that was abolished after less than one year also had a temporary effect on success rates.

A planned measure that could influence the effects of the bachelor innovation is the abolishment of the basic grant from September 2015.

Besides the bachelor innovation, several other large educational projects were taking place at the university during the period 2010–2014, also having an impact on the organisation and workload of management, teaching and support staff. Examples are:
- IKS: institutional quality assurance in preparation of institutional audit- TOO: improvement of educational support organisation and systems supporting the new bachelor curricula
- Atlas: setting up a university college integrating technical and social sciences

Motive: Sense of Urgency

Stakeholder level 1. Institutional–Executive Board

The bachelor innovation at the University of Twente was originally initiated from a content-related vision on education[12]: the broadly educated and flexible engineer; the T-Shaped Professional (figure 13).

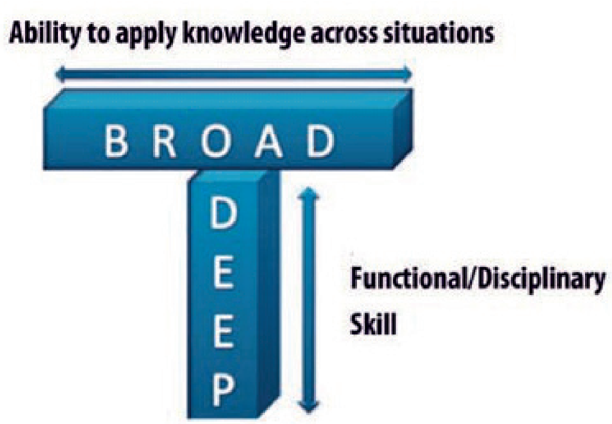

Figure 13: T-Shaped professional (University of Twente, 2012)

In today's (working) society, the connection between education and function is loosening, also for engineers. This leads to the necessity to educate students, keeping the increasing mobility within functions in mind. The new engineer needs depth as well as breadth, is able to integrate technology with societal context and is a continuous learner.

The UT aims to educate experts that can make a difference in the competition with automation and well-educated engineers from abroad.

Motives that were added in a later phase are:
- The emergence of online learning and the need to stand out in the market with demand-driven education
- Study and drop-out rates: OC&W performance agreement and personal consequences for students
- Market share: shrinking market share leading to shrinking budget, mainly amongst male students and Dutch students. Limited growth of most engineering programmes.
- Government cut-back plans lead to UT cut-back plans (3.5 million = 10%)

Stakeholder Level 2. Department and Programme

At the programme level, several motives play a role, but do so differently for all programmes, depending on their student intake numbers, market position and other factors. What also influences their sense of urgency is the time that passed since their last curriculum innovation. For some programmes, this was just one or two years.
Motives that can be found in several programmes[13] :
- Implementation BSA: need for an earlier timing of the selection function of the first year of the programme
- Increase success rates (financial necessity or demand from NVAO after accreditation)
- Positioning, enlarging market share
- Need for curriculum innovation after several years (based on evaluation data)
- Connecting with changing target group (more technically oriented students or more HTHT)
- Reacting to changing demand from work field (for technical people)

Some programmes felt little or no sense of urgency for the innovation.

[12] Interview with Tom Mulder, advisor of the rector and the programme office (August 25th, 2014)
[13] Sense of urgency inventory and UT approach progammes regarding the bachelor innovation (November 2014)

Stakeholder Level 3. Teaching Staff

The sense of urgency at the level of teaching staff is very low (Inventory, November 2014). A need for more efficiency in education is felt by some staff members because of cut backs and more time needed for obtaining research funds. Others are interested in implementing new teaching methods to help students gain deeper insights in subject matter.

4.2 Preliminary Investigation

Initiative and Process at Institutional Level

Initiative

The initiative for the bachelor innovation was taken by the new rector, supported by a staff member of the Strategy and Policy department. After appointment as rector and board member in charge of the educational portfolio, the rector started with a strong focus on innovation and improvement of the bachelor programmes, leading to broad and flexible engineers.

In December 2010, several UT staff members were invited to take part in the bachelor innovation taskforce. The taskforce was filled with innovative and education-minded people from all departments (teaching staff, professors and programme directors) and one student member. The taskforce was chaired by the rector.

Decision-making

The initial assignment to the taskforce was to meet with the rector once every three weeks and brainstorm about the innovation of the UT bachelors and deliver a more specific programme for bachelor innovation at the education day in April 2011, consisting of:

- an outline for a university-wide educational model
- possible clustering of programmes in broad bachelors
- conditions for the educational organisation
- a planning for implementation
- a first budget estimation

Taskforce members were asked to take a 'Green Field Approach' and not be limited by existing programmes and practices.

In March 2011, after the basic ideas for the curriculum innovation were already formulated, a study trip to three universities was planned for inspiration and examples.

- Aalto University, Finland: design lab, curriculum redesign from new (disciplinary) clusters
- DTU Denmark: math learning theme, Danish flag model (curriculum in four components with ample room for electives and limited basic programme)
- Aalborg, Denmark: project based learning, full time modules, high success rates

The new educational vision and plans were presented to UT staff and students[14] during the education day on April 8th, 2011, by the rector and the taskforce. After the education day, all programme directors were asked to design so-called 'charcoal sketches' representing the basis of their programme in six modules. The charcoal sketches were discussed in a meeting with the taskforce and all programme directors in November 2011. The focus of the bachelor innovation then shifted towards design and development at the programme level.

[14] Ed Brinksma: 'De toekomst van het onderwijs aan de UT', presentation at the education day, April 8th, 2011.

Pilots

Preliminary to the university-wide implementation of the new bachelor model, two programmes served as a pilot. Biomedical Technology (BMT) started implementing modular project education in academic year 2011-2012. One year later, Electrical Engineering (EE) also started with a pilot. Both pilots were evaluated extensively by the Educational Service Centre (OD) (Hahnen-Florijn, 2012). Results were used as input for the implementation process of the new bachelors in other programmes.

Initiative and Process at Programme Level

At the programme level, the initiative for designing the new bachelor curricula lies with the programme directors. Within the design guidelines from the taskforce, programme directors were free to make their own design, looking for possibilities of sharing (parts of) modules within the clusters.

Different approaches were chosen, varying from very top-down approaches with strong input from the programme director to very bottom-up approaches where the design was almost fully delegated to the teaching staff.

In most programmes, a curriculum committee was installed a May 2011 to work on the first version of the charcoal sketches. After discussion of the sketches in November 2011 with all programmes and the taskforce, smaller module teams continued with the blueprints for the modules of the first year.

Eventually, all clusters of programmes delivered a design matching the design guidelines, except the guideline 6 (core in six modules) and 7 (limited choice in modules 2.3 and 2.4). Especially for the technical programmes, it turned out to be too hard to fit their disciplinary basis in six modules and still maintain the selective function of the first year (see table 5). After some discussion, it was decided to cancel this guideline.

Design guideline	IBA	EPA	BS	Eng.	Sci.	ICT	Health
1. Retain CROHO number[15]							
2. 15 EC modules							
3. Thematic, project core							
4. Module 1.1 sports theme							
5. Module 1.1 and 1.2 selective and referring							
6. Core = six modules							
7. Conditional elective in module 2.3 and 2.4							
8. Module 3.1 and 3.2 free elective							
9. Capstone including academic formation							
10. Design in cluster							
11. Maximum collectivity (sharing modules)							

Legend

Abbreviations and full names of the seven clusters:

- IBA = International business administration
- EPA = European public administration
- BS = Behavioural sciences
- Eng. = Engineering technology
- Sci. = Science & technology
- ICT = Science & technology
- Health

Design Guideline:

= not met

= partially met

= met

Table 5: Comparison of cluster designs with design guidelines (Visscher-Voerman, 2012)

[15] See also appendix 4. Design framework for the design of the new bachelor

Stakeholders

Several stakeholders were involved in the design and implementation of the bachelor innovation. The most important groups and individuals and their role in the bachelor innovation process are listed below in table 6.

Role	*Task/Responsibility*
Rector (Executive Board)	Initiation bachelor innovation
Taskforce bachelor innovation	Developing vision and plans for bachelor innovation. Decision-making on redesign
Sounding board bachelor innovation	New role of the taskforce after starting implementation phase (summer 2012); Advising on implementation
Steering group 'Tafel van Ed'	Strategic consultation regarding all large educational projects.
Programme team educational innovation	Coordination of all large educational projects (financial, organisational)
Programme office bachelor innovation	Coordination and support of the bachelor innovation (content-related)
Core team/cluster leaders	Development and implementation of new bachelor model in own cluster, realisation of joint modules
Expert committee	External group installed on request by University Council; Responsible for feasibility check and preventing tunnel vision
University council	Council for employee and student participation; Has 'right of consent' regarding the bachelor innovation
Programme director	Design and implementation of new bachelor curriculum within design guidelines; Set up and coordinate project organisation at programme level

Table 6: Important stakeholders in the bachelor innovation process

Participation & Support Base

Programme directors were informed about progress and plans of the taskforce during meetings organised with the taskforce and all programme directors.

The plans were presented to the rest of the UT community during the education day on April 8th, 2011. Staff and students who attended the education day had the opportunity to join several workshops led by someone from the taskforce and an educational advisor and give input for redesign of the new bachelor programmes and other aspects of the bachelor innovation (math learning-line, Atlas, etc.).

In December 2011, the official proposal for the new bachelor model (University of Twente, 2011) was submitted for approval to the University Council. The request for approval was then withdrawn because of several concerns of the University Council, focusing on:

- Clustering of programmes and the future role of the programme directors
- Management of the bachelor innovation in relation to other large educational projects
- Costs of the bachelor innovation in relation to the planned cut backs
- Student participation
- Inflexibility of the model (regarding students with functional impairments and student activism)
- Lack of focus on educational quality

A modified version of the plan (University of Twente, 2012) including design guidelines for the programmes was submitted to the University Council in June 2012, which was eventually approved by the council. From that moment on, the new bachelor module was called TOM (Twents Onderwijs Model).

Project Organisation and Support

An external consultant was hired to set up a project organisation for all large educational projects at the university (e.g. University College/Atlas, Institutional Quality Assurance). The educational innovation programme team was set up in January 2012, with the initial task to coordinate all educational projects and distribution of budgets. From November 2012, a smaller programme office dedicated to the bachelor innovation continued with a more content-related role.

At the programme level, support for programme directors and module design teams was provided by the programme office in cooperation with the educational support centre. The provided support is aimed at evaluation and exchange of expertise and experiences (e.g. inspiration market, theme sessions at the departments and organisation of exchange meetings with programme directors)[16].

Objectives

The objectives of the bachelor innovation are clearly stated in the bachelor innovation plan:

Objective	Aimed at
- An efficient and sustainable educational organisation. Responsibilities lie at the right place and level.	*Efficiency*
- A recognisable 'Twents' educational profile o High Tech/Human Touch o Research, Design, Organise o Entrepreneurial attitude	*Positioning*
- Reduce drop-out in programmes - 70% leaves UT with a degree - 30% drop-outs referred to the right place a.s.a.p. (preferably 1st semester)	*Success rate*
- Increase succes rate. In the long run, 90% of re-enrollers obtain bachelor degree within four years.	*Success rate*
- Reduce educational costs by increasing in scale and simplifying support. Cut-back measure 10%.	*Efficiency*
- Increase student intake and market share (especially at engineering programmes) by offering higher chance to successful completion and room for differentiation.	*Positioning*

Table 7: Objectives for the bachelor innovation

[16] Event programme on intranet: http://www.utwente.nl/onderwijs/twents-onderwijsmodel/intra/Evenementen/

4.3 Tentative Products & Approach

Timeline: Phases in the Innovation Process

At the University of Twente, the innovation process started in 2009, with the appointment of the new rector. At this time, the innovation process is still in progress with the redesign of year one, the implementation of year two and the design of year three running parallel to each other.

