Effects of curriculum characteristics on achievement in science and technical higher professional education

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15 March 2017

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Abstract

Over the past 15 years, study-success in higher professional education in the Netherlands has gradually declined. The focus of this research is the relationship between curriculum organisation and achievement in science and technical higher professional education. A multilevel analysis was done on study progress data of 2,683 1st year students in 4 cohorts and 1,175 2nd year students in 3 cohorts studying in 10 technical and applied science programmes in higher professional education. The majority of the students had a SGSE (HAVO) prior education (64% of the 1st year students). The research showed that for 1st year curricula the variation in the student achievement was related to curriculum characteristics, while no such relationship was found for the 2nd year curricula. Achievement is defined as the number of credits students obtain in one year of study. The hours on the timetable (planned contact time), organisation of the exams in terms of weeks between exams and exam re-sits and the number of parallel activities did not predict achievement. The curricula were characterised by the curriculum integration ratio. This ratio is a measure for the level of integration in a curriculum ("discipline" focus versus "real world" focus). Student achievement was found to be higher in less integrated 1st year curricula. Also the larger number of final grades, curricula with courses carrying smaller study load, and the time planned in laboratories and workshop, showed a positive relationship with achievement. The student's perception of the curriculum was derived from national student survey data. Curricula on which students reported that they participate in all scheduled activities showed a higher achievement. This research showed that the effects of curriculum characteristics on achievement in higher professional education, with a majority of SGSE (HAVO) students, differed from research findings in academic universities with mainly PUE (VWO) students. To improve achievement of the SGSE (HAVO) students it is recommended to build curriculum models, that accommodate smooth transfer from secondary into higher professional education. Achievement at the start of the study career in higher professional education is promoted by a curriculum model, with limited integration, more opportunities to obtain credits (smaller courses) and activating (obligatory) contact time.

Keywords: curriculum characteristics, effectiveness, higher education, higher professional education, progress, science education, study-success, technical education

Foreword

At the start of this report I want to add a few personal lines for the readers and express my gratitude to the people who supported me in one way or another during the research and writing of the report.

Good reliable data were a core ingredient of this research. I want to thank Greet van Voorthuizen for her support in providing student baseline data. These data were the backbone of the tables constructed. Also my thanks to Mirjam Aartsen who supplied the National Student Survey data, which provided the student's view on the curricula. Combining the student progress data from the BISON database with the student baseline data was a major endeavour, that could not have been done without the ideas and Excel sheets of Johan Smits. Without the help of Mirjam, Greet and Johan the research would have been impossible.

My interest in curriculum development was the major driving force for taking up my studies at the University of Twente, so I was happy that I was able to conduct research in this area. It was interesting to notice that the way I learn has not changed that much over the years. Studying is fast and easy when you are with other students in a group, but more challenging when you are on your own. With or without a group learning requires deadlines. The way I learned about the basics of curriculum development with Sifa Masuki and Benny Lugoe in Kidatu working from deadline to deadline and this present research into curriculum characteristics in Enschede were in this sense similar experiences. I needed and enjoyed the regular meetings with Bernard Veldkamp, Fer Coenders and Rene Nijssen and I want to thank the three of you for your support, careful reading and feedback.

Learning is about "time on task" and I want to thank Christiaen Slot and Rene Nijssen for taking over my regular work so that I could concentrate on this research task.

Finally I want to thank my wife Ans and daughter Lianne for their company and support. Especially for the last months, while I was hiding in my room.

The last words are for the reader, I hope you enjoy reading the report. Do not hesitate to ask questions and search for answers and join the data based discussion on how we can best improve higher professional education.

Wim Harmsen

Zutphen, 15 March 2017

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Introduction

On the 19th of June 1999 the Bologna declaration was signed by twenty nine European countries. The Countries committed themselves to establish an "European higher education area" by 2010. Fundamental to this goal is synchronising the level of education throughout Europe. The first step towards this goal was made in Dublin by drawing up descriptions, phrased in terms of competence level, of the 3 cycles (Bachelor, Master, PhD) of higher education (Bologna Follow-Up Group, 2005). These descriptions became commonly known as the "Dublin Descriptors", see Figure 1.

Dublin Descriptors

A level descriptor with five components:

- Knowledge and understanding
- Applying knowledge and understanding
- Making judgements
- Communication
- Lifelong learning skills

Figure 1: Dublin descriptors

The "Dublin Descriptors", drawn-up in 2003, were a building block for the European Qualification Framework (European Commission, 2008). In this framework the outcomes of education are described by statements on knowledge, skills and competence. The framework is attached in Appendix A: European Qualifications Framework (EQF). The report of Huisman, Witte, and File (2007) described progress in the first 5 years on curriculum reform across Europe regarding: two-cycle structure, competence-based learning, flexible learning paths, recognition and mobility. For all these goals outcome based descriptions of learning are a necessity. This can either be done by the use of competence descriptions or by providing descriptions of intended learning outcomes (ILO's). Huisman et al. (2006) showed that from the start of the European cooperation the choice between the use of ILO's or competence based descriptions has led to debate. Within the Netherlands as well as in other countries the national competence frameworks were developed around 2002-2004 for related educational programmes (domains). In higher professional education in the Netherlands this resulted in a new didactical approach, called competence based learning. In recent years the ILO's have gained popularity as it is expected to lead to more compact and clearer descriptions for flexible higher professional education and lifelong learning, as discussed in Kan (2015).

Within the higher education area in the Netherlands, the majority of fulltime students (365,300 students, 54,5% in 2014/2015, CBS (2017)) take part in higher professional education (HBO) at bachelor level (level 6 of the European Quality Framework (EQF), European Commission, 2008). A smaller group of students (297,800 students, 45,5% in 2014/2015) studied at research universities at bachelor (level 6) or master level (level 7 of the EQF). In the Higher education and Research plan of 2005 (Onderwijsraad, 2005) the government tasked higher education to contribute to the transition towards a knowledge society in line with European ambitions. One of the aims is to work towards an employment population of which at least 50% is educated to bachelor level by the year 2050.

Science and technical higher professional education in the Netherlands

The focus of this report is the science and technical higher professional education in the Netherlands. In terms of the ISCED standardisation (ISCED-F, 2013), the area's 4: Science and 5: Engineering, manufacturing and construction. In the Netherlands the sector is known as "betatechniek" and is divided in 4 domains: built environment, applied sciences, engineering and ICT. The domains took up the task of drawing up the competences for the domains based on the Dublin descriptors and the requirements of their domains. Within Engineering the domain competences were first defined in 2006 (Bachelor of Engineering, 2012). In the version of the domain description of 2012 all bachelor programmes added a Body of Knowledge and Skills (BoKS), as the competences alone were found to be insufficient to describe the educational outcomes. In the next version of the domain description, expected to be published in 2017, a drive towards defining learning outcomes is foreseen. The relationship between Dublin descriptors, domain competences and BoKS for an engineering programme is shown in Figure 2.

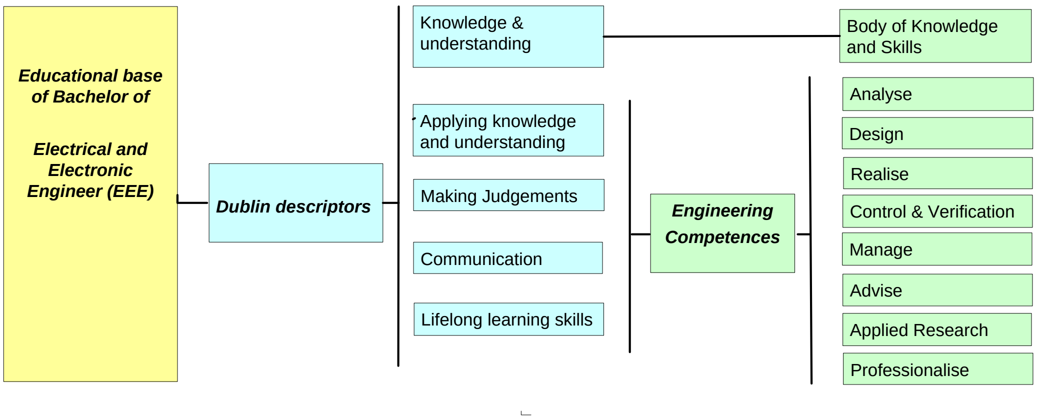


Figure 2: Dublin descriptors, BoKS and engineering competences

In the Netherlands 4 groups of students enrol in higher professional education; students from senior secondary vocational education (SSVE (MBO)), senior general secondary education (SGSE (HAVO)), pre-university education (PUE (VWO)) and a group of international students (INT). The international students come from within and outside Europe and have various educational backgrounds. Only a small percentage of bachelor programmes are open for international students. For technical higher professional education the enrolment of SGSE (HAVO) students is the largest with 57% in 2015, followed by SSVE (MBO) with 23% and the PUE-VWO group with 9% of the total enrolled students. Figure 1 shows an overview of the prior education of students enrolled in the years 2011 till 2015.

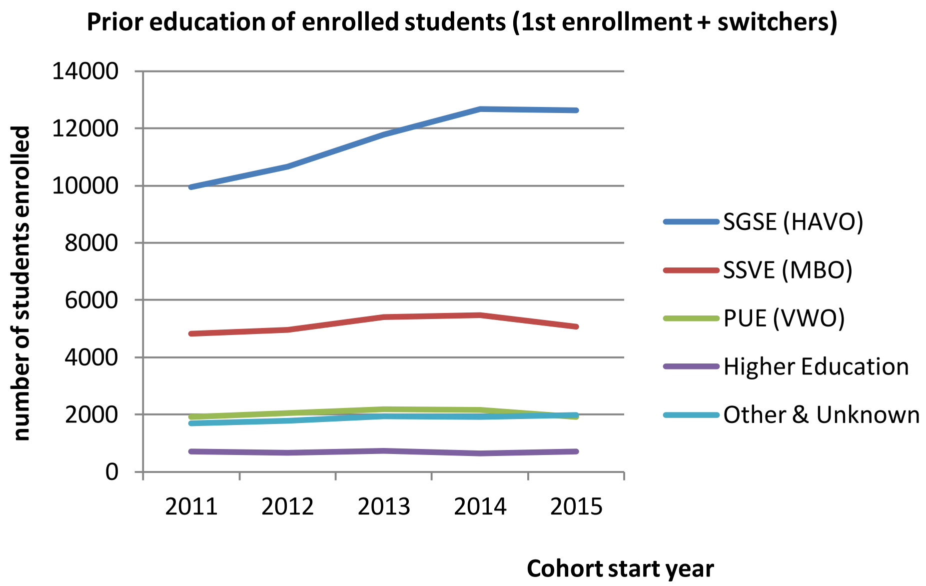


Figure 3: Prior education of enrolled students in higher professional education ISCED 4 and 5, “betatechniek” (source: VHS, 2017).

Challenges in higher professional education in the Netherlands

The Netherlands intends to develop towards a knowledge economy with a highly educated workforce (50% bachelors in the workforce by 2050). The commitment of government towards increasing enrolment in higher education, combined with concerns about students leaving without graduation (drop-out) and the quality of the education provided, resulted in an agreement being drawn-up between the government and the institutes providing professional higher education (HBO-raad-OCW, 2011). In binding agreements between institutes and government, 7% of the budget in the period 2012-2016 was made conditional depending on achieving goals related to study success, quality of education and organisation. The institutes had to commit themselves to indicators related to study success. The indicators measure: 1. drop-out (from the institute) and 2. efficiency (after nominal study duration + 1 year). The agreement had a considerable impact, in drawing the attention of the institutes towards study success. Table 1 provides an overview of enrolment, switchers (students who re-enrolled in a different institute), drop-out and the efficiency.

Table 1

Switchers, efficiency and drop-out

	2011	**2012**	**2013**	**2014**	**2015**
Enrolment in year 1					
Total enrolment (ISCED 4&5)	20594	21253	23065	23950	23230
percentage switching students *)	14,4%	14,4%	15,3%	15,4%	14,8%
Efficiency (graduation within 5 years)					
SSVE (MBO)	58,0%	58,1%	56,2%	51,0%	50,2%
SGSE (HAVO)	46,5%	45,1%	45,5%	42,3%	42,2%
Drop-out (within 1 year)					
SSVE (MBO)	18,3%	19,3%	19,2%	21,9%	20,2%
SGSE (HAVO)	12,1%	12,7%	10,9%	12,0%	12,1%

*) Switchers (2nd enrolment in higher education, 1st enrolment in an other institute)

Kamphorst (2013) stated that drop-out rates in higher professional education are a persisted problem and called for interventions based on “empirical evidence” from within a domain and warned that a general approach is not likely to work. Van Asselt (2016) provided an overview of the trends in efficiency, which in the Netherlands is often referred to as: “study success”. The number of graduates receiving their diploma within 5 years is the outcome measure for “study success”. For all sectors in higher professional education (except arts) the same trend is seen (Figure 4).

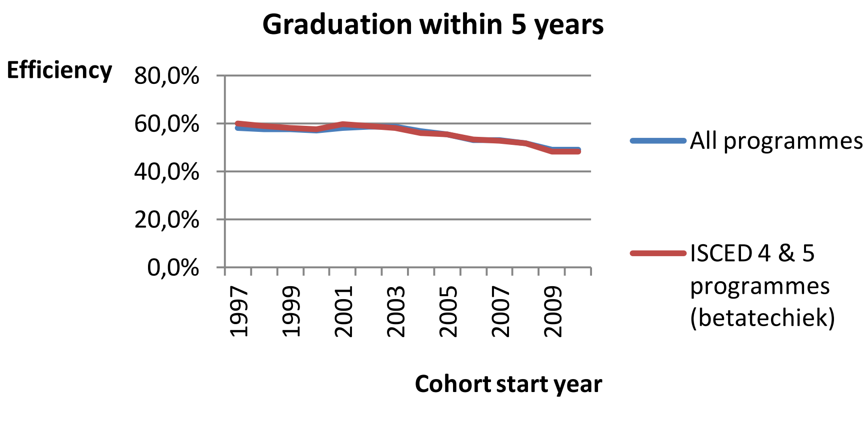
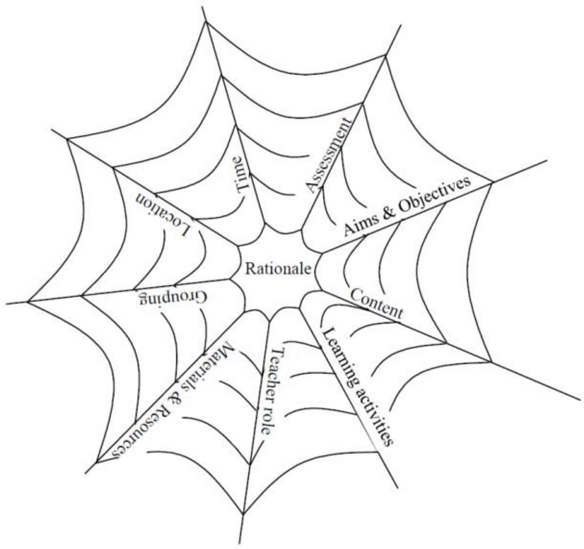


Figure 4: Efficiency for ISCED 4 and 5 programmes in higher professional education, “betatechniek” (source: VHS, 2017)

From the break-point year 2008 (the cohort starting in 2003) a gradual decline of "study success" was observed. In higher technical professional education "study success" reduced from 58,3% in 2008 to 48,4% in 2014. The reduction was the highest for SSVE (MBO) minus 13,8% followed by minus 9% for SGSE (HAVO) and minus 4.8% for PUE (VWO). The report of Van Asselt discussed 8 possible causes for this reduction in "study success": 1. The increased number of students, 2. Student characteristics, 3. The changes in the prior education programmes. 4. Policies of admittance, 5. Study choice coaching. 6. Time (available, needed, used), 7. The organisation of the programmes and 8. pedagogy and educational quality. Some of the possible causes such as, educational policy, the type of students or changes in prior education cannot be addressed within the institutes responsible for the organisation of the higher professional education. Other possible causes however, those related to the curriculum, were considered to be within the span of control of the higher professional education institutions.

A curriculum (a plan for learning) has different representations. Knight (2001) distinguished between the "planned"-, "created"- and "understood"-curriculum. Van den Akker (2003, 2006) used the terms "intended"-, "implemented"- and "attained"- curriculum. With the different curriculum representations Van den Akker acknowledged that what is intended/planned for in an educational programme will differ from what is implemented/created by the teaching staff and that, with all good intentions, this differs from what the learners have actually attained/understood.

Van den Akker (2003) described the curriculum with 10 components and visualised these in a curricular spider web (see Figure 5) to show the interconnections and its vulnerability. Only when all the components of the curriculum web are intact, the curriculum will be able to serve the purpose it was designed for.



Curriculum Components

Rationale
Aims & objectives
Content
Learning activities
Materials & resources
Teacher role
Assessment
Grouping
Location
Time

Figure 5: Curricular spider web (Van den Akker, 2003)

The present research focused on what can be done by the institutions at the programme level. Van den Akker (2006) defined this level as the "meso level" in curriculum. The general question addressed in this report is:

What is the relationship between curriculum components and academic achievement in professional higher education?

The next chapter provides an overview of research into effectiveness in higher education. Wherever possible, research findings related to achievement in the science and technical domain are mentioned. The purpose was to determine the relationship between curriculum components and effectiveness and select the relevant components for investigation. The chapter on effectiveness in higher education is concluded by describing the relationship between the curriculum components and the selected relevant components to be investigated. These relevant components are called "curriculum characteristics" throughout this report. Based on the findings of the educational effectiveness research a more specific research question was formulated and a research model chosen. The research model included both “curriculum characteristics” and “student characteristics” and is highlighted at the end of the next chapter.

Separate chapters provide overviews of research into the relations between student- and curriculum characteristics and achievement. For the relationships investigated in this research, a separate research question was formulated together with a hypothesis on its expected functioning. The methodology chapter describes the application of the research model on data of the engineering and life science department of SAXION University of Applied Science. The report is concluded with a discussion of results, conclusion and recommendations.

Effectiveness of higher education

This chapter provides an overview of the research in effectiveness of higher education and describes the major research lines that have been pursued over the past decades. The emphasis is on curriculum components, on how they were measured and on how they predicted achievement in the various research lines. Based on this overview a suitable research model is chosen and the linkage between curriculum components and curriculum characteristics described. For the outcome measure of effectiveness studies the term achievement or academic achievement is used, although it may have been named differently in the original text.

Educational productivity model

Caroll (1963) was one of the first to develop a model for school learning and over the years the model was extended and improved. Based on Caroll’s model, Reynolds and Walberg (1992) described an educational productivity model with factors in three groups: 1. Student characteristics (aptitude, ability, motivation), 2. quantity and quality of instruction (time spend on learning, pacing, structuring, monitoring) and 3. social psychological environment (home-, peer- and classroom environment). The model was designed for primary education, but extended to be used in high school. An important finding, dating back to Carroll (1963) was “time on task”. Achievement of students increased with time spend on a learning task. It was concluded that schools should promote “time on task” by providing an optimal environment with high quality of instruction and opportunities to learn.

Bruinsma (2003) used the same “Walberg educational productivity model”, with factors in three groups (student, instruction, environment), to investigate a sample of 1st year students in a research university. The quantity of instruction was taken from paper sources, which described the credits to be earned and contact hours. Modelling the quality of instruction was done by measuring the student perspective through a questionnaire on the quality of assessment, content, structure /organisation and the instruction pace. For the classroom environment student’s perception was measured with a questionnaire on the quality of classroom climate and support by peers. Achievement was measured by the grades received per course. It was found that the classroom climate, the quality of the assessment and the quantity of instruction affected achievement. The quantity of instruction was measured by the planned contact hours, which had a significant positive effect on the grades. The study load of a course, measured in credits assigned, had a significant negative effect on achievement.

Social integration and motivation

Another way of explaining effectiveness of higher education is through the social integration model (Tinto, 1975, 1987, 1997). Whether or not a student decides to drop out of a study programme, depends in this theory on how well a student feels socially and academically integrated. Motivation is considered an essential aspect for persistence and achievement in education. The expectancy-value model for motivation was linked with self-regulated learning (Pintrich & De Groot, 1990). Another major theory for human motivation is the self-determination theory (Deci & Ryan, 2008). The Self-Regulation Questionnaire-Academic (SRQ-A) and Academic Motivation Scale (AMS) were developed based on the self-determination theory (see Guay et al., 2008). Bruinsma (2003) used a motivation model to study the direct effect of motivation on achievement and the effect through an intermediate variable the “amount and quality of information processing” The research model described the relationship between: 1. quality of instruction (instructor and assessment quality, through student ratings), 2. quantity of instruction (active, passive, and self-study hours from paper sources), 3. student characteristics (information processing approach and motivation measured by self-report questionnaires) and academic achievement. Achievement was measured by the total number of credits received in a year of study. Student ability and motivation had a positive effect on achievement, but the effects of instructional quality and quantity were inconsistent across year groups and departments.

The social integration theory was used by Kamphorst (2013) in developing models to study motivation, social & academic integration and learning for different academic disciplines in relation to academic achievement taking in account some student characteristics (anxiety, gender). The study had a cross sectional design and was carried out with population of 1st year students in higher professional education. The outcome measure for achievement were drop-out, perceived competence and credits earned. The study showed that academic and social integration and the "intention to stay" played a very important role and the advice was to design interventions aimed at "belonging" and "engagement". Kamphorst found differences based on gender. For female students, preparation for active learning and self-study are predictors, while for male students the exam results in prior study for mathematics predicted academic achievement. Other findings were the differences related to Becher's theory of academic tribes (Becher, 1994). Kamphorst differentiated between four domains: economics, engineering, health care and social studies. For students in the engineering domain, satisfaction with active learning and satisfaction with knowledge & skills were found to be predictors. In the health care domain contact hours and self-study predicted academic achievement.

Approaches to study / learning styles

Studies into the way people learn have a long tradition. The common way to investigate the approaches to study is by self-report questionnaires. Kappe (2011) treated the approach to study, like a student characteristic, assuming that each person has his own "learning style" similar to a personality trait. By using the Grade Point Average (GPA) of 5 types of learning environments (Classroom lectures, Skill training, Team projects, Internship and Thesis) as outcome variables the student characteristics (Intelligence, big five personality traits, intrinsic motivation, and learning style) were investigated in higher professional education. Contrary to expectation no relationship between "learning styles" (activist, theorist, reflector, pragmatist) and achievement could be established. Bruisma (2003) did also not find a relationship between approaches to study and achievement.

Biggs (1987) distinguished between only two approaches to learning in higher education, the surface- and deep approach to learning. The approaches are measured by the Study Process Questionnaire (SPQ). A surface learner scratches the surface of learning, by using reproductive strategies, spending the least possible time and avoiding to get really involved in a task. The deep learner does the opposite and tries to develop a real understanding of a task. In the view of Biggs and Tang (2007) the learning approach of the students is a direct result of the "teaching and learning environment" the student is exposed to. Changing the learning approach is therefore an important parameter for course design. A well designed "teaching and learning environment" will encourage the learner to move from a surface- to a deep approach of learning.

Curriculum characteristics

The studies of Jansen (1996, 2004), Van der Hulst and Jansen (2002), and Schmidt et al. (2010) used a different approach to studying curriculum characteristics. In these studies multilevel analysis was used to separate student factors from curriculum factors. A comparison of the results of these studies is provided in Appendix B: Overview of effects in multilevel studies.

The model of Jansen (1996) studied the indirect effects of student characteristics and curriculum characteristics through the black box "student effort" on achievement in terms of numeric returns (passing first year exam within 1 or 2 years and the total credits obtained after 1 year). The research was carried out in 5 departments (history, medicine, pharmacy, pedagogy/andragogy, business studies) and 5 cohorts in the late 1980's in an academic university. Curriculum characteristics were; organisation (the spread of study load), effectiveness of instruction and formal exam rules. To model the effectiveness of instruction a distinction was made between the orientation function, practice function and the control/feedback function of the learning environment. Variables on effectiveness of instruction did not provide the expected effects on achievement and seemed to be dependent on the department offering the programme and less on curriculum characteristics. Jansen (1996) stated that the way the variable "effectiveness of instruction" was made operational may have contributed to this. For "formal examination rules" no effect was found, but "curriculum organisation" showed an effect on study progress. Less subjects in parallel, less spread in re-sits and better spread of the exams across the year all had a positive influence on study progress. Differences were found for students who passed their 1st year exam within one year and other students who took two years to achieve this goal. Not for all students a Grade Point Average (GPA) at prior education was available, therefore in the analysis for the total population "Prior education" was used as a student characteristic. This did not change the conclusions drawn from the research.

The article of Jansen (2004) is based on the same results of Jansen (1996), but only the PUE (VWO) group, for which the grades in pre-university education were available, was taken into account. The curriculum characteristics studied were; organisation characteristics and instruction characteristics. The outcome measure: "passing first year exam within 1 year" was used. In the more homogeneous group of students no effect of age was found. For the curriculum, effects were found on the number of courses in parallel (fewer), hours of lectures (more), hours for tutorial (fewer) and courses with additional practise (more).

Van der Hulst and Jansen (2002) reported on a similar study in the engineering department with 4 cohorts in 3 disciplines. They considered curriculum organisation (spread of study over the year), instruction characteristics and examination characteristics. Compared to Jansen (1996) instructional effectiveness was made operational in a different way. It was assumed that more hours for practice (tutorials) will lead to a more active approach with more opportunities for practise and feedback. A two level model (student level and curriculum level) was used for the analysis. The number of credits obtained in the first year of study was the outcome measure.

Van der Hulst and Jansen (2002) found effects for age, in the PUE (VWO) group, gender and ability of the students. Appendix B: Overview of effects in multilevel studies provides a comparison with Jansen (1996, 2004). An effect of fewer courses in parallel was also found, as well as effects for theoretical course (fewer), a preparation week before the exam (beneficial) and the number of final grades (fewer). No effect for the hours of tutorials or hours of lectures could be established. This could have been the result of the way instruction characteristics were made operational. Active instruction methods may result in improved quality of learning, but this does not necessarily affect study progress in terms of credits obtained. Activating instruction could also result in better mastering of the learning materials offered and in higher grades. Van der Hulst and Jansen (2002) suggested to use grades as well as credits obtained as outcome measures, as the grades are likely to be related to educational quality.

Schmidt et al. (2010) provided an alternative to Tinto's social integration theory. The research was done in medical education in the Netherlands on the 4 year in-school curriculum for 10 cohorts of students in 8 Dutch medical schools. Study duration and graduation rate (percentage of students completing the programme) were used as outcome measures for achievement. A strong relationship between these two was found. The hours available for practicals and tutorials did have an effect on achievement, but a strong negative effect was found for hours of lectures. It was shown that the student's "time-for-self-study", as reported by external review committees (accreditation reports), was the major factor in achievement. More "time-for-self-study" and less time on lectures reduced study duration and had a positive effect on graduation rate.

The results of these types of studies are summarised in Appendix B: Overview of effects in multilevel studies. The factors related to the curriculum were divided into three groups: instruction-, examination- and organisation- characteristics. The instruction characteristics deal with the quality of the learning environment and the time related to learning, examination characteristics relate to the number of examinations in the programmes, while organisation characteristics describe the spread of teaching and examination activities over an academic year.

Curriculum components and the research model

Table 2 shows the relationship between curriculum components as defined by Van den Akker (2003) and the curriculum characteristics derived from the research on effectiveness in higher education. During the design of a curriculum the curriculum components: rational, aims & objectives and content are drawn-up based on the often conflicting views of different stakeholders. The stakeholders involvement in the design of programmes in higher professional education is also important, but is not part of the present research.

The curriculum components: Learning activities, Materials & resources" and Teacher role" are all related to the curriculum characteristic "Instruction". In the educational productivity model (Bruinsma, 2003) instruction included both quality and quantity of instruction. "Time on task" should therefore be seen as a dimension of the curriculum component: Learning activities. The teacher, the resources and activities all play a role in the learning environment, however in Bruinsma (2003) it proved to be difficult to measure the quality of the learning environment. The curriculum component: Assessment, with an important role for the teacher to ensure high quality, is related to the curriculum characteristic "Examination". In the multilevel studies the examination characteristics were measured in quantitative terms like; the quantity of exams or the quantity of final grades in an academic year. Biggs and Tang (2007) described that the quality aspects of the instruction characteristics are directly related to the Teaching & Learning Activities (TLA's), while the quality of the examination characteristics are related to Assessment Task (AT's). It is the teacher's role to safeguard the quality of both aspects.

Table 2

Relation between the curriculum components and curriculum characteristics

Curriculum Components	**Questions to be answered**	
Rationale	Why are they learning?	Not a part of this research
Aims & objectives	Toward which goals are they learning?	
Content	What are they learning?	
		Curriculum Characteristics
Learning activities	How are they learning	*Instruction:* - Characteristics of the learning environment - Time related to instruction and learning
Materials & resources	With what are they learning?	
Teacher role	How is the teacher facilitating their learning?	
Assessment	How to assess their learning progress?	*Examination:* - Number of exams in a programme
Grouping	With whom are they learning?	*Organisation:* - Location: within the institute - Time: related to the spread exams and instruction over an academic year.
Location	Where are they learning?	
Time	When are they learning?	

The curriculum components: Grouping, Location and Time are all related to the curriculum characteristic "Organisation". The questions concerning, where and when the students learn, were addressed by the studies of Jansen (1996, 2004), Van der Hulst and Jansen (2002) and Schmidt et al. (2010). The curriculum component: Grouping was not taken as a separate factor in these studies. In higher professional education learning is often located in the "world of work", through internship or graduation projects. However, the present research focuses on in-house curricula only. As the relationship between the curriculum components and curriculum characteristics has been clarified, the general research question can be rephrased to be more specific:

What is the relationship between the curriculum characteristic, describing instruction, examination and organisation, and academic achievement in the in-house curricula of professional higher education?

A multilevel model was used, to study the effect of the curriculum characteristics on achievement and answer the research question. The model is shown in Figure 6. A similar model was used in de studies of Jansen (1996, 2004) and Van der Hulst and Jansen (2002).