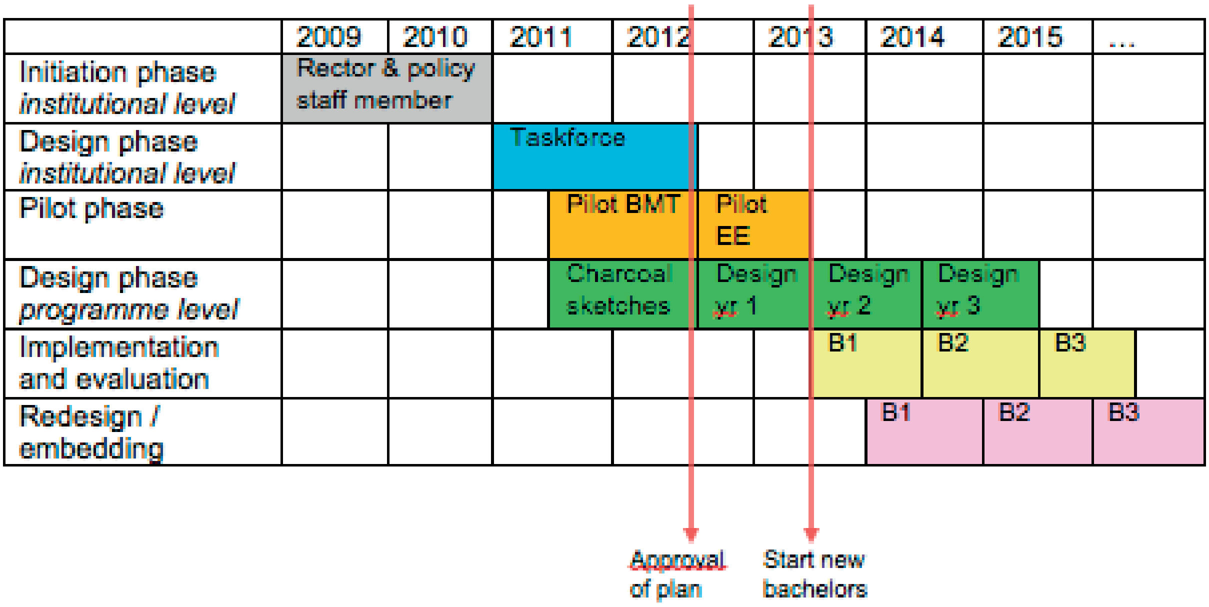

Figure 14: Timeline from initiation to implementation of the curriculum innovation

Intended Curriculum

Focus & Principles

The UT bachelor innovation focuses on innovation of the educational model that enables students to learn in a different way (active, self-responsible and in cooperation with fellow students). Besides this, several design requirements for the programmes are stated that are less content-related. See appendix 4: Design framework for designing the new bachelor.

Structure

Clusters: Programmes are placed into clusters of content-related disciplines. For each cluster, one programme director has been appointed as cluster leader with the task to define a set of modules looking for maximum collectivity within the cluster. At first, six clusters are defined:

1. Science & technology
2. International business administration
3. Engineering technology
4. European public administration
5. Health
6. Behavioural sciences

At a later time, a seventh cluster is added: Information and communication technology.

Modules: The new educational model is based on thematic modules, educational units in which (multi-) disciplinary knowledge, skills and attitudes are integrated. Characteristics of the modules at the UT include:

1. Module components are linked to each other by a theme or subject.
2. A project is a substantial part of every module.
3. Every module has a clear beginning and end to attain a flexible modular system without strict sequencing.
4. All modules are full-time and equal in duration (10 weeks) and study load (15 EC) to maximise interchangeability.
5. Students receive one final grade for the entire module. Failing a module means that the entire module has to be re-done.

Selection and transfer: The first two modules have a selective and referring function. A student must be able to determine if the programme matches his or her talent and interests quickly after the start of the programme. When this turns out not to be the case, an easily accessible transfer is made possible to another programme with minimum delay. This is facilitated by striving for maximum collectivity (sharing modules) within the clusters.

Electives: The basic programme of sic modules (90 EC) is followed by four elective modules (60 EC). These consist of two discipline-related modules and two modules that can be chosen freely.

The modules offered as electives are (when possible) modules designed for more than one major.

Capstone–connection to master: Every bachelor provides the student with access to at least one master programme.

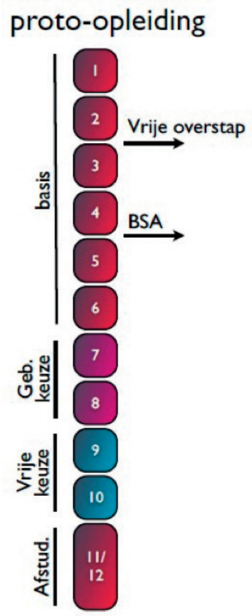

Figure 15: Schematic overview of a module (University of Twente, 2012)

The bachelor progamme is completed with a capstone module with the duration of two modules (30 EC), in which a capstone project is accompanied by other educational activities. Part of the space in this semester is dedicated to reflection and academic education. The remaining space can be filled up by the programme.
The capstone phase can also give students an opportunity to work on deficiencies in case they choose a master that does not directly connect with the chosen bachelor.

Educational Model

In thematic project education, the core of every module is a project (or a series of smaller projects). These projects are realistic (design) problems on which students work together in teams with supervision of a tutor. During these projects, knowledge and skills are applied and new knowledge is obtained. A project can be design-oriented, but can also focus on a research or organisational problem. Problems are derived from the scientific or professional context of the discipline.

The project is accompanied by several educational activities related to the project and the module theme. Programmes are free in the design of these activities, but are stimulated to avoid lecturing in favour of other (more activating) teaching methods.

The specific design and character of the project can be freely chosen by the programme and can vary from one module to another. It is possible to integrate a large design project or a research project including lab work, but it can also be a case study or problem-based learning according to the PGO model of Maastricht University.

Excellence & Differentiation

Parallel to the design and development of the new TOM bachelor modules, a university college was set up at the University of Twente. In this university college, technical and social sciences are integrated.

In September 2013, ATLAS started with the first cohort of students working on interdisciplinary challenges. Besides being a programme for excellent students, ATLAS was also set up with the intention to be an experimental environment for TOM. Successful educational practices from ATLAS can be disseminated to the other bachelor curricula.

Besides the university college, the regular bachelor programmes should also have an offer for students looking for an extra challenge[17]:

1. Institutional honours trajectories with broad reflection on science, technology and society (Organisation)
2. Interdisciplinary design projects (Design)
3. Specialisation within the discipline or in math (Research)

Regarding differentiation, project education offers students the opportunity to add their own personal (content-related) accents.

Assessment & Re-sits

Every TOM module has explicit learning objectives and an assessment matrix indicating the weight of the different module components.

Students receive one final assessment for the entire module. When a student fails, the entire module has to be re-done, including all module components. To inform students about their progress in the module, it is important they receive feedback at several intervals. This can either be done by summative or formative testing.

Assessment methods are not prescribed. The advice is to look for efficient methods that give quick feedback results to students and that do not add too much workload on teaching staff.

Compensating within modules is possible but also not prescribed.

One of the underlying principles of the TOM bachelor programmes is: 'If you participate, you pass', meaning that a student (with sufficient capacity) that actually puts in the full-time effort should be able to pass the module.

Re-sits are an exception but can be offered to students if necessary. These re-sits are called 'repairs' and are planned after a vacation period if possible so projects do not suffer from team members studying for repairs. Another option is a repair week at the beginning of the summer period.

[17] See for current offer of excellence programmes: http://www.utwente.nl/excellentie/en/

Content

Balance between Technology & Society

High Tech, Human Touch is an important part of the educational vision and profile at the University of Twente. The student should not only have profound knowledge within one of the disciplines, but also should be able to see the context of his or her actions and cooperate with specialists from other domains. Reflection on the limitations of his/her own expertise and translation to other domains is an important characteristic of the T-shaped professional the UT is aiming for. Reflection education should be integrated throughout the entire bachelor. The main part, however, should be included into the capstone phase.

Balance between Design, Organisation and Research

In the bachelor, all students should develop a basic competence in each of these roles (Ruijter & Miedema, 2010). Further specialisation in one of the '3 Os' takes place during the master phase. The '3 Os' describe the competences a student should have in the areas of Research, Design and Organisation (Onderzoeken, Ontwerpen, Organiseren). The bachelor innovation taskforce included these in their description of the final qualifications of UT bachelor-graduates(University of Twente, 2012). Organisation (aimed at combining knowledge from different scientific disciplines and using this to solve complex societal problems) should be addressed during the capstone phase. The specific design for integration of these competences into the bachelor curricula is determined at programme level.

Interdisciplinary and Multidisciplinary Education

This is not explicitly mentioned in the innovation plans, except for the remark that the possibility to work in a multidisciplinary project should stimulate the development of the T-shaped professional.
In itself, however, the description of the T-shaped professional has a very interdisciplinary character combining High Tech with Human Touch (see also paragraph 11.1). Also, joint modules designed and organised by different programmes have the potential to offer students a worthwhile interdisciplinary experience. Design and development of joint modules is explicitly stimulated in the bachelor innovation.

Professional and Academic Skills

Skills are mentioned as important. In the educational vision of the UT, academic and professional skills are specifically indicated as one of the four areas in which students should develop themselves during their time at the UT. There is no further description of how these skills should be integrated into the new bachelor curricula. This is decided at the programme level.

Integration of Math Education

There is a collective math learning line for the first year of the bachelor going through all modules. This model is based on the model of DTU (Technical University of Denmark). Increasing in scale makes it possible to provide students with a richer learning environment and provide the opportunity for remedial teaching and differentiation to specific learning styles. Besides this, a collective math line can lead to a sense of community between students from different programmes.
The math line will be planned for a fixed day of the week ('Monday = Mathday').
As some bachelor programmes are fully taught in English (e.g. Atlas, Advanced Technology and Electrical Engineering), the math line will also be taught in English.

Other

Stimulating Active Study Behaviour

An important part of the educational vision of the UT (University of Twente, 2011) is the development of an 'entrepreneurial attitude'. The UT strives to stimulate students to look for opportunities and challenges and not just follow the trodden paths. Being an independent and self-responsible learner matches with this vision. One of the five principles[18] underlying the TOM educational model is self-responsibility. This is partly realised by project education enabling students to work independently on a complex problem, guided by a tutor. Besides this, the aim is to give students increasing influence on their own learning process and thus more responsibility.
Furthermore, the modular TOM model has a strong focus on full-time studying with continuous effort and regular feedback or assessment moments to keep the student 'on the ball'. This should also be propagated by teaching staff. The aim is to make nominal study progress the standard.

ICT/Blended Learning

ICT or blended learning are not explicitly mentioned in the innovation plans, with the exception of the remark that the new online education that is available should be internalised in the UT curricula by making them more demand-driven and teach students how to deal with large amounts of information with varying quality. In the TOM model, the focus is more on activating educational methods and challenging education and less on the means available to realise this.

Intended Curriculum at Programme Level

Within the general design framework set up by the bachelor innovation taskforce (see: appendix 4), the programmes were free to design their own bachelor curricula. With the exception of the requirement to have a basic major programme of six modules and offer conditional electives in module 2.3 and 2.4, all programme designs largely met the design criteria. For the engineering programmes, offering a basic programme in six modules and still maintaining the selective function of the first semester turned out to be an impossible combination. Therefore, these design requirements were abandoned later (see also: paragraph 4, initiative and process at programme level).