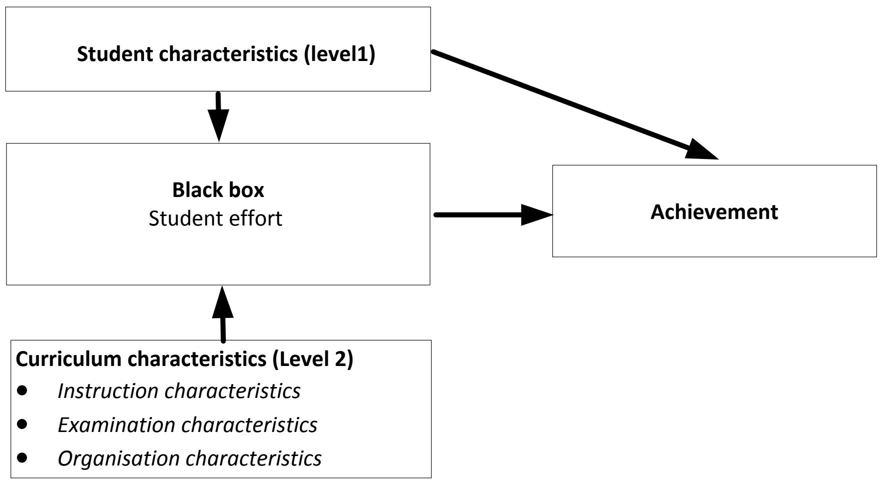


Figure 6: Research model

Student characteristics like ability, gender and age showed, in various studies, to have a direct effect on achievement. The student- and curriculum characteristics also have an indirect effect on achievement through the black box: student effort. Student effort depends on the student's motivation, learning approach and other factors of which the exact relationship is unknown. By using a multilevel analysis it was possible to control for individual differences of student characteristics and find the effects of the curriculum characteristics on achievement.

The relationship between the student- and curriculum characteristics and effectiveness are discussed in the next chapters. For these characteristics, specific research questions were formulated, together with hypothesis on the expected function of the variables in the research model.

Student characteristics and effectiveness

Direct effects of the student characteristics on achievement have been found in various achievement studies. Van der Hulst and Jansen (2002) found the grades for mathematics, physics and the Dutch language in prior education to be predictors of achievement for 1st year engineering students. Kamphorst's (2013) results showed that for male students the exam results in prior study for mathematics predicted academic achievement. In the studies of Jansen (1996) and Van der Hulst and Jansen (2002) female students performed better than male students and younger students better than older students. The research questions regarding gender and age were:

RQ 1 *What is the effect of gender on achievement?*

Hypothesis *Female students show higher achievement than male students*

RQ 2 *What is the effect of age on achievement?*

Hypothesis *Younger students show higher achievement than older students*

Within higher professional education Dutch students with 3 types of prior education enrol: SGSE (HAVO), PUE (VWO) and SSVE (MBO). For these groups the nominal study duration in secondary education, after completing primary education, is 5 years for SGSE (HAVO), 6 years for PUE (VWO) and 8 years for SSVE (MBO). Concerning the ability in mathematics it is commonly agreed, by staff in higher professional education, that the ability of the groups differ and that ranking from lowest to highest ability is: SSVE (MBO), SGSE (HAVO) and PUE (VWO). Prior education may therefore be useful as an ability scale. When the validity of this ability based on prior education scale can be established the following question could be answered:

RQ 3 *What is the relationship between prior education and achievement?*

Hypothesis *The groups perform equally well, differences are explained by age and not by prior education.*

Curriculum characteristics and effectiveness

In this chapter recent developments in higher professional education are discussed in relation with the curriculum characteristic being investigated in this study. For all three curriculum characteristics the underlying factors are examined. The relevance of the factors is described and for all factors, hypothesis are given on how the factor is expected to be functioning in the research model.

Instruction characteristics

The curriculum framework

In curriculum design internationally two main developments are seen according to Edström and Kolmos (2014), Project/Problem Based Learning (PBL) and the Conceive Design Implement Operate methodology (CDIO). CDIO pioneers were the Massachusetts Institute of Technology (MIT) from the USA and the Swedish institutions; Chalmers University of technology, KTH Royal Institute of Technology and Linköping University. In PBL pioneers were Maastricht University (Netherlands), McMaster University (Canada) and Aalborg University, Roskilde University from Denmark (Kolmos et al. (2013).

CDIO provides a process of designing an integrated curriculum (Edström & Kolmos, 2014). In CDIO, as Biggs and Tang (2007) pointed out, disciplinary knowledge and professional engineering skills are part of a course. Both are part of the Intended Learning Outcomes (ILO's) of a course and both are assessed in the Assessment Tasks (AT) of a course. During the design of the curriculum, the programme learning outcomes are used to make sure that the professional engineering skills become a part of the ILO's of the courses. This is schematically shown in Figure 7.

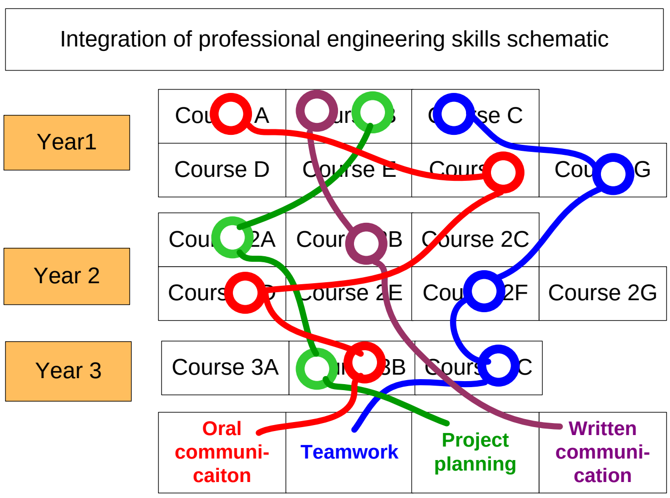


Figure 7: Assignment of programme learning outcomes in CDIO (Edström, 2014).

Edström and Kolmos (2014) stated that PBL and CDIO have a different point of departure. In PBL rethinking the educational process is fundamental, while CDIO starts of with rethinking the outcomes of education. Edström and Kolmos showed that the methods are compatible and have over the years developed towards each other. Nowadays the curriculum frameworks resulting from CDIO and PBL are quite similar and methods of each one reinforce the other.

In PBL the learning process is aligned with professional practice and in this way the professional engineering skills are integrated in the courses. Students work in groups on different types of projects: assignment projects (narrow and well defined), discipline projects (more open) and problem projects (broad and ill-structured). Students need to become familiar with the PBL learning principles, in order to be able to participate. Kolmos et al. (2013) show how the PBL model of Aalborg university was reconstructed, following government regulations requiring individual examinations. The old and new model for PBL in Aalborg, with some additional information, are given in Figure 8.

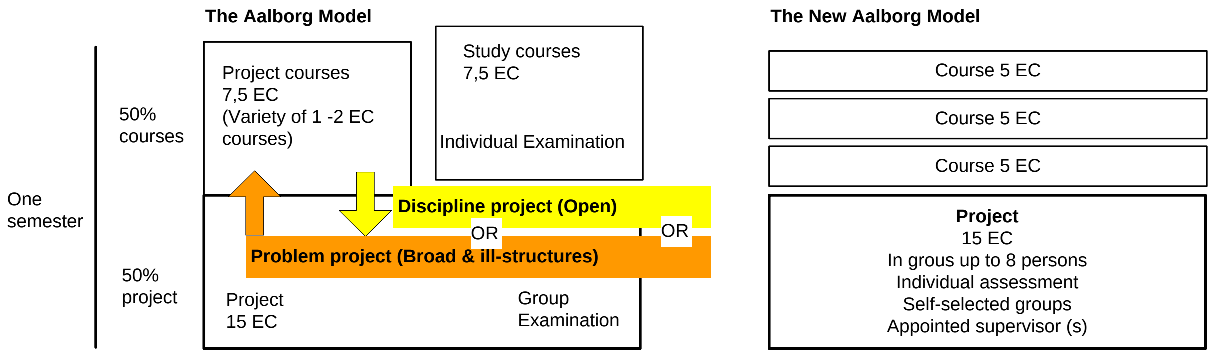


Figure 8: The old and new Aalborg PBL model. (Kolmos et al., 2004; Edström & Kolmos, 2014)

In the Netherlands the Competence Based Learning (CBL) approach is used in higher professional education for designing curricula aligned with the “world of work”, (Van Asselt, 2016). The CBL curriculum is thematic and structured around typical tasks of the profession (Dutch: beroepstaak). Descriptions of competences and indicators of the competence level, guide students through their studies. The CDIO framework, which describes the engineering process: Conceiving, Designing, Implementation and Operation of products, processes and systems, has much in common with the Dutch national engineering domain competences (Bachelor of Engineering, 2012). The engineering domain competences are shown in Figure 2 (page 7). The competences: Analyse, Design, Realise and Control/Verification describe the engineering process just like in CDIO. These are complemented by the general competences: Manage, Advise, Applied research and Professionalise. The general competences are labelled “professional engineering skills” in the CDIO terminology.

Depending on the particular profession the programme caters for, the CBL curricula can be shaped in different ways. The curriculum could use PBL, more conventional disciplinary courses or hybrid approaches. The ways of integrating the general competences in CBL can be done through projects (PBL) or learning outcomes (CDIO). Although the three approaches have al lot in common, there are also unique features. In CDIO design there is a very strong focus on the stakeholders while developing the curriculum at programme- as well as course level. Biggs and Tang (2007) showed how the view of stakeholders is optimised through the principles of the Constructive Alignment Theory (CAT). CAT is a set of principles for curriculum design to create “Teaching and Learning activities” (T&L’s) and “Assessment Tasks” (AT) to achieve “Intended Learning Outcomes” (ILO’s), aligned to the views of the stakeholders. Vanfretti and Farrokhabadi (2015) gave an example of how CAT can be used for building an activating course in electrical engineering.

Kappe (2011) characterised CBL programmes according to 5 different learning environments: theory classes, skills training, team projects, internship and individual graduation projects. In the foundation years theory classes, skills training and team projects are the relevant learning environments. In designing curricula, whether it is by CDIO, PBL or CBL, agreeing on the right mix of theory, skills and projects is a challenge. In projects students integrate knowledge and skills and work on tasks relevant to their future profession. To what extent a curriculum is integrated and the effect integration has on achievement are therefore relevant factors to investigate. First of all a measure for integration needs to be defined and it should to be established whether the level of integration is a meaningful way to characterise the present curricula in higher professional education. Thereafter the following specific research question could be answered:

RQ 4 *Does a more integrated curriculum (measured by a ratio of credits for "projects" and/or "real life tasks" versus the total credits in a curriculum year) promote achievement?*

Hypothesis *Integrated curricula promote achievement, but differences will be observed between the year 1 and year 2 curricula.*

Time on task: intended-, attained- and obligatory contact time.

A lot has changed since Caroll (1963) posed the question: "what actually happens in the classroom?". Today the setting of providing education is much more diverse. The question to be asked could be: "What happens in the social media discussions, in the MOOC, in the project workgroups, in the computerised learning environment and of course in the classroom?" Interaction between students and between students and teachers took new forms. Traditionally instructor was a synonym for teacher, but focus has changed from teaching to learning. Biggs and Tang (2007) stated that it is the teacher's fundamental task to get students to engage in learning activities that are likely to result in achieving the desired outcomes in a reasonably effective manner. Biggs and Tang named the newly created environment the "teaching and learning environment". Whatever form the environment takes, "time on task" is likely to have remained a key factor in promoting effective learning.

The "teaching and learning environment" is often supported by electronic means (digital learning environment, flipped classroom approach, digital testing, etc.) and other ways to make the teaching and learning environment more activating. These approaches are first of all linked to support learning of theory/knowledge, traditionally the domain of lectures and tutorials. In the research of Jansen (1996, 2004) activation is assumed to be linked to the number of hours on tutorials and to courses with additional practice, but evidence is not clear and contradicting. The number of courses with additional practice had a positive effect on achievement, but hours of lectures also promote achievement. For a comparison of results see: Appendix B: Overview of effects in multilevel studies. In medical schools (Schmidt et al., 2010) the hours of lecture reduce achievement, while in engineering education (Van der Hulst and Jansen, 2002) no effects were found for both hours of lectures and hours of tutorials. Most probably the wide variety of approaches teachers used to organise the learning environment made it difficult to capture the activating effect of learning environment in terms of hours on lectures, practicals and tutorials.

Although opportunities for digital communication were booming, universities remained the physical place were students come together with the intention to learn. Under the agreement with government (HBO-raad-OCW, 2011), the universities of applied science committed themselves to provide a minimum number of "contact hours". The indicator the institutes had to adhere to was defined as: "The percentage of bachelor programmes with less than 12 clock hours scheduled in a week in the 1st year of the programme". Most institutes committed themselves to make sure that this percentage was smaller than about 5%. Due to the focus on "contact hours" the data was carefully recorded for all curricula from cohort 2013 onwards.

According to Hoeben (1994) allocating less time, reduced "time on task" and therefore it may restrict the possible learning outcomes. Schmidt et al. (2010) showed, in a study on 10 cohorts in 8 Dutch medical schools, that constraining "time-for-self-study" had a negative effect on achievement. The "time-for-self-study" is not scheduled "self-study", but time becoming available by not planning student activities. They found that a timetable with too many scheduled activities (especially passive lectures) may have actually impeded and not promoted learning and student achievement. In medical schools, according to Schmidt et al. (2010), students prepare for exams by: "extensive processing of often-large amounts of information, summarizing, elaboration, and rehearsal". In engineering education exam preparation would be described in a way less directed to rote learning. Whether the learning environment should provide “direct instruction” or that “minimal guidance” is preferred for optimal learning was the issue in a fierce scientific debate (Kirschner et al., 2006). In engineering education, “direct instruction” is widely practiced as shown by a study of Perdigones et al. (2014) carried out in Spain. The effects of hours of instruction in 3 core engineering subjects were monitored over 3 years. It was concluded that at least 120 instruction hours per subject were required to make sure that graduates have basic competence (basic knowledge, comprehension and application) at graduation. Providing more than 200 hours of instruction per subject did not result in higher outcomes. Similar findings are known from the work of Van der Drift and Vos (1987), who found that a minimum number of lectures were necessary to stimulate self-study. They found, for the programmes investigated within academic universities, an optimum value for contact hours between 325 and 400 hours per year.

Whether these figures are also applicable to the present practice in higher professional education is not known. The contact hours in the present curricula are allocated in a variety of ways, to projects, theory classes, laboratories and work sessions. To make a distinction between active and passive hours from the curriculum planning data is problematic. Participation in activities is seen as important in higher professional education and curriculum designers take measures to promote “time on task”, which is the driving force behind activation. One of these measures is to make scheduled activities “obligatory”, but it is not clear whether this promotes achievement. In order to investigate the functioning of time, the distinction between the intended (planned) curriculum and the attained (perceived) curriculum, as described by Van den Akker (2003), is of importance. The data for “contact hours” for each programme combined with the data for “obligatory contact hours” provided information about the intended (planned) curriculum. The information regarding the attained (perceived) curriculum, the perception of students, was obtained from the yearly National Student Survey. In this survey the student perception was asked regarding: 1. Time on study, and 2. Contact time. The complete information on the relevant National Student Survey questions is provided in Appendix E: National Student Survey Questions.