What was added, on the other hand, was the math learning line (see also: 4.11). All engineering programmes incorporated the same shared math line into the curricular design of the first and second years.
The open design requirements led to a wide variety of curriculum designs, differing in:

1. Size and character of the project-based part of the module
2. Integration of professional and academic skills
3. Number of module components within one module
4. Focus on design, research and organisation throughout the curriculum
5. Choice of activating teaching methods
6. Regulations for assessment, repair options and compensation
7. Extent to which modules (or module parts) are shared with other programmes

Appendix 3 shows examples of the first drafts (charcoal sketches) of programmes made after this was requested by the bachelor innovation taskforce. See also: paragraph 4.3, initiative and process at institutional level. These examples are programmes from three different clusters: Science & technology, Engineering technology and Information & communication technology.

[18] TOM principles: http://www.utwente.nl/onderwijs/twents-onderwijsmodel/TOMprincipes/

5. Results: Similarities and Differences

In 2010, a nationwide discussion was taking place about the profiling of universities in the Netherlands, instigated by the report from the Veerman Committee (2010). Around the same time, the Ministry of Education, Culture and Science (OC&W) was developing plans for making performance agreements with all institutions of Higher Education in the Netherlands, aiming to improve success rates and educational quality. In this context, all three technical universities initiated their bachelor innovation. The central question in this study was in what way the three technical universities realised their bachelor curricula innovations. The previous chapters and appendix 5 provide a summary of the intended bachelor curricula innovations. While at a first glance the impression might be that all three institutions are doing practically the same thing, substantial differences exist in focus and scope of the bachelor innovations. In these concluding paragraphs, we point out differences and similarities between the three intended curricula and indicate what the consequences might be for the implemented and attained curricula. Also, common themes are identified that can be used as a basis for further (3TU.CEE) research and cooperation between the three Dutch universities of technology.

5.1 Differences between the 3TU Bachelor Innovations

Focus of the Bachelor Innovation

Some elements in the innovation process are the key drivers. In this comparison, one of the largest differences is the difference in focus of the bachelor innovations. TU Delft has chosen to focus specifically on increasing the success rate of its programmes. The TU Eindhoven and the University of Twente include measures to improve study success, but also focus on strengthening their university profile and enlarging their market share. The TU/e profiles itself by offering large possibilities for differentiation, making their programmes attractive for a broader target group. Twente focuses on improving its educational model and the content of the curricula with students working independently on realistic projects with the aim to better prepare them for their future as an engineer.

Process and Scope

In all three institutions, the initial design of the bachelor innovation was a rather quick and top-down process in which a committee or taskforce appointed by the Executive Board set down the general guidelines for the bachelor innovation. After this, the University of Twente and the TU Delft score high on autonomy given to the programmes. Within a set of general design guidelines, programmes are free to design their own curricula, leading to very different interpretations of the bachelor innovations at the programme level. The TU/e has also changed the structure of the organisation, placing all programmes in the Bachelor College and reducing the influence of the departments to only the disciplinary courses. Less variation is seen between programmes or disciplines, resulting in a more recognisable university profile. A possible risk of this approach could be that staff members have a lower sense of ownership towards their own programme, having had less influence on the design. For the next phase in this comparative study, ownership and acceptance of the bachelor innovation could be an interesting topic.

At all three institutions, a taskforce for the bachelor innovation was appointed by the Executive Board. Approaches were somewhat different. At the TU Delft, the taskforce formulated its recommendations based on an advisory report made by a research committee. At the University of Twente, the taskforce generated ideas through local brainstorm sessions and inspiration from international peers. The TU/e reviewed scientific literature, visited peer institutions to see examples in practice and performed market research on their own (potential) target group.

However, TU Delft made an explicit choice not to limit re-sits in the first year whereas TU/e and UT apply this limitation to their entire bachelor curricula.
- Compensatory assessment is something all three are interested in, with the difference that TU Delft and UT only allow for compensation within modules and the TU/e also for compensation between modules or programme components is stimulated.

There is no clear 'right or wrong' here. Along different lines of reasoning, the three universities have chosen different ways to structure their modules. For further research, a recommendation is to find out from the literature in combination with evaluation of experiences what combination of measures works well and what doesn't, thus allowing the transfer of successful models to each other.

5.2 Similarities between the 3TU Bachelor Innovations

Vision

In their rationale of the bachelor innovation, both the TU/e and the UT talk about educating the engineer of the future. While the UT uses the phrase 'T-shaped professional' (Harris, 2009) and the TU/e talks about 'the multidisciplinary engineer with his or her own unique selling point' (Meijers & den Brok, 2013), they both have the same aim: educate an engineer that is prepared for working in the future society by having in-depth knowledge, but also is able to move flexibly across disciplines and make a connection between technology and society. At the TU Delft, the profile of the future graduates is not part of the bachelor innovation.

Process

Looking at the 'sense of urgency', all three institutions seem to have the same starting point with a clear sense of urgency felt at the institutional level, a wide variation of motives and sense of urgency at the programme level and little-to-no sense of urgency at the staff level.

It is noticeable that at all three institutions, little effort was made to involve staff and students in the initial design of the bachelor innovation. At the TU/e, a student think tank was asked for input on measures for improving study success, and an e-mail box was opened for staff to send in their ideas, but besides this, staff and students other than the few that were invited to participate in the design taskforce did not have much opportunity to give input on the main outline for the bachelor redesign.

At the other two institutions, no documentation was found on initiatives to involve staff and students in the initial design. At later stages, input was asked for further development of the outline and the implementation process. The advantage of such an approach is that it can be fast and lead to results in a very short time. The question is, however, if the participation base will be large enough to ensure a successful and sustainable implementation of the innovation (Graham, 2012).

Content

All three bachelor innovations were initiated and designed in a context of financial cutbacks and performance agreements with the Ministry of Education, Culture and Science. Despite the differences in focus described above, all three bachelor innovations were largely affected by these financial incentives. As a result, all three curriculum redesigns contain elements to increase study success and remove barriers that might cause delay for potentially talented students. Table # gives an overview of these measures specifically aimed at study success.

	UT	TU/e	TU Delft
Structure	Modular education (15 EC) Thematic cohesion.	Courses (modules) max. 5 EC More self-study, less contact hours	Modules are min. 5, max. 10 EC Aim for thematic cohesion within and between modules
Selection and transfer	1st and 2nd module referring and selective Easy transfer facilitated by modules.	Easy transfer facilitated by large freedom of choice	Not part of the bachelor innovation
Active study behaviour	Working (in teams) on projects Full-time study programme Active teaching methods Regular feedback on progress	More self-study, less contact hours Active teaching methods Formative/ intermediate testing	More self-study More than 12, but less than 25 classroom contact hrs/wk Active teaching methods Formative testing
Coaching/study counselling	Project guidance by tutors Study counselling (not part of bachelor innovation)	Study career support aimed at defining moments of choice and personal study path, progress and developing occupational perspective	Study planning schedules (at week level) available to students Recommendation to commit to extra study counselling
Assessment	Regular feedback concerning progress Overall assessment: 15 EC or nothing Teacher extensive assessment methods	Formative (intermediate) testing Spreading assessment moments Desired minimum pass rate per course of 65%	Every programme has an assessment and examination plan Modules may include formative assessments (advice: compulsory participation) Total # of summative assessments limited to max. 1 per 2.5 EC, planned at the end of a period
Compensation and re-sits	Compensation within module possible Re-sits (repairs) are an exception, not an acquired right	Compensatory assessment within and between programme components Limit participation in re-sits	Compensatory assessment within modules possible (not between modules) Recommendation for limited participation in re-sists (except in the 1st year)

Table 8: Measures aimed at study success

It is noticeable that sometimes contradictory measures were implemented with the same goal in mind:

- Twente has 15 EC (full-time) modules that are assessed as one unit to keep students at full pace, whereas the TU Delft uses a maximum of 10 EC to prevent delay for students that are not able to study full-time in a certain period.
- All three institutions aim at stimulating active study behaviour recommending the use of active teaching methods and regular feedback by formative assessment or otherwise. But where the TU/e and TU Delft try to achieve this by incorporating more self-study and limited contact hours, the UT focuses on a full-time study programme with more project or group work.
- Concerning assessment, all three institutions have limited the possibilities for taking re-sits for students. However, TU Delft made an explicit choice not to limit re-sits in the first year whereas TU/e and UT apply this limitation to their entire bachelor curricula.
- Compensatory assessment is something all three are interested in, with the difference that TU Delft and UT only allow for compensation within modules and the TU/e also for compensation between modules or programme components is stimulated.

There is no clear 'right or wrong' here. Along different lines of reasoning, the three universities have chosen different ways to structure their modules. For further research, a recommendation is to find out from the literature in combination with evaluation of experiences what combination of measures works well and what doesn't, thus allowing the transfer of successful models to each other.

6. Conclusion and Discussion

Concluding our study, the main conclusions are given following the structure in the introductory chapter. A full comparison of the innovations is available in appendix 5.

6.1 What were the main drivers for the innovation process at each technical university?

In the introduction the drivers of successful curricular change as identified by Graham have been stated. These drivers for change were (1) a crisis or discussion about the market position of an institution, (2) crisis as a result of regulations enforced at the national level to reform education and (3) an institutional profile of risk taking and innovation. According to these, TU/e and UT typically had 'the greatest crises' situation involving both the market position and national regulations that were reinforced. The driver for change at the TU-D were the national regulations. The national regulations are measures with respect to the success rate and retention of students at all three institutions. In the similarities and differences paragraph, we have seen that the focus of innovation differentiated according to the drivers of change. Focus on market share was strategically translated to market position and institutional profiling. Focus on study success to meet national measures with respect to students' pass rates and performance indicators on the quality of education emphasised strategies for consolidating learning by means of student support and assessment measures.

6.2 In what way is the leadership of the innovation process and implementation structure organised?

The bachelor innovations differ in leadership, process and scope. Each institution used an engineering curriculum design approach, albeit with a difference in emphasis. At the TU/e, the users were at the heart of the design process, yet were not involved in the determination of the curricular structure. Despite this fact, the TU/e curriculum can be called the most people-oriented design approach, as they have tried to match the interests and ambitions of the users (students and teaching staff) as closely as possible (Stolk et al., 2008). Primarily, by having customer surveys amongst students, alumni and labour market and by trying to discern what teaching staff needed to make the necessary renewal to the curriculum. Thus, they strengthened the intrinsic motivation of the users to make the change a success. It translated itself together with the drivers for change to a broad scope and entirely new curricular and organisational structure for education.

At the UT and TU-D requirements were set, after which the design was handed down in the organisation, following a more product-politics type of approach, whereas the UT definitely has more emphasis in the politics direction, involving a larger number of staff to shape and reshape the vision after consultation for a new curriculum, as opposed to Delft where in the requirement setting a stronger product approach has been followed. The second process phase, handing down the requirements to the faculties, did require staff to create within the framework of set requirements their own approach to realise a new programme. Due to the drivers for change, the set requirements were technocratic (TU-D) or visionary (UT) in scope. In both contexts, the programme director played a key role in using a top-down approach forcing ownership of the requirements[19] or a bottom-up approach in which teaching staff were challenged to seize the opportunity to create within boundaries their new curriculum. The risk of handing down the set of requirements is that the change is not sufficiently monitored and becoming visible into a coherent design across the institution. When the driver of change is also market position, the political approach may thus become an obstacle for the desired change.

[19] Naturally, this is an exaggeration as it will always be informed and negotiated consent.

6.3 What are the key characteristics of the intended curriculum?

Fullan (2011) identified four intrinsic drivers for sustainable change:
1) constructive alignment with student engagement,
2) social engagement and peer learning,
3) pedagogy in the driving seat for technological change and
4) a whole-systems approach.

Criteria by which these four intrinsic drivers are measured are the level of intrinsic motivation; engaging educators and students for meaningful learning, teamwork for capacity building amongst teacher and students and a 100% influence on the attitude of students and teachers towards the change.

Are these intrinsic drivers embedded in the approaches at the 3 technical universities and do they meet the criteria for sustainable change?

If we consider the intrinsic drivers constructive alignment with student engagement, it can be stated without hesitation, irrespective of TOM (UT), the Bachelor College model (TU/e) or study success of TU-D as the basis for change, that constructive alignment and active methods for teaching and learning are embedded as core values in all of the programmes across the institutional boundaries.

Student engagement is typically realised by an increase in formative feedback and assessment at each institution. Yet when we look at the extent to which student engagement is embedded to realise intrinsic motivation, we notice salient differences between the university.
At the UT they have the TOM-model to engage students with authentic problems and work in a project oriented way. Stimulating meaningful learning for both students and staff. The UT with the TOM model aspires to engage through active, self-responsible and cooperative principles, choosing a modular thematic structure across the institution, which includes projects in each module. The projects are proposed to engage students in real world problems working across multidisciplinary teams to solve them.

The TU/e engages students by allowing for more personalised learning trajectories supported by intensive coaching to build up their unique professional profile throughout their studies. The USE (user, society, enterprise) package consolidates the broader scope of engineering by emphasising the history and ethics of technology as well as in emerging and growing fields like patents and robotics. Both UT and TU/e emphasise reflection and teamwork as professional skills.
At the TU-D, student engagement is primarily a planning issue (read: planning of the student). This does not mean it is not or has not been addressed at the departmental level; it is, however, not explicitly stated in the intended curriculum change and the set of requirements, which means it may have been present already and did not need any upgrade, or it may mean that it is not immediately felt as relevant. The extrinsic driver "Market Position" seems to stimulate a more thorough analyses of how to engage students in meaningful learning. It is expected the follow-up study on the implemented curriculum will probably shed light on this issue.

The second intrinsic driver for change is social engagement in which team teaching and team learning are at the heart of the change are especially strong in Twente, where ATLAS, the University College, is an explicit and experimental environment for the exploration and dissemination of new teaching methods. Team teaching teams across the institution reinforce this teamwork and capacity-building approach. At TU-D, team teaching is specifically mentioned as a requirement. Both UT and TU/e mention interdisciplinary learning of real world problems as a feature of their profile. TU/e has a focus on the students contributing with their individual passions to society as a whole, creating a reciprocal learning cycle in which teachers are challenged by the learning path and passions of the students.

The third intrinsic driver; Pedagogy-driven technological innovation is only mentioned at the UT as an aspect to pay attention to. Although, blended learning and online education are nowhere mentioned as features of the bachelor renewal at TU-D, technological innovation is a very strong feature of the institution, driving many educational innovations. TU/e and UT both have programmes to stimulate teachers' use of ICT-tools in their educational practice, but this is not an explicit part of the bachelor innovation.

Last but not least is the intrinsic driver of using a whole-systems approach. At each institution to varying degrees, the whole system is affected. Whether the systemic changes challenge the teacher and the student to grow in their learning and/or promotes continuous passion for learning and capacity building, is largely a result of the approach taken toward change. 100% influence of student and staff towards change is extremely hard if extrinsic drivers for change such as those mentioned by Graham (2014) help to influence students and staff and get a grip onto the whole system to change.

6.4 In what way did the three technical universities address their bachelor curriculum innovation objectives?

Extrinsic drivers for change seem to be predetermining the strategies used to implement a new bachelor curriculum. The objectives mentioned below are a measure of their success.

- Efficiency (simple and effective educational organisation to cut costs);
- Positioning (including student intake, student satisfaction and excellence and implementation of key features into the High Tech Human Touch, health, energy and smart mobility, etc. programmes);
- Success rates, dropout rates and pass rates;

Whether the chosen strategies will be the right ones will become visible in the future. At this point in time, we can only observe whether the strategies chosen are consistent with the objectives that are to be realised.
The table below finally clusters the extrinsic drivers for change (Graham, 2012), the strategy for change stated by the institution to realise the objective, the process parameters as defined by Stolk (2008) (political, people, product) and the objectives that should have been realised by the bachelor renewal according to institutional documents. The table primarily aims at creating an overview of approach and consistency and may serve as an inspiration to further discuss the match between process and objectives as effective strategies for change.

Extrinsic drivers for change	Strategy for change	Process	Objectives
Efficiency	Organisational shake up	Political	Cost cutting and effective use of educational expertise while improving quality
Positioning	Reorganisation of the structure and features of the bachelors, including challenging elements, teamwork, elements for intrinsic motivation, capacity building	Political/people	Student intake, satisfaction excellence and implementation of key features into the High Tech Human Touch, health, energy and smart mobility, etc. programmes. USE profile of TU/e
Study, drop out and pass rates	Restructuring of course units, study-load, assessment and student support	Product/ political	Increase/decrease against set targets

Table 9: Extrinsic drivers for change

7. Themes of Interest for Future Cooperation and Recommendations

In this last chapter we try to identify themes that are relevant for all three Technical Universities in relation to their bachelor innovations and recommend topics that might be points of departure for cooperation and further research.

From chapter 5, it becomes clear that study success and measures focusing on formative and summative assessment have a common interest at the 3TUs. Local initiatives have already started. The TU/e started with several projects on feedback within the CEE programme and TU Delft is starting an initiative around adaptive digital testing. Besides this, it might be worthwhile to sit together and formulate a joint project around assessment based on the common questions and issues
.
Focusing at formative and summative assessment is one way to stimulate active study behaviour. A different approach to activate students is focussing on intrinsic motivation and stimulation of self-directed study behaviour. In Twente, a small-scale research project will start on this topic. On an international level, there is increasing interest in student engagement, for example at Olin College, where teaching staff conduct research on student engagement and apply their findings within their own courses (Stolk & Martello, 2014). As mentioned before within 3TU, all bachelor innovation plans mention commitment and active study behaviour as being important. For the nearby future, this might be a topic to consider for a joint 3TU initiative.

A third theme of interest is interdisciplinary education to prepare the future engineer who has deep knowledge of the discipline but can also be broad and flexible (the T-shaped professional, Harris, 2009). TU/e and Twente have explicitly mentioned this type of engineer as the intended outcome for their bachelor innovation. TU Delft has not, but is setting up an 'Education Think Tank' that will develop a vision on engineering education in 2030. Together, the 3TUs have formulated and started a joint research project on interdisciplinary engineering education to compare examples from educational practices and make suggestions for improvement.

A fourth theme is the integration of math and other basic subjects (e.g. physics, design) into the curriculum. Twente made a choice to have a collective math learning line for the first year of the bachelor curriculum, whereas the TU/e included all basic subjects in a 30 EC collective basic programme. TU Delft used to have collective math education, but currently offers students programme-specific math courses. Efficiency is one of the main reasons for common basic courses. What would be interesting to know is what would be most effective; educating all engineering programmes together sharing the same basic knowledge or offering this generic content within the context of the discipline?

Both the University of Twente and TU Delft offer thematic and coherent modules in which multiple skills are combined. At the same time "one size fits all" learning is offered for Mathematics to offer students a firm engineering basis. There seems to be a tension between the thematic coherent modules and the 'one size fits all' learning theme. Is it possible to create thematic and coherent modules and at the same time offer students a shared basis? And if so, what would be the best way to do this? This could be an interesting topic to investigate together in collaboration with AMI, a 3TU cooperation of the math departments of the three universities[20]. International partner universities with an engineering profile can be consulted as well.

Finally, it will be interesting to look at ownership, support and sustainability of the bachelor innovations. As mentioned above, participation of staff and students in the initial design and sense of urgency at staff level were rather low. In later stages of the innovation process, staff (and sometimes students) were involved in working out the

[20] http://www.3tu.nl/ami

design at the programme level and the implementation of the new programmes. Ruth Graham (2012) presents several conditions for successful and sustainable change, e.g. the understanding of the critical need for change by staff members and the engagement of staff members in the design process. Evaluating to what extent these conditions are met at the three universities and where improvements can be made can strengthen the bachelor innovations and improve their sustainability.

Looking back, it has been a worthwhile exercise to compare the bachelor innovations of the 3TUs and look for contrasts and common interests. The comparison (appendix 5) gives us a clear overview of the different paths the three universities have taken towards improvement of their educational quality. Besides this, several themes were identified that can be used for further research or cooperation projects. Some of these topics like student engagement and interdisciplinary education are already addressed in 3TU.CEE research projects. Other themes like study success and sustainability of the bachelor innovations can be input for the next phases of this research that will look at the implemented and attained curricula.

Appendix 1: TU/e Bachelor College Guidelines

September 2011

(1) Bachelor programme components

- Each bachelor programme contains four components:
  - a major of 90 credits;
  - a basis of 30 credits;
  - a USE component of 15 credits;
  - an elective component of 45 credits.

(2) Major

- The core of each bachelor programme is the major of 90 credits, with 10 of these credits reserved for a concluding final project that can be extended by the student to 15 credits by using the scope within the elective component.
- A programme may comprise more than one major within the same CROHO position, with each major leading to a specific master or master track.
- Departments decide on the contents of the major(s).
- A major allows unencumbered access to at least one of the masters of the respective department.
- A major can count on particular basic knowledge acquired in parts of the basis.
- If a programme contains one major, this can be configured according to one of the following two design models:
  - (a) full major in common;
  - (b) part of the major in common, part selection from different tracks that all lead to a specific master or master track.

(3) Basis

- Each bachelor program contains six basic subjects, each worth 5 credits, namely:
  - Mathematics;
  - Physics;
  - Engineering;
  - Design;
  - Humanities & Social Sciences;
  - Professional skills.
- The basis for professional skills is contained in the major, creating a portfolio for which five credits can be gained in the event of a positive assessment. These are not offset against the 90 credits for the major but are awarded for the professional skills 'basic subject'. Students can continue to develop these skills within both the major and the elective component.
- As for the other five basic subjects, these are common to all programmes or programme clusters that are offered. For each basic subject, there is a maximum of three cluster variants. For each basic subject, the degree program managers consult with each other about the options for a cluster.
- The mathematics and physics basic subjects are taught in the first semester.

(4) USE

- In addition to the humanities & social sciences basic subject worth five credits, each bachelor program contains a USE component of 15 credits in which technology, with reference to human and social sciences, is put in a User, Society and/or Entrepreneurial perspective. Several variants of this component are offered from which students can choose an elective. Students can also choose USE subjects and learning paths within the elective component.

- Several USE component variants are offered so that each major has a disciplinary association with at least one USE variant. In this regard, the degree program managers under the stewardship of the Dean-elect of the TU/e Bachelor College will come to a consensus with the multidisciplinary project team established to organise the USE component.
- The Executive Board will ultimately decide which USE subjects and learning paths will be offered, a decision based on the recommendation of the Dean-elect of the TU/e Bachelor College. Moreover, account will be taken of the recommendations concerning the Platform for Academic Education, the Taskforce for the Implementation of Bachelor Program Reforms, the Degree Program Managers Board and the University Management Committee.

(5) Electives
- Each bachelor programme comprises electives worth 45 credits.
- Departments propose coherent elective packages, each of which is worth a maximum of 15 credits. There is also scope in the elective component for individual subjects worth five credits each.
- Coherent packages can be offered that lead up to a specialization in a master as well as subjects and coherent packages for broadening the student.
- If students opt for design model (a) for the major selecting a coherent package geared to the connecting master, they must be able to specialise more in that area than in the current bachelor programmes.
- If a student has not pursued such a coherent package in the bachelor when opting for design model (a) for the major, it should be possible for the student to pursue this package in the elective component of the connecting master.
- In design model (b) for the major, the major tracks will also be offered as coherent packages in the elective component to enable a student, if required, to gain access via this route to other masters or prepare specifically for particular master tracks.
- Coherent packages are also accessible for students with other majors. If need be, a maximum of one subject or program component (in the free elective) can be demanded as foreknowledge.