First of all it was of importance whether the data from the National Student Survey provides an insight about time aspects of the learning environment and whether the data on planned curriculum and attained curriculum correlate. If so the following research question can be answered:

RQ 5 *What is the relationship between contact time planned, contact time perceived and achievement?*

Hypothesis *The contact time planned in a curriculum and contact time as perceived by students has a positive relationship with achievement. However the relationship is not linear and will have a maximum, above which the achievement no longer improves.*

The other research question investigated the relationship between “time on tasks” as reported by students and achievement:

RQ 6 *Do curricula for which students report “more hours spend on study”, show a higher achievement?*

Hypothesis *The relationship between reported hours spend on study and achievement is positive.*

Examination characteristics

Van der Hulst and Jansen (2002) found that the total number of examinations in a programme did not have an effect on study progress. However fewer final grades, through a system of compensation, had a positive effect. But it remained unclear how well these results can be generalised, as it might just have reflected the specific situation of exam organisation in one university. Cohen-Schotanus (2016) stated that achievement was promoted by a fewer number of large courses with a more integral examination consisting of various parts such as: assignments, reports, intermediate exams, verbal tests. Other measures suggested are to provide regular partial examination during the instruction period with sufficient feedback and to make sure that the examinations are of high quality. It was suggested to make an organisational shift from courses with fewer credits to larger courses with more credits and related coursework.

In what way this organisational shift contributes to improving achievement is not clear. For the larger courses additional coursework is included, to regulate study pace and provide feedback to students. The course exam activities are made formative instead of summative, but the credits are still attached to a number of course activities that are required to be assessed. What is likely to be an important factor are the rules and regulation regarding compensation at course level. Also in a curriculum with smaller courses additional coursework could be added, to regulate study pace and provide feedback. When courses are small this may lead to too many deadlines and competition and hence may reduce achievement. However in a well coordinated curriculum, with carefully designed amount of additional course work, this negative effect may not take place.

Whatever course size is chosen, administration of (partial) results needs to be done. The administration can be done in a central results database or be left to the teachers organising the courses. With a central registration the additional exam activities are more likely to be treated as conditional for receiving the final grade.

The total number of final grades in a curriculum year is a measure for the size of courses (number of credits per course). It can also be argued that a smaller course size (more final grades) will give more opportunities to obtain credits and this will motivate students and therefore result in higher achievement. On the other hand, when assuming the simple logic of numbers, the more final grades and conditional exam activities, the more changes to fail and the lower the achievement will be. The course size and the number of opportunities to fail were investigated by observing the following characteristics of the curricula:

1. The total number of final grades in a curriculum over a year. The smaller this number the larger the average amount of credits assigned to a course.

2. The total number of conditional exam activities in a curriculum over a year. When the number is equal to the total number of final grades every course has only one exam activity.

The research questions investigated were:

RQ 7 *What is the relationship between the number of final grades in a curriculum and achievement?*

Hypothesis *A smaller number of final grades has a positive effect on the achievement.*

RQ 8 *What is the relationship between the number of conditional exam activities in a curriculum and achievement?*

Hypothesis *The logic of number prevails, fewer conditional exam activities in a curriculum promote achievement.*

Organisational characteristics

The organisational aspects investigated in Jansen (1996, 2002) and Van der Hulst and Jansen (2002) were; the number of modules parallel, exam schedule, exam re-sit organisation, instruction weeks and preparation week before exam. Schmidt et al. (2010) found that “Time-for-self-study” promoted achievement. The factors related to organisation included in the present research are: parallel scheduling of instruction activities (courses), organising self-study time, the scheduling of exam re-sits and the way the students perceive the organisation of the curricula.

Activities in parallel

The number of courses in parallel was part of the studies of Jansen (1996, 2002) and Van der Hulst and Jansen (2002). It was shown that study progress increased by fewer courses in parallel. Assuming that this was a linear relationship it was suggested by Jansen (2016) that programming one or at a maximum two activities in parallel is preferable (e.g. 4 week blocks on a single theme). The new Aalborg PBL model (Edström & Kolmos, 2014) scheduled 3 courses and a project in parallel during a semester. The courses were not necessarily related to and supporting the project, so in the Aalborg model the students are exposed to 4 areas of attention in a study week during a semester. How many different areas of attention within a week's work can a student cope with? Therefore the following research question was investigated:

RQ 9 *What is the relationship between the number of parallel scheduled activities (courses) in a study week and achievement?*

Hypothesis *Fewer parallel scheduled activities will result in higher achievement. However the function is not linear and planning only one or two activities is not necessarily the optimum.*

Organising "self-study" time

Schmidt et al. (2010) found that "Time-for-self-study" promoted achievement in medical education. Organising preparation and self-study time in curricula for higher professional education may therefore have the same effect. Time for self-study can be allocated within an instruction day or an instruction week, by scheduling self-study time in the time-table or by deliberately not planning any activities (scheduling fewer "contact hours"). Time can also be allocated in the academic year planning. Education is organised in blocks, trimesters or semesters. Within these units time is reserved for instruction, exam preparation and exams. More time allocated for exam preparation and exams will reduce instruction time. Van der Hulst and Jansen (2002) did not find effects for the number of instruction weeks in academic university education, but a positive effect was found for "preparation week before the exam". This is contrary to the believe that preparation weeks lead to procrastination and therefore reduce study progress. The approaches used for organising preparation and "self-study" time in the curriculum were investigated and the effectiveness examined by the following research questions:

RQ 10 *In what ways is "self-study" time incorporated in the curricula?*

RQ 11 *Which measures aimed at increasing "self-study" time promote achievement?*

Hypothesis *Preparation days before the exam period and reducing the number of instruction weeks as well as other measures, will promote achievement.*

Scheduling the re-sits of examinations

The re-sits can either be scheduled within a few weeks of the exam or in the next examination period (after 10 weeks in a 4 blocks a year planning system). No conclusive research evidence was found on this issue. Cohen-Schotanus (2016) stated that re-sits shortly after the regular exam could lead to procrastination and competition with other activities. It will make a difference however whether a re-sit within a few weeks is offered, for students who scored 5 out of 10 or for students who scored a very low mark on the regular exam. Regulation on who is allowed to take part in a fast re-sit may be necessary. The variable "Weeks between exam and the re-sit for that exam" should be studied in relation with the total number of exams in a programme and exam regulations in place. The following research question was answered:

RQ 12 *Is achievement improved by reducing the time between regular exams and re-sits of the exams?*

Hypothesis *A shorter time between exams and the re-sits of the exams, 3 to 5 weeks instead of 10 to 12 weeks, will not improve overall achievement.*

Students perceptions of the organisation

Within the National Student Survey (NSS) a number of questions is posed related to the organisation of the curricula. Investigation regarding the student's perception on the feasibility of deadlines, the distribution of study-load, and whether students reported to participate in all scheduled activities were part of the surveys. The actual phrasing of the questions is given in Appendix E: National Student Survey Questions. The NSS data was first of all investigated to establish whether it is useful to predict achievement of a curriculum. The related research question was:

RQ 13 *Do curricula for which students report higher satisfaction on the "Distribution of study load", "Feasibility of deadlines" and score high on "following all the scheduled activities" show a higher achievement?*

Hypothesis *A well organised curriculum, in the perception of students, shows a positive relationship with achievement.*

Summary of research questions

The general research question is :

What is the relationship between the curriculum characteristic, describing instruction, examination and organisation, and academic achievement in the in-house curricula of professional higher education?

The Specific research questions are:

Student characteristics

RQ 1. What is the effect of gender on achievement?

RQ 2. What is the effect of age on achievement?

RQ 3. What is the relationship between prior education and achievement?

Curriculum characteristics

RQ 4. Does a more integrated curriculum (measured by a ratio of credits for "projects" and/or "real life tasks" versus the total credits in a curriculum year) promote achievement?

RQ 5. What is the relationship between contact time planned, contact time perceived and achievement?

RQ 6. Do curricula for which students report "more hours spend on study", show a higher achievement?

RQ 7. What is the relationship between the number of final grades in a curriculum and achievement?

RQ 8. What is the relationship between the number of conditional exam activities in a curriculum and achievement?

RQ 9. What is the relationship between the number of parallel scheduled activities (courses) in a study week and achievement?

RQ 10. In what ways is "self-study" time incorporated in the curricula?

RQ 11. Which measures aimed at increasing "self-study" time promote achievement?

RQ 12. Is achievement improved by reducing the time between regular exams and re-sit of the exams?

RQ 13. Do curricula for which students report higher satisfaction on the "Distribution of study load", "Feasibility of deadlines" and score high on "following all the scheduled activities" show a higher achievement?

In the following methodology chapter, the application of the research model in higher professional education is elaborated. In the results chapter the research questions are answered using 4 cohorts of students passing through in-house curricula of 10 different programmes in science and technical higher professional education.

Methodology

To test the hypothesis on the relation between achievement and the curriculum characteristics, the research model was tested with data of 4 cohorts of students in 10 different bachelor degree programmes in science and technical educations. The bachelor degree programmes are built from courses, the terminology used by Biggs and Tang (2007) for units, modules or subjects. The programmes were offered by the Academy “Life science, engineering & Design” of SAXION university of Applied Science in the Netherlands.

The data was obtained from the educational records kept in a database (known as BISON). Both student progress as well as curriculum information were retrieved from the database. For analysis of the instruction characteristics of the curricula, outline documents were studied, and when necessary curriculum owners interviewed. Data tables were built up by using Excel and thereafter imported into SPSS 14 for analysis with a multilevel model. An overview of the research model with all variables is given in Appendix C: Model for multilevel analysis

The next sub-chapter provides background information on multilevel analysis. Another sub-chapter gives an overview of the programmes, information on drop-out, continuation from year 1 to 2 and students switching between programmes. The sub-chapter also provides a more specific research question for the situation within SAXION. The remaining sub-chapters describe the outcome, student and curriculum variables and show step by step how the data was prepared for analysis.

The statistical model

As described by Field (2004) the multilevel model, also known as random coefficient model, linear mixed model or hierarchical linear model is an extension of the basic linear statistical model:

$$Y_i = b_o + b_1 X_i + \varepsilon_i$$

The outcome Y_i is predicted by X_i. The error term is ε_i. The relation between the outcome and the predictor is characterised by: the intercept b_0 and the slope b_1. In this regression model the intercept and slope have fixed values. With this model the direct effect of predictor Age (X_i) on outcome variable Achievement (Y_i) can be found for student *i*. The relationship is described by the intercept b_0 and the slope b_1. Age is a variable at level 1.

In a multilevel model a random intercept and a random slope are introduced into the general linear model. The intercept is replaced by $b_0 + \mu_{0j}$ and the slope by $b_1 + \mu_{1j}$, the μ_{0j} and μ_{1j} provide information about the variation. This gives for the multilevel model:

$$Y_{ij} = (b_o + \mu_{0j}) + (b_1 + \mu_{1j}) X_{ij} + \varepsilon_{ij}$$

In the multilevel model the outcome variable Achievement (Y_{ij}) depends on both the student i as well as the curriculum j. The random intercept and random slope depend on curriculum j. With two variables in the model the “age” (AGE) and the “number of contact hours” (NCH) the equation for “achievement” (ACH) becomes:

$$ACH_{ij} = (b_o + \mu_{0j}) + (b_1 + \mu_{1j}) NCH_{ij} + b_2 AGE_{ij} + \varepsilon_{ij}$$

The multilevel model predicts the effects of both “number of contact hours” (NCH_{ij}) and Age (AGE_{ij}) on Achievement (ACH_{ij}). The variable “number of contact hours” (NCH) is a curriculum variable at level 2.

Programmes, cohorts and curricula

In technical and applied science bachelor programmes in higher professional education in the Netherlands a clear distinction was seen in the educational approach in the first two years with a focus on knowledge & skills, small projects and an in-house curriculum, compared to the approach in the last two years (outside-school, large projects). This difference was also observed in the SAXION University of Applied Sciences as shown in Figure 9. The in-house curricula of the first two years of the SAXION programmes were the focus of the research on the curriculum characteristics. The 3rd and 4th year of the bachelor programmes all showed a similar structure: internship (30 EC), a large multidisciplinary project and courses of choice (24 EC + 6EC), a minor (30 EC) and a graduation assignment (30 EC) providing a final bridge to the "world of work".

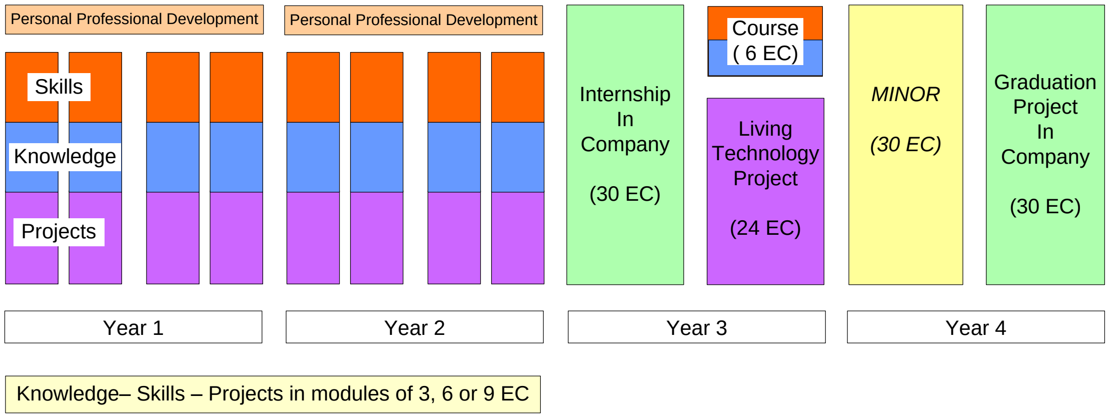


Figure 9: Frame work of bachelor programmes (applied science and engineering) in SAXION UAS

Within the academy "Life Science, Engineering & Design" (LED), 10 different bachelor programmes were offered in 3 domains. Engineering domain programmes are: industrial design (ID), electrical and electronic engineering (EEE), mechanical engineering (ME), mechatronic engineering (MT). The life science domain programmes are: chemical technology (CT), Chemistry (CH), bio-medical laboratory (BML), applied physics (AP) and forensic science (FS). The ICT domain: applied computer science (ACS). For the specific situation in SAXION the research question was rephrased as:

> *What is the relationship between the curriculum characteristic and academic achievement in terms of number of credits obtained, for ICT, applied science and engineering students in the first and second year of professional higher technical and science education at SAXION University of Applied Sciences?*

For the 1st year curricula the year the cohorts of 2012, 2013, 2014 and 2015 were included. Successful students continued in 2nd year the curricula in 2013, 2014 and 2015. Of the total population of students, students with shorter curricula were excluded (short degree programme, evening programmes, associate degree programme). An overview of the drop-out, switch and successful students for the whole population is shown in Table 3. In the dataset students are included who are new at SAXION, with a history in Higher Education (HE) at other institutions and students who switched from one bachelor programme to another within SAXION after one year of study. Table 4 shows the size of the student populations in each year.