(6) Reforming the organisation of education to enhance study
- All program components (subjects and projects) are five credits or a multiple thereof.
- Each quartile comprises a maximum of three parallel program components.
- Each major consist of subjects and DBL, in which all three elements of ‘knowledge acquisition’, ‘knowledge practice’ and ‘knowledge application’ (for instance in design issues) are adequately catered to.
- All programme components are being redesigned with a focus on activating forms of education (fewer lectures and more self-study).
- Within a programme component, compensatory tests will be introduced since a maximum of 70% of the final grade is determined by the final exam, with requirements made only of the final grade, not for the grades gained for the individual components.
- Compensatory tests among programme components within coherent clusters are recommended as a way of enhancing study.

(7) Miscellaneous
- Learning outcomes will be defined for each major and for the coherent packages.
- The first academic year for reformed bachelor programs will begin in September 2012, with the second and third academic years starting in September 2013.
- The issue of the language of instruction of the bachelor programmes falls outside the scope of the Bachelor Programme Reform. Programmes may use English (in part) as the language of instruction provided they have (or gain) permission to do so from the Executive Board; the other programmes will use Dutch as the language of instruction. For students not competent in Dutch and who wish to follow programme components only offered in Dutch, a pragmatic solution must be sought. Experience in using Dutch and English as the languages of instruction in bachelor programmes will be monitored and assessed. Depending on the outcome, the Executive Board and University Management Committee may, if needed, reconsider policy.

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Appendix 2: Charcoal Sketches of the changed Bachelor Programmes

Automotive

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Introduction Modelling	Basic USE
	Automotive trends I	Dynamics	Automobility	Systems
	Computation for AU	Elective	Signals	Elective
Year 2	Basic Design	Electromechanics (incl. OGO)	Power Electronics (incl. OGO)	Sensing, computing and actuating
	EM Fields and circuits	Automotive trends II (incl. OGO)	Vehicle dyn. & mech. Vibrations	Powertrains
	Elective - USE	Elective - USE	Elective - USE	Elective - USE
Year 3	Vehicle Networking	Automotive software engineering	Elective - BEP*	BEP
	Control Engineering	Driver-centric innovation (incl. OGO)	Elective	Elective - BEP*
	Elective - USE	Elective - USE	Elective	Elective

* Totaal BEP = 10 EC, in blok of in lintvorm

Biomedical Technology

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Inleiding Modelleren	Basis USE
	Celbiologie	Organische chemie I	Informatica I	Biochemie
	OGO De menselijke verbrandingsmotor	Keuze	Keuze	OGO Mechanica van het bloedvat
Year 2	Basis Design	Moleculaire celbiologie	Fysica II	Imaging I
	Wiskunde II	Mechanica I	OGO Project III	OGO Project IV
	Keuze - USE	Keuze - USE	Keuze - USE	Keuze - USE
Year 3	Fysica III	Statistiek	Keuze - BEP*	BEP
	Materiaalkunde	OGO Project 5	Keuze	Keuze-BEP*
	Keuze - USE	Keuze - USE	Keuze	Keuze

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Biomedical Technology

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	calculus	bouwstenen van de Fysica	basis design	basis USE
	P-atelier / handtekenen (OGO)	P-atelier / autocad / handtekenen/ (OGO)	constructief ontwerpen /mechanica/practicum	realisatie en transformatie
	architectuur en stedebouw	keuze	P-atelier / revit / portf. 1	keuze
Year 2	inleiding modelleren	architectuur+stedebouw geschiedenis / visualiseren	construeren met materialen / mechanica 2	processen woonvastgoed
	T - O - P Project (OGO)	T - O - P Project (OGO)	T - O - P Project (OGO)/pf 2	T - O - P Project (OGO)
	keuze - USE	keuze - USE	keuze - USE	keuze - USE
Year 3	ontwerpanalyse (primaire elementen) / stedebouw	bouwfysisch ontwerpen 2 / integratie gebouw en installaties	Keuze	keuze
	multidisciplinair project (OGO)	multidisciplinair project (OGO)	Keuze	BEP
	keuze - USE	keuze - USE	Keuze	BEP

Electrical Engineering

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Introduction Modelling	Basic USE
	Signals I (incl. OGO)	Circuits I (incl. OGO)	Transistor circuits	Systems
	Computation I (incl. OGO)	Elective	Math for EE I	Elective
Year 2	Basic Design	Electromechanics (incl. OGO)	Computation II	Math for EE II
	Fields in EE	Electrical power systems (incl. OGO)	Intro Telecom	Electromagnetics incl. T-lines
	Elective - USE	Elective - USE	Elective - USE	Elective - USE
Year 3	Signals II	Communication Theory	Elective – BEP*	BEP
	Control systems (incl. OGO)	Electrical Circuits	Elective	Elective-BEP*
	Elective - USE	Elective - USE	Elective	Elective

* Totaal BEP = 10 EC, in blok of in lintvorm

Medical Sciences and Technology

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Inleiding Modelleren	Basis USE
	Celbiologie	Organische chemie I	Hart & Long	Biochemie
	OGO De menselijke verbrandingsmotor	Keuze	Keuze	OGO Mechanica van het bloedvat
Year 2	Basis Design	Moleculaire celbiologie	Biomechanica	Immunologie & infectie
	Uitwisseling & Regulatie	Diagnose & Interventie	OGO Project III	OGO Project IV
	Keuze - USE	Keuze - USE	Keuze - USE	Keuze - USE
Year 3	Signalering & homeostase	Statistiek	Keuze - BEP*	BEP
	Medische beslissystemen	OGO Project 5	Keuze	Keuze - BEP*
	Keuze - USE	Keuze - USE	Keuze	Keuze

* Totaal BEP = 10 EC, in blok of in lintvorm

Psychology & Technology

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Introduction Modelling	Basic USE
	Introduction P & T	Technical Course	Brain, body behavior	Technical course
	OGO Programmeren	Elective	Research methods 1	Elective
Year 2	Basic Design	Research methods 2	Perception	Technical course
	Social Psychology and Consumer behavior	Technical course	OGO qualitative research	Sociology & Technology
	Elective - USE	Elective - USE	Elective - USE	Elective - USE
Year 3	Decision making	Human Factors	BEP	BEP
	OGO quantitative research	Advance Research Methodology & Research Ethics	Elective	Elective
	Elective - USE	Elective - USE	Elective	Elective

Chemical Engineering

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Inleiding Modelleren	Basis USE
	Practicum Basischemie	Wiskunde 1	Fysische Chemie 1	Fysische Transport-verschijnselen 1
	Inleiding Chemie + Chemische Technologie	Keuze	Organische Chemie	Keuze
Year 2	Basis Design	Scheidings-technologie	Anorganische Chemie	Chemische Reactorkunde
	Fysische Chemie 2	Wiskunde 2	Fysische Chemie 3	Practicum Organische en Analytische Chemie
	Keuze - USE	Keuze - USE	Keuze - USE	Keuze - USE
Year 3	Practicum Procestechnologie	Integrerend project Health	Keuze	BEP
	Materiaalkunde	Integrerend project Sustainable Energy	Keuze	BEP
	Keuze - USE	Keuze - USE	Keuze	Keuze

Software Science

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Introduction Modelling	Basic USE
	Programming	Computer systems	Data structures	Automata & processes
	Logic & set theory	Elective	DBL robotics	Elective
Year 2	Basic Design	Datamodelling & databases	Programming methods	Comp. Networks & security
	Discrete structures	DBL Algorithms	Softw. Spec. & testing	Probability theory & statistics
	Elective - USE	Elective - USE	Elective - USE	Elective - USE
Year 3	Business information	Software Eng. & architecture	Elective	BEP
	Operating systems	Algorithms	Elective	BEP
	Elective - USE	Elective - USE	Elective	Elective

Sustainable Innovation

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Introduction Modelling	Basic USE
	Sustainable development in a global context	Technical Course	Science Techn. & Society	Technical Course
	Economics of innovation	Elective	Research methods 1	Elective
Year 2	Basic Design	Research methods 2	OGO Managing Techn. In Society	Technical Course
	Managing Techn. In Society	Technical Course	Technology Sustainability & Policy	OGO Technology Sustainability & Policy
	Elective - USE	Elective - USE	Elective - USE	Elective - USE
Year 3	Economics of innovation II	IS integration project	BEP	BEP
	Science Techn. & Society II	IS integration project	Elective	Elective
	Elective - USE	Elective - USE		

Industrial Engineering and Management sciences

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Inleiding Modelleren	Basis USE
	Deterministic Operations Management	Mathematics I	Methodology for IE Research	Organization, Strategy & Innovation
	W&O Psychology: Basic	Keuze	Business Modeling	Keuze
Year 2	Basis Design	Statistics	Marketing, Purchasing & Innovation	Design of Business Information systems
	Business Economics	Mathematics II	Stochastic Operations Management	Product Innovation Processes
	Keuze - USE	Keuze - USE	Keuze - USE	Keuze - USE
Year 3	Information Management	W&O Psychology: Advanced	Keuze - BEP*	BEP
	Supply Chain Management	Quality & Reliability	Keuze	Keuze - BEP*
	Keuze - USE	Keuze - USE	Keuze	Keuze

* Totaal BEP = 10 EC, in blok of in lintvorm

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Applied Physics

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Inleiding Modelleren	Basis USE
	Experimentele Fysica 1	Experimentele Fysica 2	Mechanica	OGO Instrumentele fysica
	Krachten, deeltjes en energie	Keuze	Keuze	Elektromagnetisme
Year 2	Basis Design	Optica	Inleiding Quantumfysica	Thermische Fysica
	Voortgezette calculus	Lineaire algebra en differential-vergelijkingen	Experimentele fysica 3	Signalen en Systemen
	Keuze - USE	Keuze - USE	Keuze - USE	Keuze - USE
Year 3	Transportfysica	Gecondenseerde materie	Keuze - BEP*	BEP
	Toegepaste Quantumfysica	Fysica in perspectief	Keuze	Keuze - BEP*
	Keuze - USE	Keuze - USE	Keuze	Keuze

* Totaal BEP = 10 EC, in blok of in lintvorm

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Applied Mathematics

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Inleiding Modelleren	Basis USE
	Verzamelingenleer & Algebra	Analyse 1	Analyse 2	Programmeren + Modelleren
	Lineaire Algebra 1 + Latex	Keuze	Lineaire Algebra 2 + Mathematica	Keuze
Year 2	Basis Design	Analyse 3	Voortgezette Algebra	Stochastische Processen + Modelleren
	Inleiding Numerieke Analyse + Modelleren	Kansrekening + Modelleren	Gewone differentiaal vergelijkingen + Modelleren	Complexe Analyse
	Keuze - USE	Keuze - USE	Keuze - USE	Keuze - USE
Year 3	Statistiek + Modelleren	Modelleren	BEP	BEP
	Keuze van 1 uit 2: Grafentheorie & Combinatoriek **OF** Algoritmen in Discrete Wiskunde + Modelleren	Keuze van 1 uit 3: Functionaalanalyse **OF** Algoritmen in Algebra en Getaltheorie **OF** Regressie- en Variantie Analyse	Keuze	Keuze
	Keuze - USE	Keuze - USE	Keuze	Keuze

Web Science

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Introduction Modelling	Basic USE
	Programming	Logic & set theory	Data structures	Human-technology interaction
	Introduction Psychology & Technology	Elective	DBL Hypermedia	Elective
Year 2	Basic Design	Datamodelling & databases	Programming methods	Comp. Networks & security
	Discrete structures	Web technology	DBL App development	Probability theory & statistics
	Elective - USE	Elective - USE	Elective - USE	Elective - USE
Year 3	Business information systems	Software Eng. & architecture	Elective	BEP
	Infonomics	Web analytics	Elective	BEP
	Elective - USE	Elective - USE	Elective	Elective