Table 3

Overview student data: starters, efficiency, drop-out, switch (sum for cohorts 2012, 2013, 2014, 2015)

Student groups	Description	Number	Percentage
Total starter in bachelors		**2,683**	
Fresh starters	new in HE & new in SAXION	2,256	84.1%
Starters with 1 year in HE		215	8.0%
Starters with 2 years in HE		113	4.2%
Starters ≥ 3 years in HE		99	3.7%
After year 1			
Continuing in year 2	in the same programme	**1,175**	43.8%
Drop-out	stopped studying in SAXION	1,209	45.1%
Switching	to a bachelor within academy LED	140	5.2%
	to a bachelor of another academy	159	5.9%

Table 4

Number of students per year

Cohort Year 1	n Year 1	Cohort Year 2	n Year 2
2012	609	-	-
2013	679	2013	364
2014	667	2014	422
2015	728	2015	389
Total	**2,683**		**1,175**

Outcome variables

The outcome was measured in terms of credits earned by a student in a year, while being exposed to the curriculum of the particular year and programme. The SAXION student-results database provided the credits earned per quarter, which was used to calculate the credits earned in the 1st year. This is also the value of the variable “EC in year 1”. For the 2nd year students the progress results did not show whether the credits obtained belong to year 1, year 2 or year 3 of the programme. The records simply showed credits earned and not the origin of the credits. The minimum number of credits students should obtain in their 1st year of study (propaedeutic exam) in order be allowed to re-register in the same programme the next year (Dutch: bindend negatief studieadvies) has been increased within the academy over the last years from 37 EC in 2012 to 51 EC in 2015 (not all programmes used exactly the same norm every year, but by 2015 the 51 EC norm was implemented by all programmes). The examination board could decide to deviate from the norm in case of individual student circumstances. The credits earned in the 2nd year of study may in fact contain some credits belonging to the 1st year curriculum. The variable “EC in year 2” was not corrected for EC belonging to year 1, as in most of the years the maximum difference would be 9 EC. To allow for the additional credits obtained in year 2, the maximum of the variable “EC in year 2” was set to 60 + 12 = 72 EC. It was observed in the data set that 62 students in year 1 were able to obtain more than 60 EC. This originated from students being registered for 2 bachelor programmes (switching and double degree), or late registration of credits in case of February intake. For all these students the maximum number of credits for variable “EC in year 1” was set to 60 EC. For the 2nd year students, 30 records were removed, because the credits in year 1 were found to be 0 EC. This most likely originated from incorrect recording of the start year in the student data (student who registered, but only started a year later).

The descriptive statistics of the outcome variables in year 1 are given in Table 5.

Table 5

Outcome variable “EC in year 1”, descriptive statistics

Study year 1	n	Minimum	Maximum	Mean	Std. Deviation
2012	609	0	60	34.92	21.28
2013	679	0	60	37.70	21.50
2014	667	0	60	35.90	23.02
2015	728	0	60	38.19	22.83
Total	2683	0	60	36.75	22.23

To allow better insight in the impact of changing the rule on minimum credits from 37 EC to 51 EC (Dutch: bindend negatief studieadvies) the switch and drop-out percentages are given in Table 6.

Table 6

Drop-out, switch and continue in year 2

	Year 1			
	2012	2013	2014	2015
Continue in year2 [%]	59.8	62.2	58.3	n/a
Switch [%]	14.9	14.4	16.5	n/a
Drop out [%]	25.3	23.4	25.2	n/a

The difference in achievement between 2012 and 2015 was 3.3 EC. This was a significant increase, $t(1335) = -2.70$, $p = 0.007$. From the drop-out and switch rates for 2012 – 2014 no trend could been established. Data on drop-out and switching for 2015 were not available. Although an increase of achievement was observed, it is too early to make definitive conclusions regarding the 51 EC rule in the first year. In Table 7 the descriptive statistics for the 2nd year are given. Figure 10: Outcome variables versus years compares the values of the outcome variables for year 1 and year 2.

Table 7

Outcome variable "EC in year 2", descriptive statistics

Study year 2	N	Minimum	Maximum	Mean	Std. Deviation
2013	361	0	72	48.75	16.63
2014	411	0	72	52.01	16.00
2015	373	0	72	48.02	17.62
Total	1145	0	72	49.68	16.82

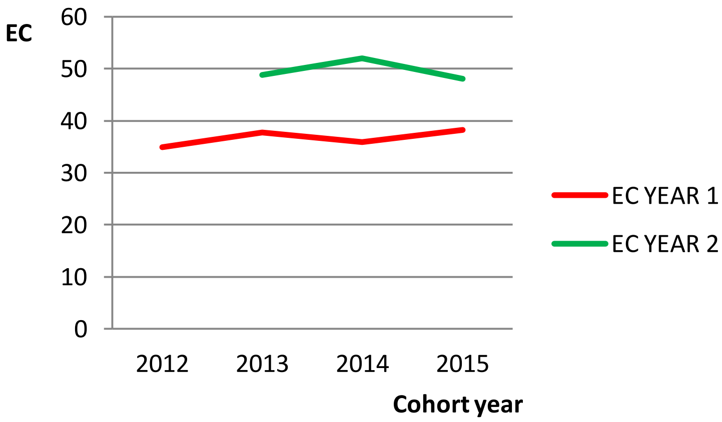


Figure 10: Outcome variables versus years

On average the students in the 2nd year scored 13 EC more per year than the starter group of the 1st year. The credits earned in a year varied over the years in the different programmes. In Figure 11 the credits obtained in year 1, for students in their 1st year from 2012 – 2015, are compared for the programmes in the 3 domains. The ICT domain had the smallest group of students 121 (4.5%), followed by the Engineering domain with 1,102 (41.1%) students and the Applied Science domain with 1,460 (54.4%) students.

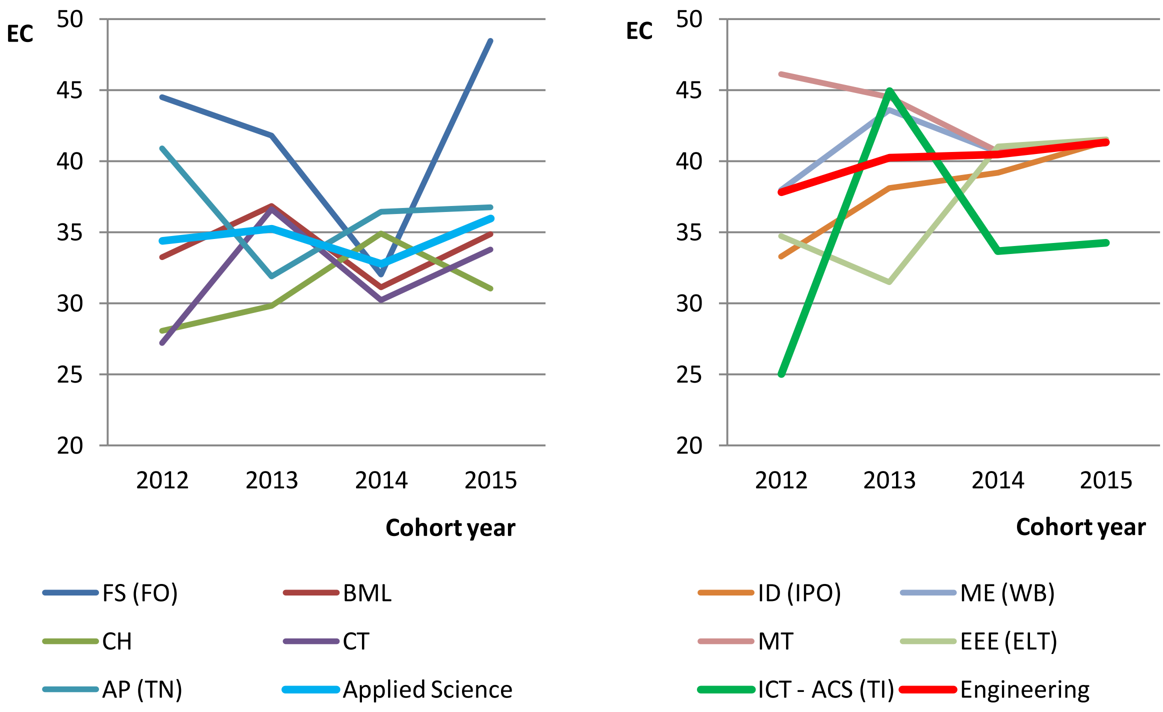


Figure 11: EC in year 1 for programmes and domains

The mean values of the credits obtained by students in the three domains were significantly different, $F(2,2680) = 21.79$, $p < 0.01$. Over the years students in the Engineering domain obtained 5.5 EC more than the Applied Science students and 7.6 EC more than the ICT domain students. The achievement of FS (FO) students showed a dip in 2014. In 2014 the focus of the FS (FO) team was on preparation of the completely new curriculum which was implemented in 2015 and while doing so students of the 2014 cohort seem to have been neglected. The ACS (TI) programme became part of the LED academy in 2014. Before 2013 the data of the ACS(TI) programme were combined with data of a non related Associated Degree programme. Untangling the data proved to be difficult and the swing in achievement in 2012 and 2013 resulted from unreliable data. However from 2014 onwards the data were correct. In 2014 and 2015 the 1st year programmes for ACS (TI) and EEE (ELT) were for 85% identical and only differed in 3 courses. In these almost identical programmes, the students of ACS (TI) scored 7.4 EC less in their first year than the EEE (ELT) students. This difference is significant $t(172) = 1.98$, $p = 0.049$.

Student characteristics

Data on gender, age and previous study was provided by the SAXION data-warehouse. The variable age was recalculated and reflects the age of the student on 1st of October in the first year of study. The variable used in the analysis was age minus 16 years. Students older than 27 years old were excluded from the sample. See for more details, Appendix I: Student progress data processing. Table 8 provides an overview of the descriptive statistics for the year 1 and year 2 population and Table 9 gives an overview of the number of female and male in the year 1 and year 2 population.

Table 8

Age of the Year 1 and Year 2 student population

	n	Minimum	Maximum	Mean	Std. Deviation
Age on 1 Oct when starting in Year 1	2683	16.00	26.00	18.95	1.94
Age on 1 Oct when starting in Year 2	1175	17.00	27.00	19.97	1.96

Table 9

Gender in Year 1 and Year 2 student population

	Year 1		Year 2		Year 1 to Year 2 Success rate
	Frequency	Percent	Frequency	Percent	
Female	750	28.0	372	31.7	49.6
Male	1,933	72.0	803	68.3	41.5
Total	2,683	100.0	1175	100.0	43.8

For previous education the 6 groups were made. The SSVE (MBO) group was split in students who came from a different domain (e.g. economics) and the students who remained in the science and technical domain when starting in higher professional education. The group with unknown prior education contained a variety of Dutch as well as international students. The educational backgrounds of the students in the year 1 and year 2 total population is given in Table 10.

Table 10

Prior education in the Year 1 and Year 2 student population

	Year 1		Year 2		Year 1 to Year 2 Success rate
	Number	Percent	Number	Percent	
SSVE2(MBO) other domain	120	4.5	28	2.4	23.3
SSVE1(MBO) same domain	360	13.4	176	15.0	48.9
SGSE (HAVO)	1,706	63.6	696	59.2	40.8
PUE (VWO)	295	11.0	184	15.7	62.4
Foreign diploma	81	3.0	38	3.2	46.9
Unknown	121	4.5	53	4.5	43.8
Total	2,683	100.0	1,175	100.0	43.8

Over the years investigated in this study the educational background of the students starting in the programmes did not change much for the SSVE(MBO), PUE (VWO) and foreign diploma groups, however the inflow from SGSE (HAVO) increased by 49.4% as shown in Table 11.

Table 11

Educational background of students in year 1 (2012 - 2015)

	Year of study				
Prior Education	2012	2013	2014	2015	Total
SSVE2(MBO) other domain	48	23	23	26	120
SSVE1(MBO) same domain	95	84	84	97	360
SGSE (HAVO)	332	433	445	496	1,706
PUE (VWO)	72	85	72	66	295
Foreign diploma	25	16	20	20	81
Unknown	37	38	23	23	121
Total	609	679	667	728	2,683

A good predictor for achievement of students in engineering and science education are the grades they score on abstract subjects (math & physics) (Van der Hulst and Jansen, 2002; Kamphorst, 2013). When teachers are asked to rate ability on mathematics and physics for the different groups participation in technical and science higher education from low to high ability the scale will be: SSVE (MBO), SGSE (HAVO), PUE (VWO).

Within the data two other groups were distinguished, the international group (90% foreign diplomas) and the SSVE (MBO) group who changed domains when entering higher education (Van Asselt, 2016). Rated on the ability scale the domain switching group was inserted at the lowest level of the scale. The international students only studied in two programmes, EEE (ELT) and ACS (TI). To insert the international students and the students with unknown previous study on the ability scale a number of scenarios were tested as shown in Appendix I: Student progress data processing. The scenario with foreign diplomas equivalent to PUE (VWO) and unknown diplomas equivalent to SGSE (HAVO) was chosen for the ability scale, as shown in Table 12.

Table 12

Use of the prior education variable as an ability scale?

Previous study	Value Previous study	Ability scale A	Ability scale F
		NL	Test5
SSVE2(MBO) other domain	0	0	0
SSVE1(MBO) same domain	1	1	1
SGSE (HAVO)	2	2	2
PUE (VWO)	3	3	3
Foreign diploma	4	-1	3.1
Unknown	5	-1	2.1
-2LL (in whole population)		23944.80[+)]	23938.39[+)]
		df = 6	df = 6

[+)] In the whole population with “age-16” and gender as predictors the reference value for the -2LL = 24014.32, df =5. With a Chi^2 change = 75.9 and df =1, this is highly significant change of Chi^2.

Curriculum characteristics

A distinction was made between the curricula in the first year and the second year of a programme. In the 2nd year only successful students participated (43.8% of the first year students continue in year 2). The student populations of year 1 and year 2 are not the same, therefore separate analysis was done on the 1st and 2nd year curricula. The variables included in the research model are divided into 3 groups: instruction, examination and organisation. Table 13 provides an overview of the descriptive statistics for the curriculum variables for the year 1 curricula and Table 14 shows the data of the year 2 curricula.

The curriculum variable had different origins. The variables reflecting student perception were derived from the data of the National Student Survey (Dutch: NSE). Data on contact time (planned), number of examinations, activities in parallel were obtained from the records of the planning database (SAXION BISON). The data on weeks between examination and re-sit were found in yearly planners, records of the exam planners dug up from the data waste bins. The curriculum integration variable was derived from interviews with curriculum experts and study of curriculum documents. The modelling of curriculum integration and the use of the National Student Survey data is discussed in separate sub-chapters.

Table 13

Variables describing curriculum characteristics for year 1 curricula

Curriculum variable	N	Minimum	Maximum	Mean	Std. Deviation
Instruction					
Curriculum Integration ratio (%)	40	11.11	37.50	25.29	7.851

Curriculum variable	N	Minimum	Maximum	Mean	Std. Deviation
Contact time - planned (hours/year)	34	439	825	690.59	97.55
Obligatory contact time - planned (hours/year)	34	198	825	452.06	168.05
Time on study - student perception (hours/week)	28	22.27	37.33	30.62	3.18
Contact time - student perception (hrs/week)	28	13.00	23.56	18.57	2.55
Examination					
Final grades (#)	40	11.00	20.00	16.63	2.73
Conditional exam activities (#)	40	11.00	32.00	19.20	4.89
Organisation					
Parallel activities (#)	37	4.00	7.75	5.20	0.78
Weeks between exam and re-sit (#)	38	2.30	8.60	6.07	2.18
Distribution of study load - student perc.(scale+)	28	2.67	4.07	3.59	0.27
Feasibility of deadlines - student perc.(scale+)	28	2.67	4.15	3.66	0.27
Participation scheduled activities - student perc. (scale+)	28	3.75	4.67	4.18	0.23
Valid N (list wise)	27				

+) scale: 1 to 5; 1 = very dissatisfied, 5 = very satisfied , or ; 1 = never, 5 = always.

Table 14

Variables describing curriculum characteristics for year 2 curricula

Curriculum variable	N	Minimum	Maximum	Mean	Std. Deviation
Instruction					
Curriculum Integration ratio (%)	30	23.15	50.00	38.92	8.31
Contact time - planned (hours/year)	29	404	857	639.93	128.30
Obligatory contact time - planned (hours/year)	28	126	750	409.64	166.85
Time on study - student perception (hours/week)	28	18.33	40.26	31.14	4.72
Contact time - student perception (hours/week)	28	8.79	25.20	15.59	3.98
Examination					
Final grades (#)	30	13.00	19.00	16.38	1.20
Conditional exam activities (#)	30	13.00	25.00	17.83	2.70
Organisation					
Parallel activities (#)	30	3.50	8.00	5.35	1.10
Weeks between exam and re-sit (#)	30	4.20	11.10	8.55	2.09
Distribution of study load - student perc.(scale+)	28	3.00	4.40	3.51	0.32
Feasibility of deadlines - student perc.(scale+)	28	3.06	4.60	3.62	0.33
Participation scheduled activities - student perc. (scale+)	28	3.55	4.93	4.29	0.23
Valid N (list wise)	26				

+ scale: 1 to 5; 1 = very dissatisfied, 5 = very satisfied , or ; 1 = never, 5 = always.

An overview of the invalid curricula is provided in Appendix H: Curriculum missing data

Student perception

Student perception on some aspects of the curriculum was measured by the National Student Survey (NSS) in 2013, 2014 and 2015. The questions answered by the students are provided in Appendix E: National Student Survey Questions. The average student perception was calculated from all the responses in a given cohort. In the survey, students indicate in which year they follow most of their classes. This information was used to separate the year 1 and year 2 responses. Table 15 provides an overview of the average number of respondents per curriculum per year.

Table 15

Summary for NSS (NSE) response per programme (for valid curricula)

Programme code	Croho	Average NSS (NSE) for Programme (n= number of students)
FS (FO)	34112	26.3
BML	34397	48.5
CH	34396	28.8
CT	34275	7.5
AP (TN)	34268	20.9
ID (IPO)	34389	39.3
ME (WB)	34280	62.2
EEE (ELT)	34267	29.9
MT	30026	24.1
ACS (TI)	34475	8.0

The average number of respondents to National Student Survey was rather low, every year around 40% of the students take part in the survey. For the CT and ACS (TI) programmes the response was too small. The opinion of the student was not measured in a reliable way.

Curriculum integration ratio

For all curricula, outline documents were studied, a curriculum owner interviewed and when necessary the course descriptions and assessment matrices studied. The credits attached to general skills, discipline skills, knowledge, knowledge & skills (applied), limited project and full project were recorded for all 1st and 2nd year curricula in the cohort years 2012, 2013, 2014 and 2015. Appendix F: Characterisation of teaching and learning environment, gives an exact description of the rules applied to find the number of credits for each category. Also see Appendix G: Example of course characterisation.

In the curricula the credits on general skills varied from 0 EC to 7 EC per year. The teaching and learning activities related to general skills were in most curricula a mix of basic skills training and more integrated approaches aiming at higher level skills. The credits were found to be attached to basic skills training or the portfolios. The general skills courses were often a bit of everything and also acted like an organisational glue. Because of the variation it was impossible to use the general skills as a separate variable to compare the curricula.

In the investigation process it became clear that for some curricula (in the engineering domain) an additional category: knowledge & skills (applied), was helpful in describing the curricula in a satisfactory way. The credits in the curriculum (excluding the credits for the general skills) were used to calculate the ratio between the credits on applied knowledge & skills and projects versus the total amount of credits. This new variable: "curriculum integration ratio" was used as a measure for the discipline or real-life focus of learning environment of a curriculum. The higher the "curriculum integration ratio", the more "integrated" the curriculum was and the more it focused on tasks from the "world of work". This is shown schematically in Table 16. The general skills, as discussed before, can be on either the basic skills side or the project side in this characterisation model.

Table 16

Defining the curriculum integration ratio variable

Credits on general skills	Basis skills			
	↑		↑	
Credits on discipline skills	↑		↑	
Credits on knowledge	More discipline focus		Less integration	
Credits on knowledge & skills (applied)		More “real life” focus		More integration
Credits on limited projects		↓		↓
Credits on full projects		↓		↓
Credits on general skills	Meta cognitive skills			

Over the years the curricula were adjusted.In some curricula adjustments were made every year (e.g. ACS (TI)), while other curricula had already been in use for 10 years (ME (WB)) or showed a 5 year up-date cycle (AP(TN)). The curricula of the Applied Science domain have grown towards a similar structure in recent years. Curricula differ in terms of integration Table 17 and Table 18 provide overviews of the integration variable for all programmes in year 1 and 2. Appendix L: Curriculum variables versus time, shows graphs of the curriculum integration ratio and other variables over the period 2012 – 2015.

Table 17

Curriculum integration ratio (%) for all 10 programmes year 1

Year	Programme	N	Minimum	Maximum	Mean	Std. Deviation
1	FS (FO)	4	28.57	33.33	32.14	2.38
	BML	4	16.98	35.71	29.91	8.87
	CH	4	23.21	37.50	33.03	6.60
	CT	4	23.21	37.50	33.03	6.60
	AP (TN)	4	21.05	21.43	21.24	0.22
	ID (IPO)	4	28.07	30.00	28.55	0.96
	ME (WB)	4	13.89	13.89	13.88	0.00
	MT	4	20.18	24.53	23.44	2.18
	EEE (ELT)	4	11.11	20.37	16.038	5.04
	ACS (TI)	4	19.82	22.22	21.628	1.21
	Total	40	11.11	37.50	25.29	7.86

Table 18

Curriculum integration ratio (%) for all 10 programmes year 2

Year	Programme	N	Minimum	Maximum	Mean	Std. Deviation
2	FS (FO)	3	33.33	33.33	33.33	0.00

Year | Programme	N	Minimum	Maximum	Mean	Std. Deviation
BML	3	32.41	32.41	32.41	0.00
CH	3	23.15	23.15	23.15	0.00
CT	3	42.59	50.00	45.06	4.28
AP (TN)	3	29.82	34.82	33.16	2.88
ID (IPO)	3	47.50	50.00	49.17	1.44
ME (WB)	3	42.98	44.07	43.34	0.63
MT	3	44.64	47.37	45.55	1.57
EEE (ELT)	3	36.84	37.72	37.28	0.44
ACS (TI)	3	40.35	50.00	46.78	5.57
Total	30	23.15	50.00	38.92	8.31

In the next chapter the way analysis was carried out is described and the results that where found using the multilevel analysis of the data.

Results

Correlation tables provided a first view of the relationships between the variables. The tables are given in Appendix J: Correlation tables year 1 and Appendix K: Correlation tables year 2. Separate correlation tables were made for student characteristics (age, gender, ability) and the 3 groups of curriculum variables (instruction, examination and organisation). It was observed that the variable “curriculum integration ratio” showed small ($0.1<r<0.3$) and medium ($r>0.3$) correlation with most of the other curriculum variables. The “curriculum integration ratio” was therefore included in all 3 groups, instruction, examination as well as the organisation. Many correlations between the variables were found and one can only speculate about their meaning. E.g. a medium size negative correlation was observed between the “curriculum integration ratio” and gender in year 1 ($r=0.360$, $p<0.01$), and the correlation was positive in year 2 ($r=0.368$, $p<0.01$). But what does it mean, that being male correlates positively with a less integrated curriculum and why is the correlation negative in the 2nd year?

The correlation tables showed that “Number of Final Grades” and “Number of Conditional Exam Activities” have a large correlation ($r=0.842$, $p<.01$) in year 1, but the correlation was smaller ($r=0.483$, $p<0.01$) in year 2. In year 1 the two variables interacted with the other curriculum variables in a similar manner.

Some variables measuring student perception correlated with the curriculum variables as expected, e.g. the “obligatory contact time” showed a positive correlation with the “student perception on contact time” (year 1: $r=0.489$, $p<0.01$ and year 2: $r=0.189$, $p<0.01$). When the correlation of “planned contact time” and “planned obligatory contact time” were compared in year 1, the correlation for “obligatory time” was much larger ($r=0.517$, $p<0.01$ versus $r=0.148$, $p<0.01$). Other correlations were more puzzling. What does it actually mean when e.g. “number of parallel activities” and the student perception on “distribution of study load” correlate positively with medium effect ($r=0.440$, $p<0.01$)?

With a multilevel analysis of the data, the curriculum effects were separated from the students effects in search for meaningful relationship between the variables and achievement. Multilevel analysis was done for achievement of the 1st and 2nd year student groups. The direct effects of student characteristics on achievement were analysed for students participating in 40 curricula in year 1 and 30 curricula in year 2. For the level 2 analysis some curriculum data were missing and not all the students were part of the analysis. In case of the student perception data obtained from the National Student Survey, no data was available for 2012 and only data of students in 27 of the 40 curricula could be analysis. The -2 Log-Likelihood (-2LL) was used to establish whether adding a variable provided a statistically better fit of the model with the data.

Effect of student characteristics on achievement (level 1)

For the level 1 analysis of achievement in year 1 the intercepts and slopes were estimated for students of the 40 curricula in year 1 and 30 curricula in year 2. The results are summarised in Table 19 and Table 20.

Table 19

Effect of gender, age, ability on achievement in year 1 (40 curricula, n=2683)

Variable	Empty	Model 1	Model 2
Intercept (EC year 1)	36.88*	44.28**	31.39**
Age - 16		-0.92**	-0.43**
Gender		-6.15**	-6.16**
Ability F			5.99**
-2 log-likelihood	24192.34	24139.75	24055.94
df	3	5	6
Chi^2		52.59	136.40
p		< 0.0001**	< 0.0001**

* p<0.05 two-sided, ** p<0.01 two sided

Table 20

Effect of gender, age, ability on achievement in year 2 (30 curricula, n=1145)

Variable	Empty	Model 1	Model 2
Intercept (EC year 2)	48.79	53.28**	54.25**
Age - 16		-0.54*	-0.57**
Gender		-4.00**	-4.02**
Ability F			-0.43
-2 log-likelihood	9663.18	9646.39	9646.07
df	3	5	6
Chi^2		16.79	0.33
p		0.0002**	0.8496

* p<0.05 two-sided, ** p<0.01 two sided

For both year 1 and year 2 the hypothesis of research question RQ1 was confirmed, female students showed higher achievement than male students. Also the hypothesis for research question RQ 2 was confirmed as for both year 1 and year 2; younger students showed higher achievement than older students. Regarding research question RQ3: “What is the relationship between prior education and achievement?” The hypothesis, stating that the different groups SSVE (MBO), SGSE (HAVO) and PUE (VWO) would perform equally well, and that the differences are explained by age and not by prior education, was confirmed for the 2nd year. In the 1st year adding an ability scale, which was derived from prior education, reduced the predictive power of age and showed that an ability scale predicted achievement. Table 21 provides a summary of the research question and the results found for year 1 and year 2.

Table 21

Summary of research questions and direct effects for year 1 and 2

	Research question	Result in year 1	Result in year 2
RQ 1	What is the effect of gender on achievement?	+ Positive for females	+ Positive for females
RQ 2	What is the effect of age on achievement?	+ Positive for younger students	+ Positive for younger students
RQ 3	What is the relationship between prior education and achievement?	+ Positive for higher level of prior education	not significant

In the multilevel model only gender and age were used as predictors at level 1. The reasons to do this are explained in the discussion chapter. The age variable scales, which ranges from 16 – 26 years in the 1st year and 17 – 27 years for the 2nd year students, were re-scaled and the variables "Age-16" and "Age-17" were used.

Effect of curriculum characteristics on achievement (level 2)

For direct level 1 effects in year 1, gender and "Age-16" were used as predictors. For the 40 curricula, data were available for 3 variables: "Final grades" (NoFG), "Conditional exam activities " (NoCEA) and "Curriculum integration ratio" (CIR). For 33 curricula four additional variables were available: "Planned contact time" (CTp), "Obligatory contact time" (CTo), "Parallel activities" (PA) and "Weeks between exam and re-sit" (WER). In 27 curricula the complete information was available, the 7 variables mentioned before plus the data on student perception derived from 5 National Survey questions. All level 2 variables describing the curriculum were centred on their group mean to prevent multicollinearity problems in the statistical procedures. For the 3 variables for which data was available in 40 curricula, the group mean in 33 curricula and 27 curricula was slightly different. The same happened for the group mean of the variables available in the 33 curricula when analysed in 27 curricula. In the interpretation of the estimates this shifting of the group means was taken into account. Curriculum variables were brought into the same range before analysis. Contact time variables were divided by 100 and the student perception variables multiplied by 5. In the interpretation of the estimates the scaling was taken into account.

The fit of the variables in the model was tested one by one for a as large as possible number of curricula. The change in -2 log-likelihood was observed and the Chi^2 used to find the significance of the improvement of the fit in the model. For the curricula with missing data on a particular variable the students studying in these curricula were exempted from the analysis for that variable. The analysis was done separately for the group of 40, 33 and 27 curricula.

The analysis showed that in the complete dataset with 40 curricula and gender and "Age-16" as predictors at level 1 (-2LL = 24139.75), the "Final grades" (NoFG) improved the fit significantly (Chi^2 = 15.98, df=3, p<0.0011). "Conditinal exam activities " (NoCEA), improved the fit also but less than "Final grades" (NoFG) ((Chi^2 = 14.55, df=3, p=0.0022). "Curriculum integration ratio" (CIR) did not provide a significant improvement of fit in the model (Chi^2 = 6.81, df=3, p=0.078). No combination of the variables improved the model fit in the analysis of the data of the 40 curricula.

In the 33 curricula gender and "Age-16" were the predictors at level 1 (-2LL = 20459,17). Curriculum variables fitted were: "Final grades" (NoFG), "Conditional exam activities " (NoCEA), "Curriculum integration ratio"(CIR). "Planned contact time" (CTp), "Obligatory contact time" (CTo), "Parallel activities" (PA) and "Weeks between exam and re-sit" (WER). Table 22 provides an overview of the model fit for the variables available in the group of 33 curricula.

Table 22

Overview of model fit for year 1 in 33 curricula (n = 2268)

Variables tested 1)	-2LL	df	Chi^2	df change	p
age + gender (reference)	20459.17	5	28.57		
+ CIR	20443.66	8	15.51	3	0.0014**
+ CTp_div_100 2)	20460.58	8	-1.41	3	poor fit
+ Cto_div_100	20449.89	8	9.28	3	0.0258*
+ Cto_div_100 + CIR	20445.07	12	14.10	7	0.0495*
+ NoFG	20451.53	8	7.64	3	0.0543
+ NoCEA	20443.35	8	15.82	3	0.0012**
+ NoFG + NoCEA	20458.71	12	0.46	7	1.0000
+ NoFG + CIR	20436.86	12	22.31	7	0.0022**
+ NoFG + Cto_div_100	20437.51	12	21.66	7	0.0029**
+ PA	20458.01	8	1.15	3	0.7640
+ WER	20454.81	8	4.36	3	0.2254

1) All variables centred on the highest possible curriculum group mean

2) Contact time variables were divided by 100

A similar analysis was carried out for the functioning of all variables in the group of 27 curricula. The significant effects on the curriculum variables found in the 40 and 33 curricula were also found in the group of 27 curricula. The student perception variables: “Time on study” (ToS_SP)”, “Contact time“ (CT_SP), “Distribution of study load” (DoSL_SP), “Feasibility of deadlines” (FoDL_SP) and “Participation on scheduled activities” (PoSA_SP) were tested in the model. A summary of the -2 log-likelihood and the significance of model fit is provided in Table 23.