Mechanical Engineering

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	Calculus	Bouwstenen van de Fysica	Basis Design	Basis USE
	Mechanica	Dynamica	Signalen	Structuur en eigenschappen van materialen
	Inleiding Werktuigbouwkunde	Keuze	OGO Propeller	Keuze
Year 2	Inleiding Modelleren	Regelen van mechanische systemen	Stromingsleer	Materiaalgedrag en elasticiteitsleer
	Thermodynamica	OGO Ontwerpcasus Crash-test	OGO Robotarm	OGO Verbrandingsmotor
	Keuze - USE	Keuze - USE	Keuze - USE	Keuze - USE
Year 3	Eindige Elementen Methode	Fabricagesystemen	Keuze - BEP*	BEP
	OGO CAD-FEM	Constructieprincipes	Keuze	Keuze-BEP*
	Keuze - USE	Keuze - USE	Keuze	Keuze

* Totaal BEP = 10 EC, in blok of in lintvorm

Appendix 3: Charcoal Sketches University of Twente

Charcoal Sketches: Applied Physics (B1–B2)

Source: Dr Ir. M.M. J. (Marloes) Wijnhout-Letteboer (2011)

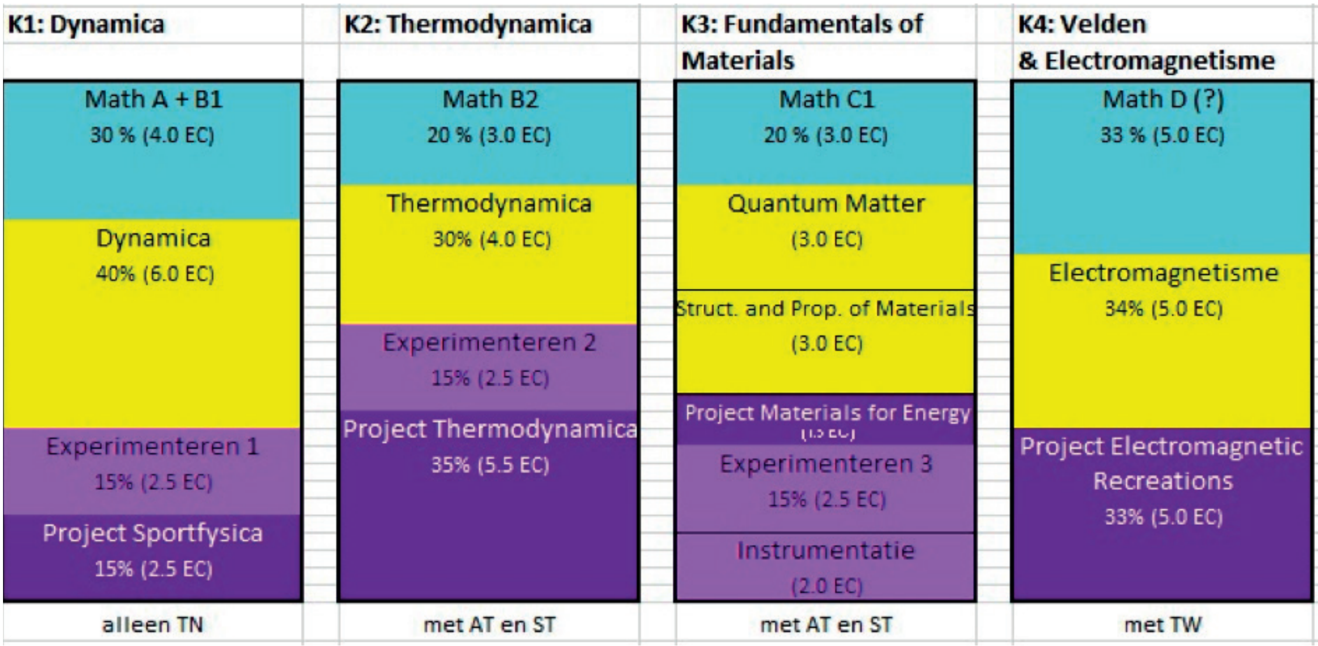

Figure 16: Charcoal sketch of the first year of the new bachelor curriculum for Applied Physics (TN)

K5: Signalen, systemen, en modellen	K6: Optica	K7: Vaste stof fysica	K8: Vloeisstoffysica
Math E (4.0 EC) (Eigenvalues & vectors, Fourier Laplace, Simulation)	Quantummechanica 1 (4.0 EC)	Quantummechanica 2* (2.0 EC)	Electrodynamica 2 (3.0 EC)
Signalen en modelleren (4.0 EC) (Modelling, DV's, FEM, Signals & filters, Signal statistics)	Statistische Fysica 1 (2.5 EC)	Statistische Fysica 2 (2.5 EC)	Klassieke Mechanica (3.5 EC)
Meten (2.0 EC)	Wiskundelijn (1.5 EC)	Electrodynamica 1* (2.0 EC)	Wiskundelijn (1.5 EC)
Project Cantilever (5.0 EC)	Optica (4.5 EC)	Wiskundelijn (1.5 EC)	Vloeistoffysica (4.5 EC)
	Practicum Optica (2.5 EC)	Vaste Stof Fysica (4.5 EC)	Practicum Vloeistoffysica (2.5 EC)
		Practicum Vaste Stof Fysica (2.5 EC)	
met AT	alleen TN	alleen TN	alleen TN
		* QM tot week 5, ED vanaf week 6	

Figure 17: Charcoal sketch of the second year of the new bachelor curriculum for Applied Physics (TN)

K9: Keuze 1	K10: Keuze 2	K11: Voorbereiding afstuderen	K12: Afstuderen
Verdiepende keuzes: Theoretische Fysica (TN)	Verdiepende keuzes: Biofysica (TN) Nanomaterialen (AT)	Keuze uit: Warmte en stofoverdracht Fysische Materiaalkunde Technische optica (5.0 EC)	Bacheloropdracht (15 EC)
		Nog niet vastgesteld (5.0 EC)	
		High Tech Human Touch (5.0 EC)	
		alleen TN	

Figure 18: Charcoal sketch of the third year of the new bachelor curriculum for Applied Physics (TN)

Charcoal Sketches: Civil Engineering Management (B1–B2)
Source: Dr Ir. C.M. (Marjolein) Dohmen-Janssen (2011)

Module:	**1. Introductie Civiele Techniek**	**2. Waterbeheer**	**3. Verkeersmanagement**	**4. Bouwmanagement**
Kleur:	Techniek en ontwerpen; thema: Sport	Techniek en modelleren (in context van beheer)	Techniek en modelleren (+ ontwerpen)	Techniek en management (+ ontwerpen)
Te behandelen onderwerpen/ vakken (inclusief eventuele practica)	Basiswiskunde (Intro 2 EC + Calculus 2 EC)	Basiswiskunde (Calculus, 3 EC)	Basiswiskunde (Lineaire Algebra, 3 EC)	Basiswiskunde (Calculus, 3 EC)
	- Mechanica 1 (Statica; 3 EC) - Materiaalkunde (beton & staal; 1 EC) - Geschiedenis & ontwikkeling CiT (1 EC)	- Water *excl. waterkwaliteit* (2 EC) - Waterbeheer *excl. waterkwaliteit* (1 EC) - Stroming aansluitend bij Calculus (3 EC)	- Verkeer (2 EC) - Vervoerswetenschappen (2 EC)	- Grondmechanica & Funderingstechnieken (3 EC) - Bouwmanagement (3 EC) (= huidige vakken Bouwen, Project Management, CM&E; daarnaast contractvormen, investerings-beslissingen, risicomanagement, etc) in verschillende fasen van het bouwproces; dwz ook uitvoeringsfase en Beheer & Onderhoudsfase
	Mechanica software? Matlab? (via project)	Matlab (via project)	Statistiek (via project)	Matlab? (via project)
	professionele vaardigheden 1 (bv samenwerken, vergaderen, ontwerpvaardigheden)	professionele vaardigheden 2 (bv reflectie modelresultaten)	professionele vaardigheden 3 (…)	Professionele vaardigheden 4 (…)
Mogelijke projecten	Civieltechnisch project in sportwereld (met water, verkeer en bouw-aspecten), bv ontwerp van een wildwaterkanobaan voor OS 6 EC, bestaande uit: - Materiaalkunde (1 EC) - Inleiding CiT (1 EC) - 'Software' (1 EC) - 'project'(3EC)	Opzetten model voor waterafvoer door riviersysteem 6 EC, bestaande uit: - Water (2 EC) - Waterbeheer (2 EC) - Matlab (1 EC) - 'project'(1EC)	Ontwerp wegvak + capaciteit wegvak in netwerk modelleren 8 EC, bestaande uit: - Verkeer (3 EC) - Vervoerswetenschappen (2 EC) - Asfalt en grondmechanica (1 EC) - Statistiek (1 EC) - 'project'(1 EC)	Ontwerp ondergrondse parkeergarage 6 EC, bestaande uit: - 'Bouwmanagement' (5EC) - Matlab? - 'project '(1 EC)

Figure 19: Charcoal sketch of the first year of the new bachelor curriculum for Civil Engineering Management (CiT)

Module:	1. Introductie Civiele Techniek	2. Waterbeheer	3. Verkeersmanagement	4. Bouwmanagement
Kleur:	Techniek en ontwerpen; thema: Sport	Techniek en modelleren (in context van beheer)	Techniek en modelleren (+ ontwerpen)	Techniek en management (+ ontwerpen)
Te behandelen onderwerpen/ vakken (inclusief eventuele practica)	Basiswiskunde (Intro 2 EC + Calculus 2 EC)	Basiswiskunde (Calculus, 3 EC)	Basiswiskunde (Lineaire Algebra, 3 EC)	Basiswiskunde (Calculus, 3 EC)
	- Mechanica 1 (Statica; 3 EC) - Materiaalkunde (beton & staal; 1 EC) - Geschiedenis & ontwikkeling CiT (1 EC)	- Water *excl. waterkwaliteit* (2 EC) - Waterbeheer *excl. waterkwaliteit* (1 EC) - Stroming aansluitend bij Calculus (3 EC)	- Verkeer (2 EC) - Vervoerswetenschappen (2 EC)	- Grondmechanica & Funderingstechnieken (3 EC) - Bouwmanagement (3 EC) (= huidige vakken Bouwen, Project Management, CM&E; daarnaast contractvormen, investerings-beslissingen, risicomanagement, etc) in verschillende fasen van het bouwproces; dwz ook uitvoeringsfase en Beheer & Onderhoudsfase
	Mechanica software? Matlab? (via project)	Matlab (via project)	Statistiek (via project)	Matlab? (via project)
	professionele vaardigheden 1 (bv samenwerken, vergaderen, ontwerpvaardigheden)	professionele vaardigheden 2 (bv reflectie modelresultaten)	professionele vaardigheden 3 (…)	Professionele vaardigheden 4 (…)
Mogelijke projecten	Civieltechnisch project in sportwereld (met water, verkeer en bouw-aspecten), bv ontwerp van een wildwaterkanobaan voor OS 6 EC, bestaande uit: - Materiaalkunde (1 EC) - Inleiding CiT (1 EC) - 'Software' (1 EC) - 'project'(3EC)	Opzetten model voor waterafvoer door riviersysteem 6 EC, bestaande uit: - Water (2 EC) - Waterbeheer (2 EC) - Matlab (1 EC) - 'project'(1EC)	Ontwerp wegvak + capaciteit wegvak in netwerk modelleren 8 EC, bestaande uit: - Verkeer (3 EC) - Vervoerswetenschappen (2 EC) - Asfalt en grondmechanica (1 EC) - Statistiek (1 EC) - 'project'(1 EC)	Ontwerp ondergrondse parkeergarage 6 EC, bestaande uit: - 'Bouwmanagement' (5EC) - Matlab? - 'project '(1 EC)

Figure 20: Charcoal sketch of the second year of the new bachelor curriculum for Civil Engineering Management (CiT)

Charcoal Sketches: Computer Science (B1–B3)
Source: Dr Ir. R. (Rom) Langerak (2011)

1e jaar	Module 1.1 (+ BIT)	Module 1.2 (+ BIT)	Module 1.3 (+ EE)	Module 1.4 (+ BIT)
	Inleiding TI 11	Software systemen 12	Netwerk systemen 12	Data & Informatie 12
Prof skills	Samenwerken	Plannen en zelfmanagement	Mondeling en schrift. presenteren	Ethiek en maatschappij
Inspan.verplichting	Wiskunde 4	Wiskunde 3	Wiskunde 3	Wiskunde 3
2e jaar	Module 2.1 (+ EE)	Module 2.2 (+ BIT)	Module 2.3 (+TW)	Module 2.4 (keuze)
	Computer systemen 15	Interactie 15	Discrete structuren 15	Smart spaces 15
Prof skills Verbetering	Samenwerken	Plannen en zelfmanagement	Mondeling en schrift. presenteren	Ethiek en maatschappij
3e jaar	Module3.1 (keuze)	Module 3.2 (keuze)	Module 3.3 en 3.4	
Prof skills	Programmeer principes 15	Wireless & Mobile 15	Bachelorreferaat 15	
Toepassen			Ontwerpproject 15	

Figure 21: . Charcoal sketch of with a total overview of the new bachelor curriculum for Computer Science (TI)

Appendix 4: Design Framework for the Design of the New Bachelor

Source: Een nieuw model bachelor onderwijs voor de UT, version 3.1 (May 2012)

For the design of the new bachelor, the following framework is given:

- Existing programmes keep their CROHO listing for the time being and should evidently remain accreditable under this listing.
- Programmes are set up in modules. These are undividable full-time examinations, part of 10 weeks (15 EC).
- The module has a thematic coherence. The core of a module is a 'project': an activity challenging students to acquire knowledge and skills in an independent way. The project is accompanied by educational activities. The challenge is to reduce the dependency on 'frontal education' as much as possible.
- The project in the first module of year 1 is related to a UT-wide theme[21].
- The first two modules explicitly have a selecting and referring function. They introduce the discipline and enable the student and the programme to make a reasonable estimation of the chance of successful completion of the programme.
- The basis of every programmes exists in six modules (90 EC), including the first two modules mentioned above.
- Subsequently there are two conditional elective modules (for specialisation or broadening within the programme). These are preferably programmed in periods 2.3 and 2.4.
- There are two free elective modules, where the student can choose for education without the domain, for example, to qualify for a specific master programme, but also for international exchange or an educational minor.

For logistic reasons, this free space should be progammed at a fixed time during the year. Periods 3.1 and 3.2 were chosen for this. The student is free to use this elective space for further specialisation within the domain.

- The progamme is completed with a capstone module in the duration of a semester, in which a capstone project is accompanied by other educational activities. Part of the space in this semester is dedicated to reflection and academic education. Size and character of this part are still under discussion. The remaining space can be filled up by the programme.
- Modules are designed in six clusters of related programmes to reduce the complexity of the design question. For every cluster, one programme director is appointed to define a set of modules in agreement with colleagues.
- Within clusters, and where possible also between clusters, maximum collectivity (sharing modules and module components) is strived for and also when this is not necessary from a financial point of view.

[21] In September 2014 and 2015, the collective theme for the first module was 'Sports'.

Appendix 5: Schematic Comparison of 3TU Bachelor Innovations

Problem definition

	UT	TU/e	TU Delft
Title	TOM (Twents Onderwijs Model) 'Modular project education'	Bachelor College 'Design your own future'	Study success 'Charting a Course for Study Success'
Context	New rector (01.01.2009): focus on innovation and improvement of education and future requirements for academics. Later: performance agreements OC&W and BSA	Large problems in the area of intake figures and success rates. The TU/e reputation was damaged and thus market share and income are lost. Incremental measures have not led to the desired results and thus a more fundamental approach is chosen to approach the problem.	Advisory memo by Brakels committee as preparation for the institutional accreditation: advice on measures for improving succes rates. New performance agreements OCW and BSA Increasing student numbers, resulting in (very) high teaching loads for academic staff
Sense of urgency *Organisational level*	Primary: Need for T-shaped professional (flexible engineer). Secondary: - Succes rate and drop out - Market share UT - Budgetary cut back plans - Necessity for positioning UT	Problems with student intake and succes rates Upcoming cutbacks Fundamental cohesive approach with more impact needed (smaller initiatives failed)	Low scores in National Student Survey (NSE) Very low succes rate of BSc-in-4 years (22%) High drop-out rate Long study duration
Sense of urgency *Programme level*	Different for each programme, e.g. a. Implementation BSA asks for curriculum change b. Changing target group and work field demand c. Raise student output (financial necessity or demand NVAO) d. Outdated curriculum e. No sense of urgency	Some programmes at risk of closing down: - Decrease student intake - Disappointing output rates - Bad National Student Questionnaire scores (for some programmes)	Combination of 'organisational level' above and 'teaching staff level' below
Sense of urgency *Teaching staff level*	Little to no sense of urgency	There isn't any evidence for a sense of urgency for the teaching staff.	Little sense of urgency to comply with OCW performance requirements. Severe concerns about combination of higher stress levels by more students, stable manpower thus increasing teaching load, stricter performance agreements and low appreciation for teaching

Preliminary Investigation

	UT	TU/e	TU Delft
Initiated by	rector magnificus	Executive board	Executive Board
Process Organisational level	Top-down approach (design by small sample-section of the UT population) leading to general framework. Taskforce educational innovation Chair: Rector. Student participants: 1.	Top-down approach restructuring of the bachelor programmes. Taskforce redesign Ba-curriculum. Chair: External. Student participants: 4 (taskforce 1)	Top-down approach leading to set of directives and guidelines. Steering Group 'Study Success' Chair: Vice President of Education and Operations + 2 professors + Head Education & Student Affairs Project Team 'Study Success' Working Group 'Didactics' Chair: programme director. Student participants: 1
Approach	Problem exploration Generation of ideas Inspiration from outside Formulate design guidelines Delivery redesign proposal vs. 1 Adjustment based on input programmes and university council Delivery redesign proposal vs .2 Start-up design at programme level	Problem exploration, literature research Research on TU/e population and marketing research Description of Future Engineer Formulate design guidelines Examples from other institutions Delivery redesign proposal Preparation of the implementation (taskforce 2) Development overall elements	Problem definition In-house research on study success (advisory report) Definition of directives and constraints based on literature study Delivery redesign proposal
Process Programme level	Bottom-up: programme specific design within loose design framework.	Programme specific design within the design framework handed in for approval. Two new majors were approved.	Bottom-up: programme specific design within given boundary conditions.
Roles & authorization Organisational level	Problem owner / client: Rector Design vision and framework: 'Taskforce educational innovation' External soundboard: Expert commission Implementation: programme office educational innovation and 'Core Team'. Employee participation: University Council, approval TOM model	Problem owner / client: CvB Design vision and framework: 'Redesign Ba curriculum' Implementation preparation: Dean bachelor college and 'Taskforce Implementation Reform Bachelor programmes. Implementation management: Programme Management Team	Problem owner / client: Executive Board Problem owner / client: CvB Advise report educational measures: Brakels Committee Discussion round and decision making Design vision and framework: Working Group 'Didactics' Implementation coordination and control: Working Group 'Didactics' Preparatory advice report educational measures: Brakels Committee Project organisation Steering group: Decision making and approval after discussion rounds Project group: Monitoring content, process and planning Working group didactics: Design vision and framework, support for the faculties: Department working groups: Implementation
Roles & authorisation Programme level	Initiative: programme director Different for every programme: Curriculum design and framework: programme director and / or curriculum committee Design at module level: Module teams or module coordinators Programme committee: approval new curriculum Assessment committee: Confirm assessment plan and pass / fail regulations	At the start of the Bachelor College every major had to hand in plans which stated (responsibility of Educational Director): goals for the major concrete operation of the first year major embedding of the professional skills A total of 15 majors1 were approved for the new bachelor, including two new ones	Responsible: Director of Education. Initiative: Education Management Team Development: different per programme Curriculum design and framework: Programme Director and / or Curriculum Committee Alongside external educational advisors were used and/or internal task forces.
Participation & support base	'Away days' to inform and gather input from programme directors Annual education day to inform and gather input from staff and students	Advisory Board Bachelor College with teachers, students, educational directors and policymakers Email address taskforce to collect suggestions from staff members Student think tank on study success Educational Colloquia to support teachers	Broad discussion rounds at TU Delft on all levels (institution, department, programme) based on advisory report from Brakels Committee Objective: department buy-in
Objectives	Effective educational organisation Lower costs for education (10%) Recognisable educational profile Increasing student input Decreasing drop out (30%) Increasing succes rates (90%)	Educate the engineer of the future Larger, more varied student intake Higher succes rates More female students Diversification of educational offering	In 2015 55% Increasing BSc-in-4 yr success rate to 70% in 2020 Reducing student drop-out

[1] an overview of all majors is available at http://www.tue.nl/en/education/tue-bachelor-college/undergraduate-programs/

Tentative Products and Approach

	UT	TU/e	TU Delft
Timeline	Assignment: December 2010 Design phase institutional level: Jan – April 2011 Pilot phase: 2011 – 2013 Design phase programme level: May 2011 - current Start new bachelors: September 2013	Assignment: January 2011 Design phase institutional level: January – May 2011 Design phase programme level: June 2011 – Aug 2012 Start new bachelors: September 2012	Assignment: August 2011 Design phase institutional level: June – October 2011 Design phase programme level: October 2011 – September 2012 Pilots / early starters: September 2012 Start new first year in bachelors: September 2013 for most programmes and some in 2014
Main focus	Educational model	Differentiation for multiple target groups	Increasing success rate
Principles	Modular education (with integrated assessment) Working (actively) in projects Responsible for your own learning process Students learning together Every student at the right place as soon as possible	Structure: every student can follow its own course Coaching: students get coaching from registration to master's choice Feasibility: An average student can obtain its bachelor's degree in 3 years	Challenging, feasible curricula inspiring students to a higher study pace Package of educational measures (primarily technocratic changes in structure, modules, assessments, BSA), maintaining the content of the programmes) Shift in teaching and study culture amongst staff resp. students
Structure Organizational level	Intention to clustering of programmes retaining CROHO listing Design of modules in 6 clusters of related programmes Aim for maximum collectivity	Every student follows a unique path of at least 180 EC Al bachelor programmes placed with one organisational unit Majors offered by departments	Not part of the bachelor innovation. Production of programmes remains unaltered
Structure Programme level	Basic programme 6 modules = 90 EC 1 Limited electives = 30 EC Free electives = 30 EC Capstone phase (reflection education and B assignment) = 30 EC	Basic courses = 30 EC Major = 90 EC (incl. 10 EC B assignment) Electives = 45 EC USE education = 15 ec	Recommendation to reduce number of subjects (in favour of more depth) and uniform schedule (recognisable structure). Study load matches with # ECs.
Structure Semester level	Module as educational unit: 15 EC Thematic (coherence) Substantial part = project	Study load is divided. All courses are at least 5 ECMaximum of three parallel courses (of which at least one is a project) per period	Modules are min. 5, max. 10 EC Duration 5 – 10 weeks. Minimum of 2 parallel modules, maximum 3; aim for thematic cohesion within and between the modules
Selection and transfer	1st and 2nd module referring and elective; easy transfer facilitated by modules	Easy transfer facilitated by large freedom of choice	Projects on selection and transfer are running at the TU Delft, but not as a part of the bachelor innovation
Electives	Limited electives (within the discipline) in module 7 and 82 Free electives in module 9 and 10 Electives are shared modules where possible.	Free electives = 45 EC Every course in the Bachelor college is an elective. USE education = 15 EC	Not part of the bachelor innovation
Excellence/differentiation	University college: ATLAS Honours trajectories institutional (focus on organisation or design). Programme specific	TU/e Honours Academy has two phases, each of 15 EC. The program is on top of the regular Bachelors Program	Sirius programma is available, but is not a part of the bachelor innovation; advice to reward extracurricular projects with ECs in the regular curriculum to limit study delay
Project education	Realistic context Integrated application and acquisition of knowledge Specific character and design of project determined by programme	Design Based Learning (no part of the bachelor innovation)	Not a specific part of the bachelor innovation and varying between programmes; some of the curricular reforms incorporated more project education, some in CDIO context
Active study behaviour	TOM principle = student takes responsibility for learning process (increasing during bachelor) Working independently (in a team) on projects Fulltime study programme with regular testing 'Nominal is the standard'	Creating more commitment by: More self-study, less contact hours Active teaching methods (assignments) Formative (intermediate) testing	Stimulating an active independent attitude towards studying by: More self-study hours 12 contact hours a week are recommended to a maximum of 25 classroom contact hrs/wk Focus on active teaching methods Formative testing (advice: compulsory participation)