Table 23

Overview of model fit for year 1 in 27 curricula (n = 1975)

Variables tested 1)	-2LL	df	Chi^2	df change	p
age + gender (reference)	17851.71	5			
+ CIR	17834.51	8	17.20	3	0.0006**
+ Cto_div_100 2)	17843.06	8	8.64	3	0.0344*
+ NoFG	17839.43	8	12.27	3	0.0065**
+ NoCEA	17833,80	8	17.90	3	0.0005**
+ ToS_SP	17850.92	8	0.79	3	0.8522
+ CT_SP	17848.98	8	2.72	3	0.4360
+ DoSL_SP	17851.23	8	0.47	3	0.9246
+ FoDL_SP	17851.16	8	0.55	3	0.9074
+ PoSA_SP	17842.59	8	9.11	3	0.0278*
+ PoSA_SP + Cto_div_100	17835.36	12	16.35	7	0.0221*

1) All variables centred on the highest possible curriculum group mean

2) Contact time variables were divided by 100

The analysis for the 2nd year was carried out using the same procedure. First of all the improvement of the model fit was analysed for the variables one by one for the 30 curricula. In this group of 30 curricula data was available on: “Final grades” (NoFG), “Conditional exam activities” (NoCEA), “Curriculum integration ratio” (CIR), “Parallel activities” (PA) and “Weeks between exam and re-sit” (WER). The results of the analysis is given in Table 24.

Table 24

Overview of model fit for year 2 in 30 curricula (n = 1145)

Variables tested [1]	-2LL	df	Chi^2	df change	p
age + gender (reference)	9646.39	5			
+ ability	9646.07	6	0.33	1	0.8496
+ CIR	9646.24	8	0.15	3	0.9856
+ NoFG	9642.76	8	3.63	3	0.3038
+ NoCEA	9633.55	8	12.84	3	0.0050**
+ PA	9644.32	8	2.07	3	0.5575
+ WER	9639.77	8	6.62	3	0.0851
+ NoCEA +WER	9636.29	12	10.10	7	0.1828

[1]) All variables centred on the group mean of 30 curricula

For 2 curricula the student perception data were missing and for 2 other curricula the contact time data. In the resulting group of 26 curricula the variables, “Planned contact time” (CTp_div_100), “Obligatory contact time” (CTo_div_100) and the student perception variables: “Time on study(ToS_SP)”, “Contact time” (CT_SP), “Distribution of study load” (DoSL_SP), “Feasibility of deadlines” (FoDL_SP) and “Participation on scheduled activities” (PoSA_SP) were analysed. All variables were centred and the student perception variables rescaled by multiplying by 5. A summary of the -2 log-likelihood and the significance of model fit is provided in Table 25.

Table 25

Overview of model fit for year 2 in 26 curricula (n = 1040)

Variables tested	-2LL	df	Chi^2	df change	p
age + gender (reference)	8733.28	5			
+ Ctp_div_100 [2)]	8729.42	8	3.86	3	0.2767
+ Cto_div_100	8729.88	8	3.41	3	0.3331
+ ToS_SP*5 [3)]	8731.07	8	2.21	3	0.5301
+ CT_SP*5	8733.09	8	0.20	3	0.9780
+ DoSL_SP*5	8732.67	8	0.61	3	0.8936
+ FoDL_SP*5	8732.54	8	0.74	3	0.8629
+ PoSA_SP*5	8732.63	8	0.65	3	0.8844

[2]) Contact time variables were divided by 100

[3]) Student perception variables multiplied by 5

Instruction characteristics

In the group of instruction variables in year 1 only the “Curriculum integration ratio” (CIR) and “Obligatory contact time / 100” (CTo_div_100) had a significant improvement of the model fit. The estimates for the intercept and slope for both variables are shown in Table 26. The effect size for the slope of the “curriculum integration ratio” is -0.54 EC per percent point and for “obligatory contact time / 100” the slope was +1.4 EC per 100 hours. The effect size for the slopes in the group 27 curricula were similar, -0.56 EC per percent point and +1.5 EC per 100 hours respectively.

Table 26

Effect of instruction variables on achievement in year 1 (33 curricula, n = 2268)

Variable	Reference	Model 1	Model 2	Model 3
Intercept (EC year 1)	43.52**	44.41**	43.55**	44.76**
Age - 16	-0.82**	-0.88**	-0.85**	-0.86**
Gender	-4.82**	-5.59**	-4.88**	-5.85**
Curriculum integration ration % [CIR]		-0.54**		-0.33*
Obligatory contact time / 100 [Cto_div_100]			1.41**	1.51*
-2 log-likelihood	20459.17	20443.66	20449.89	20445.07
df	5	8	8	12
Chi^2		15.51	9.28	14.10
p		0.0014**	0.0258*	0.0495*

* p<0.05 two-sided, ** p<0.01 two sided

The analysis of the data in the second year showed that non of the variables improved model fit significantly and no estimates for intercepts and slopes were determined.

The ratio between credits on integrated activities versus total credits, while disregarding the credits on general skills, was used as a measure for curriculum integration (the scale is in percentage points). The curriculum integration ratio for the 2nd year curricula (*M* = 3.89, *SE* = 0.15) showed a higher integration than the 1st year curricula (*M* = 2.52, *SE* = 0.12). The difference, -1.36, 95% CI[-1.75,-0.97] was significant t(68) = -7.01, *p<0.001.* This confirms part of the hypothesis of research question RQ4. The curriculum integration ration is different in year 1 and year 2 and it was found that the curriculum integration ratio was significantly higher in year 2. The other part of the hypothesis, stating that curriculum integration promotes achievement, was not confirmed in year 1. A higher integration ratio was found to have a negative impact on achievement. For year 2 curricula no relationship was found between curriculum integration and achievement.

Research question RQ5 dealt with the relationship between achievement and planned contact time. For contact time the two variables were tested. Planned contact time, which is used for making the timetable, did not confirm the hypothesis of research question RQ5. Planned contact time had no positive effect on achievement. The other variable, the contact time marked as obligatory, showed a positive effect on achievement in the 1st year. Whether the relationship had a maximum could not be established. In the 2nd year no relationship between contact time and achievement was found.

Research questions RQ5 also investigated the student perception on contact time. The data did not improve model fit and no relationship was found for the perception of the students and achievement. Also for research question RQ6: “Do curricula for which students report to spend more hours on study, show a higher achievement?” no relationship was found in year 1 and year 2.

Examination characteristics

The results of the analysis for the examination variables “number of final grades” (NoFG) and “number of conditional exam activities” (NoCEA) in year 1 is shown in Table 27. The table provides the estimates for the group of 40 curricula. With both curriculum variables fitted in the model, the fit became poorer as each of the two variables explained the same underlying effect.

Table 27

Effect of examination variables on achievement for year 1 (40 curricula, n = 2680)

40 curricula, n=2680				
Variable	Reference	Model 1	Model 2	Model 3
Intercept (EC year 1)	44.28**	44.19**	44.68**	44.88**
Age - 16	-0.92**	-0.96**	-0.96**	-0.94**
Gender	-6.14**	-6.59**	-6.74**	-6.88**
Final grades # [NoFG]		1.28**		1.17
Conditional exam activities # [NoCEA]			0.81**	0.36
-2 log-likelihood	24139.75	24123.77	24125.20	24145.30
df	5	8	8	12
Chi^2		15.98	14.55	
p		0.0011**	0.0022**	poor fit

* p<0.05 two-sided, ** p<0.01 two sided

When estimated for the group of 33 curricula, the intercept was 44.32, for “Age-16” = -0.86, Gender = -5.95 and NoFG = 1.45. (Chi^2=7.64, df=3, p=0.0543). For the 27 curricula the intercept was 44.07, with “Age-16” = -0.78, Gender = -5.75 and NoFG = 1.34. (Chi^2=12,27, df=3, p=0.0065). The estimates found for the smaller groups of curricula did not differ much from the estimates of the group of 40.

In Table 28 the analysis for the 30 curricula of the 2nd year is given. In the 2nd year the model fit for the “number of conditional exam activities” (NoCEA) was significant, but the model fit for the “number of final grades” (NoFG) was not significant. The same pattern was seen in the group of 26, 2nd year curricula. The intercept was 54.59, with “Age-17” = -0.56, Gender = -4.53 and NoCEA = 0.99. (Chi^2=12.80, df=3, p=0.0049). The slope for “number of conditional exam activities” (NoCEA) is 1 EC per additional exam activity .

Table 28

Effect of examination variables on achievement for year 2 (40 curricula, n= 1145)

Variable	Reference	Model 1	Model 2
Intercept (EC year 2)	53.28**	53.75**	54.31**
Age - 17	-0.54**	-0.52**	-0.57**
Gender	-4.00**	-3.82**	-4.69**
Final grades # [NoFG]		1.56	
Conditional exam activities # [NoCEA]			1.03**
-2 Log-likelihood	9646.39	9642.76	9633.55
df	5	8	8
Chi^2		3.63	12.84
p		0.3038	0.0050**

* p<0.05 two-sided, ** p<0.01 two sided

The hypothesis for research question RQ7: A smaller number of final grades has a positive effect on the achievement, was not confirmed in the 1st year, the opposite relationship was found. A smaller course size (more final grades) with more opportunities to obtain credits resulted in higher achievement. Also the hypothesis for research question RQ8: The logic of number prevails, fewer conditional exam activities in a curriculum promote achievement, was also not confirmed for the 1st year. Analysis showed that in both year 1 and year 2 the opposite is the case. A higher number of conditional examination activities has a positive effect on achievement.

Organisation characteristics

The results of the analysis for the organisation variables for year 1 are shown in Table 29

Table 29

Effect of organisation variables on achievement for year 1 (27 curricula, n = 1975)

Variable	Reference	Model 1	Model 2
Intercept (EC year 1)	43.77**	42.76**	42.55**
Age - 16	-0.74**	-0.73**	-0.77*
Gender	-5.67**	-4.77**	-5.02**
Participation on scheduled activities * 5 [PoSA_SP5]		2.76**	2.35*
Obligatory contact time / 100 [Cto_div_100]			1.74**
-2 Log-likelihood	17851.71	17842.59	17835.36
df	5	8	12
Chi^2		9.11	16.35
p		0.0278*	0.0221*

* p<0.05 two-sided, ** p<0.01 two sided

In the year 2 no variables showed a significant model fit. The variable “weeks between exam and re-sit” (WER) improved the fit slightly, but not significantly. The intercept was 53.52, with “Age-17”=-0.54, Gender=-3.71 and WER=1.10 (Chi^2=6.53, df=3, p=0.0885).

For research question RQ9 concerning the number of parallel activities in a curriculum the hypothesis stated: fewer parallel scheduled activities will result in higher achievement. The hypothesis was not confirmed neither in year 1 nor in year 2. The second part of the hypothesis dealt with an optimum number of parallel activities was no longer relevant as no significant model fit was found for parallel activities.

Research questions RQ10 and RQ11 were related to the ways “self-study” time was incorporate in the curricula and finding the measures which promote achievement. The hypothesis stated: preparation days before the exam period and reducing the number of instruction weeks as well as other measures, will promote achievement. Interviews and scrutiny of the academic timetable showed that no preparation days before the exam period were planned. However exam timetables were normally designed with maximum spread of the exams over the available days. In the curricula with 3 weeks between exam and re-sit the exams were part of the week 6 timetable and no preparation time was scheduled. In some curricula additional hours were planned in the timetable meant for “self-study”. The approach of FS(FO) on “self-study” time was an exception. The timetable for FS(FO) was organised in such a way that the day starts with a lecture, than time is allocated for self-study and at the end of day a wrap-up activity takes place. However this approach was not modelled in the curriculum data and was not part of the data set in the multilevel research. Research question RQ10 regarding the measures taken aimed at increasing “self-study” time and promoting achievement, could not be answered as such measures are absent in the curricula investigated.

It was found that three general planning methods were used for exams and re-sits organisation: 1) The traditional exam and re-sit planning in a 10 week block system, with exams in week 9 and re-sits in week 10. In the 4th quarter an additional week 11 is used for re-sits of quarter 4. 2) The exams are in the regular weeks and re-sits are scheduled on the Monday of week 4, 5, 6. In the last quarter an additional week 11 is used as well. This planning method frees time in the exam period for other study activities. 3) In this planning approach the exams (digital) take place in week 6 and the re-sits are organised in week 9. This method was used in year 1 of the FS(FO), BML, CH and CT programmes. Over the years the way exams were planned changed as is shown in Figure 12. A graph for the second year is given in Appendix L: Curriculum variables versus time.

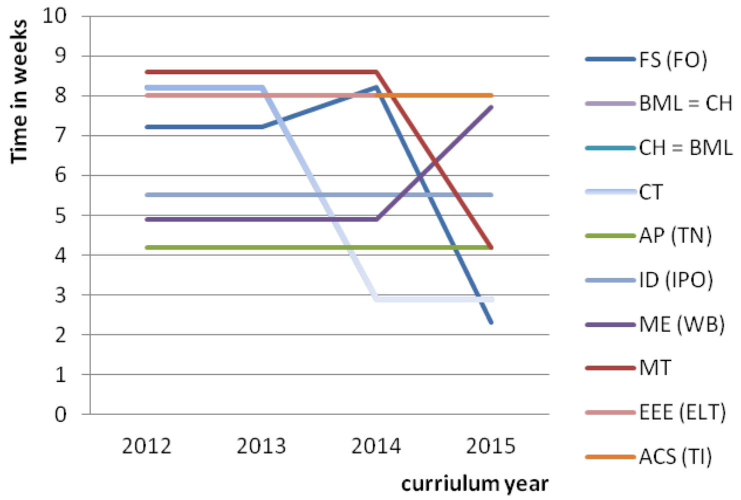


Figure 12: Year 1 curricula: change in time between exam and re-sit for each programme

Research question RQ12 investigated the examination planning: “Is achievement improved by reducing the time between regular exams and re-sit of the exams?” The organisational curriculum variable, “weeks between exam and re-sit” did not improve the fit of the model in year 1 and was not a predictor for achievement. In year 2 a small effect was found, suggesting that more time between exams and re-sits promoted achievement, but the model fit was not significant. The last research question RQ13 was related to the student perception, as measured by the National Student Survey, and achievement. For the questions regarding “Distribution of study load” and “Feasibility of deadlines” the model fit did not improve significantly. However the answer to the question: “I follow the scheduled teaching activities” (1 never, 2 rarely, 3 sometimes, 4 nearly always, 5 always) showed a significant improvement of fit and curricula for which students reported that they take part in the scheduled activities showed a higher achievement. The effect size was +0.55 EC per scale point, so with students behaviour changing from sometimes (3) to always (5), achievement is expected to increase by 1.1 EC.

In the curricula of the 1st year curriculum factors had an effect on achievement, in the second year this was not the case at all (Except of the poorly defined variable “number of conditional exam activities”, see discussion chapter). Table 30 shows a summary table of the research question and the results of the multilevel analysis.