Coaching/study counselling	Project guidance by tutors. Role and task or tutors specified at programme level. Study counselling no part of the bachelor innovation	Study career support aimed at defining moments of choice and personal study path, progress and developing occupational perspective Every student is guided by a student mentor and a trainer coach (docentcoach)	Study planning schedules (at week level) available to students Recommendation to commit to extra study counselling
ICTO / blended learning	Not explicitly mentioned; focus on activating and challenging education, not on the means and materials	Experiment with innovative (activating) educational methods and ICT support Set up of an innovation fund to stimulate teachers to experiment	Not a part of the bachelor innovation, but placed separately under extension school and O2E.
Interdisciplinary education	High Tech Human Touch: technology & society T-shaped professional: Broadly educated and flexible engineer Collective education: interdisciplinary modules and projects.	USE education (15 EC): user perspective enterprise perspective societal perspective Interdisciplinary coherent elective packages are developed Future engineer: multidisciplinary with own unique specialism	Not part of the bachelor innovation
Skills	Are mentioned as important and inherent to project led education, but not elaborated further in the TOM model; specific design is determined at programme level	Are part of the collective basic programme (5 EC) and integrated in courses of the Major program	Not part of the bachelor innovation
Math education	Collective math learning line for B1. Fixed day of the week: 'Monday Mathday'.	Included in collective basic programme (30 EC), together with physics, engineering and design; bridge between high school knowledge level and the level needed for the disciplines	The TU Delft used to have collective math education, but currently offers students programme specific math courses.
Bachelor completion	Capstone phase, 2 modules (30 EC): final project + supplementary integrating (reflection-) education Orientation on 3 Os to support profile choice	Bachelor final project 10 EC	Not part of the bachelor innovation (but quite a number of programmes chose to incorporate a bachelor final project in the 2nd semester of the 3rd year)
Assessment & Re-sits	Regular feedback concerning progress Teacher extensive assessment methods Overall assessment: 15ec or noting Compensation within module possible Specifics determined at programme level Participating = passing. Re-sits (repairs) are an exception, not an acquired right	Spreading assessment methods Limit participation in resits Aanmelden = meedoen = halen Compensatory assessment within and between programme components Desired minimum pass rate per course of 65%	Every programme has an assessment plan Modules may include formative assessments Total number of summative assessments limited to 1 per 2.5 EC Recommendation for limited participation in re-sits (except in the 1st year) Compensatory assessment within modules possible (not between modules) Summative assessments planned at the end of a period

[1] In een latere versie van het herontwerp werd de basisopleiding vergroot naar 120ec en kwam de discipline specifieke keuzeruimte te vervallen.
[2] Kwam uiteindelijk te vervallen.

Literature

3TU (2011, july). 3TU Sectorplan Technologie, 2011-2015. Retrieved from https://intranet.tudelft.nl/fileadmin/UD/MenC/Support/Internet/TU_Website/TU_Delft_Medewerkers/Faculteiten/TBM/Nieuws/Nieuwsbrieven/Nieuwsbrieven_2011/doc/3TU_uitvoering_sectorplan_2011-2015_definitief_juli_2011.pdf

Akker, J. van den (2003). Curriculum perspectives: An introduction. In J. van den Akker, W. Kuiper & U. Hameyer (Eds.), Curriculum landscapes and trends (pp. 1-10). Dordrecht: Kluwer Academic Publishers.

Bachelor College (2012). Jaarverslag TU/e Bachelor College 2011-2012. Internal document. Eindhoven: TU/e

Bachelor College (2013). Jaarverslag TU/e Bachelor College 2012-2013. Internal document. Eindhoven: TU/e

Berkel, H. Van, Jansen, E. en Bax, A. (2012)., Studiesucces bevorderen; het kan en is niet moeilijk, Boom & Lemma Uitgevers

Bos, E. (2011, August 18). Projectplan Verhogen Studiesucces TU Delft. Internal document. Delft: TU Delft

Boogaard, M. Van den (2015), 'Towards an action-oriented model for first year engineering student success: a mixed methods approach'.

Brakels et all (2011) , Adviesnotitie maatregelen TUD bevorderen studie success; Naar een bachelor in 4 jaar!, (committee Brakels)

College van Bestuur TU Delft (2012) Voorstel tot Prestatieafspraken, rapportage aan de staatssecretaris OCW, ten behoeve van de Review Commissie, Hoger onderwijs en Onderzoek. Internal document. Delft: TU Delft

Fullan, M (April 2011), Choosing the wrong drivers for whole system reform , Seminar Series 204, Centre for Strategic Education,(CSE) is the business name for IARTV, www.cse.edu.au

Gommer, E.M. (2014). Stakeholder interviews UT bachelor innovation. Internal document. Enschede: University of Twente.

Gommer, E.M. (2014). Inventarisatie sense of urgency en werkwijze UT opleidingen t.a.v. bachelor vernieuwing. Internal document. Enschede: University of Twente.
Graham, R. (2012). Achieving excellence in engineering education: the ingredients of successful change. London: The Royal Academy of Engineering.

Graham, R. (2014), Creating engineers fit for the 21st century, Keynote Kick off 3TU-CEE op 22 September 2014 http://www.3tu.nl/cee/en/events/cee-kick-off-event/summary-kickoff/

Hahnen- Florijn, M.E. (2012).Rapportage Monitor BMT, ervaringen met het kwartiel 'de maakbare mens'. Internal document. Enschede: University of Twente.

Hargreaves, A., & Fink, D. (2006). The Ripple Effect.Educational leadership, 63(8), 16-20.

Harris, P. (2009). Help Wanted: 'T-Shaped skills to meet 21st century needs'. Technology and Development 63(9), 42-47.

Honours programmes (n.d.). Retreived August 25th 2014 from http://www.utwente.nl/excellentie/en/
Informatiesite onderwijsdag – archief. (n.d.). Retrieved August 25th 2014, from http://www.utwente.nl/onderwijsdag/archief/

Intranet archief TOM. (n.d.). Retrieved August 25th 2014, from http://www.utwente.nl/onderwijs/twents-onderwijsmodel/intra/archief_tom/

Meijers, A., & Brok, P. den (2013). Engineers for the future: an essay on education at TU/e in 2030. Eindhoven: Eindhoven University of Technology

Motivaction & YoungWorks. (2010). Bèta Mentality 2011-2016 - Jongeren boeien voor bèta en techniek. Den Haag: Platform Bèta Techniek.

NVAO (2011). Adviesrapport Technische Universiteit Delft, Instellings Kwaliteitszorg.

ORAS (studentefractie), Reactie rapport Brakels, http://oras.nl/2011reactie-op-rapport-brakels/

Plomp, T., & Nieveen, N. (2007, November). An introduction to educational design research. In Proceedings of the Seminar Conducted at the East China Normal University. Shanghai: SLO-Netherlands Institute for Curriculum Development.

Ruijter, K., & Miedema, H. (2010). Ontwerpen, Onderzoeken en Organiseren. 30: het nieuwe onderwijsconcept van de Universiteit Twente. In W. U. Onderwijs, Best Practices Undergraduate Onderwijs; UGO middag 28 september 2010. Enschede: Universiteit Twente.

Somerville, M., Anderson, D., Berbeco, H., Bourne, J. R., Crisman, J., Dabby, D., Donis-Keller, H., et al. (2005). The Olin Curriculum: Thinking Toward the Future. IEEE Transactions on Education, 48(1), 198–205.

Stolk, J. , Somerville, M., Chachra, D. (2008) , Drowning in method, thirsty for values: a call for cultural inquiry IEEE Computer Society, ISBN S3G-3-S3G-7

Stolk & Martello (2014) Can Disciplinary Integration Promote Students' Lifelong Learning Attitudes and Skills in Project-Based Engineering Courses? International Journal of Engineering Education 01/2015; 31(1B):434-449.

Taskforce redesign Bachelor College (2011, june). Toekomstbestendig en Studentgericht Bacheloronderwijs van de TU/e. Eindhoven: Eindhoven University of Technology. Retrieved from https://www.tue.nl/fileadmin/content/studeren/2_Bacheloropleidingen/Bachelor_college/Eindrapportage_taskforce_Redesign_Ba-curriculum_en_Standpunt_CvB.pdf

Tonino, H. et all / Work group Didactics (2011, 5 october), Koersen op Studiesucces. Internal document , Delft: TU Delft

TU Delft (2014, September 22) Advies Rapport, Interne Audit Technische Universiteit Delft

TU Delft (2011, may). Reactie TU Delft op het Adviesrapport TU Delft (commissie Mouwen), ten behoeve van de Instellings Kwaliteitszorg NVAO, Mei 2011

TU/e (2011). TU/e 2020 - strategisch plan. Eindhoven: TU/e

TU/e (2011, 29 september). Richtlijn TU/e Bachelor College. Retrieved at 21 november 2014 from http://www.win.tue.nl/reglementen/BC/richtlijnBC29sep2011.pdf

TU/e (2011, 29 September). Programmaplan hervorming Bacheloropleidingen. Eindhoven: TU/e

Twents Onderwijsmodel (TOM). (n.d.). Retrieved August 25th 2014, from http://www.utwente.nl/onderwijs/twents-onderwijsmodel/

University of Twente (2012). Proposal performance agreements 2012. Retrieved August 25th 2014, from http://www.utwente.nl/strategie/projecten/prestatieafspraken_ut_ocw.pdf

University of Twente (2011). Strategy document Route 14+(). Retrieved August 25th 2014, from http://www.utwente.nl/organisatie/strategie/strategienota-route-14-plus.pdf

University of Twente (2011). Naar een Twents Onderwijsmodel: Versie 3.1. Enschede: University of Twente.

University of Twente (2012). Een nieuw model bacheloronderwijs voor de UT: Versie 2.3. Enschede: University of Twente.
U-raad archief / vergaderstukken/ cyclus 2012 (n.d.). Retrieved August 25th 2014, from http://www.utwente.nl/uraad/archief/

Veerman (2010). Toekomstbestendig Hoger Onderwijs Stelsel
Retrieved from http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2010/04/13/advies-van-de-commissie-toekomstbestendig-hoger-onderwi.html

Visscher-Voerman, J.I.A. (2012). Comparison of cluster designs with design guidelines for the new bachelors. Internal Report. University of Twente.

Wademan (2005), in Plomp, T., & Nieveen, N. (2007, November). An introduction to educational design research. In Proceedings of the Seminar Conducted at the East China Normal University [Z]. Shanghai: SLO-Netherlands Institute for Curriculum Development.