Table 30

Summary of research questions and results for year 1

	Research question	Result in year 1
4	Does a more integrated curriculum (measured by a ratio of credits for “projects” and/or “real life tasks” versus the credits in a curriculum year) promote achievement?	- Negative
5	What is the relationship between contact time planned, contact time perceived and achievement?	n.s. 1) + Positive for obligatory

	Research question	Result in year 1
		contact time
6	Do curricula for which students report “more hours spend on study”, show an higher achievement?	n.s. [1)]
7	What is the relationship between the number of final grades in a curriculum and achievement?	+ Positive
8	What is the relationship between the number of conditional exam activities in a curriculum and achievement?	+ Positive (See discussion chapter)
9	What is the relationship between the number of parallel scheduled activities (courses) in a study week and achievement?	n.s. [1)]
10	In what ways is “self-study” time incorporated in the curricula?	Answered
11	Which measures aimed at increasing “self-study” time promote achievement?	Not tested
12	Is achievement improved by reducing the time between regular exams and re-sit of the exams?	n.s. [1)]
13	Do curricula for which students report higher satisfaction on the “Distribution of study load”, “Feasibility of deadlines” and score high on “following all the scheduled activities” show a higher achievement?	n.s. [1)] Positive for “following scheduled activities”

[1)] n.s. – model fit not significant.

In the next chapter the meaning of the results and their implication for the design a curricula are discussed.

Discussion

As found by Jansen (1996) and Van der Hulst and Jansen (2002) female students performed better than male students and younger students better than older students in the first year of their studies. The present study confirmed these results for 1st year as well as 2nd year students. In both years, female students and younger students showed an higher achievement in terms of credits earned per year. In the first year the intercept for the number of credits achieved is 44.2 EC. For every year of age above 16 years the credits achieved reduces by 0.9 EC. The male student are expected to achieve 6.1 EC less in a year than their female study companions.

A good predictor for achievement of students in engineering and science education are the grades scored on abstract subjects (mathematics & physics) in prior education (Van der Hulst and Jansen, 2002; Kamphorst, 2013). An ability scale was designed with 4 levels (0 - SSVE (MBO) switching domain, 1 - SSVE (MBO) same domain, 2 - SGSE (HAVO), 3 - PUE (VWO). The students with unknown foreign education and SSVE (MBO) students switching domains when entering higher education were inserted on this ability scale. Creating an ability scale based on prior education is feasible and ability is a better predictor for achievement than age for the 1st year students. In the 2nd year ability does not predict achievement, which is not a surprise as the whole group consists of students with proven ability, who all successfully passed the 1st year. On the ability scale in the 1st year every unit presents 6 EC increase in achievement, hence SSVE (MBO) from the same domain are predicted to score 6 EC less in a year than the SGSE (HAVO) students. The path of SSVE (MBO) students towards higher professional education is 3 years longer compared with the SGSE (HAVO), the students will (at least) differ 3 years in age. When using age as a predictor the 3 year older students are expected to achieve 2.7 EC less in their first year. The difference probably originates from the lack of calibration of the ability scale. The largest group of students in the first year is the SGSE (HAVO) group. In the period 2012-2015 their inflow has increased by 50%. As the impact of the SGSE (HAVO) is larger in the later years (towards 2015) the ability scale is changing in time. This changing of the scale over time and the lack of calibration were the reasons for not using the ability scale as a predictor of the direct effect (level1) in the multilevel research model.

Contact hours became a focus in higher professional education after 7% of the budgets in the period 2012-2016 were made conditional on achieving goals related to study-success. Within SAXION a minimum number of contact hours was stipulated for all first year programmes. As a result of the focus on contact hours accurate records exist presently on the number of planned contact hours. This information is used for design of the timetables and is an accurate measure for the contact time between students a teachers. Some of the curricula had much larger numbers of contact hours allocated than others: the spread in year 1 was 439 – 825 hours and in year 2, 404 – 857 hours. The present research found no relationship between planned contact time and achievement. Making more contact hours available on the timetable does not promote achievement. The political and subsequent institutional pressure for more contact hours in higher professional education made no sense for the programmes investigated. However, it was found that another time variable the “obligatory contact time” had a positive effect on achievement. Obligatory contact time is a label for courses the students are obliged to attend, because education takes place in designated workshops and laboratories. In obligatory contact hours students will not be absent and are likely to participate actively. Because of the limited availability of the facilities the time allocated is carefully planned. The number of obligatory contact hours planned in the curriculum had a positive effect on achievement. The relationship was found to be 1.5 EC per 100 hours, the mean value for obligatory contact hours in the sample of 33 curricula was 434 hours. How obligatory hours function, will depend on the way the teaching teams use the obligation and how communication with students takes place.

By definition the European Credit Transfer System (ECTS) is a workload credit system. An average student with sufficient ability will use 28 hours of study time for every European Credit. With 60 EC in a year the total time on studies becomes 1,680 hrs, which is 42 weeks of 40 hours studying. Time required for learning needs to be communicated with the students and a logic measure of time will help in the communication. In an organisational system with 4 blocks of 10 weeks in an academic year, a course with a study load of 3 EC means a time investment of 1 working day a week. 3 EC matches well with the common 5 days working week.

The effect of obligatory time is most likely based on the active involvement of students during these hours. Just labelling hours as compulsory does not suffice, students should perceive the obligatory hours as essential for their learning. Being engaged and belonging to a group of fellow students can be promoted by effective use of obligatory contact hours. This is a strategy in line with the advice of Kamphorst (2013) which was based on findings in higher professional education.

Five National Student Survey (NSS) questions were examined in this research. The questions were selected because it was expected that they could provide the student’s view on curriculum characteristics related to achievement. Of the 5 questions investigated, the answer to the question: “I follow the scheduled teaching activities”, proved to have some predictive power. Curricula for which students reported that they take part in the scheduled activities showed a higher achievement. The effect size was +0.55 EC per scale point, so with students behaviour changing as a result of some curriculum action and the answer to the question: “I follow all scheduled activities”, shifts for “sometimes” (3) to “always” (5), achievement is expected to improve by 1.1 EC. The mean in 27 curricula is 4.16 (SD 0.21). This NSS question is a question to pay attention to when the results of the survey are studied, because it is likely to provide more information than just ranking.

What actually happens in the learning environment is an important instruction characteristic. How the instruction takes place, what the impact of feedback is and how other aspect work can not be easily be modelled, and leaved too much room for different ways of interpretation in multilevel studies (Jansen, 1996, 2004; Van der Hulst and Jansen, 2002). In the present research the variable “curriculum integration ratio” was used. The variable describes the type of learning environment and not what happened within the learning environment. For the characterisation of the curriculum in the categories: skills, knowledge, knowledge and skills applied, limited projects and full projects, were used. The distinction between the full and limited project was interpreted by the curriculum owners from their own perspective and a more objective measure could have been used. However, these differences in views on projects will not have had a large impact on the value of the curriculum integration variable, because of the way the ratio was calculated. From the view of the staff involved in the curricula with the largest numbers of credits per course, using the categories let to the response: “do not divide-up what has already been integrated”. The curriculum integration ratio has a negative relation with achievement in the 1st year curricula. The variable “Curriculum Integration ratio (%)” uses a percentage scale. The effect size was approximately -0,55 EC per percentage point, with a mean value of 25.6% (SD 8.8) in 33 curricula.

To investigate the examination characteristics the curriculum variables “number of conditional exam activities” and the “number of final grades” were used. The “number of final grades” is directly related to the size, measure in study load (EC), of the course in a programme, because each year contains 60 EC. The mean for the “number of conditional exam activities” (NoCEA) is 19.20 (SD 4.89), while the mean for “number of final grades”(NoFG) is 16.63 (SD 2.73) in the 40 curricula of the 1st year curricula. Differences between the domains are observed. For “number of final grades” (NoFG) in the Applied Science domain the mean is 14.95 (SD 2.74), while the mean in the Engineering domain is 18.38 (SD 1.36) and in the ICT domain 18.00 (SD 1.63). The average size of courses in the Applied Science domain was 4 EC, while in the Engineering domain the sizes of the courses were smaller with an average course size of 3.27 EC. The maximum average course size was 5.46 EC for the BML, CH and CT curricula in 2013 and the minimum average course size of 3.0 EC was found for MT and ME (WB) in 2015, EEE (ELT) in 2013/14 and ACS (TI) in 2012. The mean values for “number of conditional exam activities” (NoCEA) also showed domain differences. The mean value for the Applied Science domain is 15.25 (SD 2.61), Engineering domain 22.19 (SD 2.16) and ICT domain 27.00 (SD 3.37). The variables “number of final grades” (NoFG) and “number of conditional exam activities” (NoCEA) reflect differences in administrative approaches in the domains. In the Engineering domain, especially in the largest programme ME (WB) all exam activities are recorded in the central results database BISON and no records are kept elsewhere. In other programmes, the partial results are administrated in the Blackboard learning system, or are kept elsewhere by the lectures in charge of a course. Teachers will apply rules for compensation, these rules are specified in the course description and are often updated on a yearly basis. No overall regulations from the exam board regarding compensation are in force. In some cases results may be carried forward to the next academic year (like the results in the central database), but in other cases the partial results are only valid for one year. An example of results being valid for only one year are activation bonuses, a 10% bonus on the final mark for doing homework or a 20% bonus for a formative examination during the course. Because of this reason the “number of final grades” (NoFG) provides more objective information about the curriculum than the “number of conditional exam activities” (NoCEA). The variable “number of final grades” (NoFG) was therefore used as the main variable in the analysis. The effect size of the variable “number of final grades” (NoFG) is +1.4 EC per final grade. The mean for the “number of final grades” (NoFG) was 16.16 (SD 2.96).

The “number of final grades”(NoFG) is directly related to the course size. Analysis showed that achievement increases with a larger number of final grades and hence reducing the average course size will promote achievement. The mean for the “number of final grades”(NoFG) for all 2,680 students studying in 40 curricula is 16.26 (SD 2.96), this is the equivalent of an average course size of 3.7 EC. The stimulating effect of smaller courses and more opportunities to obtain credits is larger than the negative effect of the logic of numbers: the more courses to pass the more changes for unjustified failure. These findings contradict the advice provided by Cohen-Schotanus (2016). The research on curriculum organisation was done in academic universities with PUE (VWO) students (Jansen 1996, 2004; Van der Hulst and Jansen, 2002) or in medical schools (Schmidt et al., 2010) with numerus fixes measures limiting the intake. It now seems unlikely that results can be generalised to 1st year curricula with SSGE (HAVO) students in science and technical higher professional education.

The scheduling of the re-examination in terms of weeks between exams did not predict achievement in higher professional education. The 3 ways of organising re-examinations, (week 6 and week 9, after 3 to 5 weeks, or after 10 weeks), perform equally well or equally poor. As there is no relation with achievement the scheduling of exams is not an educational, but a purely organisational issue. “Time for self-study” could not be studied because it was not a common feature of the curricula studied. The study of Schmidt et al. (2010), which showed positive results of “time for self-study” was done in medical schoosl and it is unlikely that the results can be generalised to higher professional education.

The other organisational variable, the number of parallel activities, also showed no relationship with achievement. The issue of competition between activities as found by Jansen (2004) and Van der Hulst and Jansen (2002) in academic universities does not seem to function in a similar manner in higher professional education.

The results of the research of the examination characteristics showed that smaller courses, with more final grades had a positive impact on achievement in the 1st year. Instruction characteristics that promoted achievement were reducing the curriculum integration ratio and increasing the "obligatory contact time". Table 31 gives the values of these variables for the SAXION Engineering, ICT and Applied Science curricula of 2015.

Table 31

Significant curriculum variables and actual values in year 1 – 2015

Programme year 1 2015	Final grades (#)	Mean course size (EC)	Curriculum Integration ratio (%)	Obligatory contact time - planned (hrs)	Participation scheduled activities - student perc. (scale)
FS (FO)	17	3.53	28.6	424	4.67
BML	13	4.62	35.7	320	3.97
CH	13	4.62	35.7	320	3.91
CT	13	4.62	35.7	320	4.17 1)
AP (TN)	17	3.53	21.4	420	4.30
ID (IPO)	17	3.53	28.1	821	4.30
ME (WB)	20	3.00	13.9	455	4.22
MT	19	3.16	20.2	708	4.24
EEE (ELT)	18	3.33	20.4	386	3.75
ACS (TI)	18	3.33	22.2	482	4.00 1)
Estimate effect size	+1.4 EC per grade		-0.5 EC per % point	+1.5 EC per 100 hrs.	+0.55 Per scale point
Reference mean value	16.3	3.7	25.8	434	4.16
Estimated in n curricula	40		33	33	27
For n students	2683		2268	2268	1975

1) number of respondents too small to base conclusions on.

In the 2nd year no significant curriculum variables were found, except of the effect of the number of final grades in a curriculum. In Table 32 the average course size and the curriculum integration ratio of the 1st year and the 2nd year of the SAXION programmes are compared.

Table 32

Curriculum variables in year 2 – 2015

	Year 1 2015	Year 2 2015	Year 1 2015	Year 2 2015
Programme	Mean course size (EC)	Mean course size (EC)	Curriculum Integration ratio (%)	Curriculum Integration ratio (%)
FS (FO)	3.53	3.53	28.6	33.3
BML	4.62	3.53	35.7	32.4
CH	4.62	3.75	35.7	23.1
CT	4.62	4.62	35.7	50.0
AP (TN)	3.53	3.75	21.4	34.8
ID (IPO)	3.53	3.53	28.1	50.0
ME (WB)	3.00	3.53	13.9	43.0
MT	3.16	4.29	20.2	47.4
EEE (ELT)	3.33	3.53	20.4	37.3

	Year 1 2015	Year 2 2015	Year 1 2015	Year 2 2015
Programme	Mean course size (EC)	Mean course size (EC)	Curriculum Integration ratio (%)	Curriculum Integration ratio (%)
ACS (TI)	3.33	3.53	22.2	40.4

In most programmes in the 2nd year the curriculum integration ratio is higher and course size larger when compared to 1st year. In the CT, ID (IPO) and MT programmes the course integration ratio increases in the 2nd year to (almost) 50%. In the 2nd year the exceptions are the CH and BML programmes where course size is smaller and integration lower than in the 1st year.

This research may help to answer the main question of the recent curriculum development discussion regarding the curricula at SAXION: "Is it beneficial to overhaul the organisational structure of the curriculum and implement a 5 EC per course model?" The answer to this question has a number of dimensions. Not only achievement, but also efficiency, staff workload and quality of education needs to be considered. This research provides an answer regarding achievement only. In the 2nd year the curriculum examination characteristics did not show an impact on achievement, the course size in the 2nd year can probably be increased without a negative effect on student achievement. The situation in the 1st year is quite different. The research showed that increasing the study load per course from the present average in the engineering domain of 3.3 EC (18 final grades) to 5 EC (12 final grades) achievement of 1st year students is expected to be reduced by 1.3 (estimate) x Δ final grades = 7.8 EC. When using the mean for the final grades of 16.3 found for the 40 curricula, the reduction in achievement is expected to be 1.3 (estimate) x 4.3 (Δ final grades) = 5.6 EC per year. Efficiency, teacher workload and educational quality remain important issues to be resolved, but a 5 EC per course model is probably not an option for the 1st year curricula, because of the negative effect on achievement.

In summary it is concluded that curriculum characteristics have a relationship with student achievement for 1st year curricula, while no such relationship is found for the 2nd year curricula. In the group of instruction characteristics, modelling what happens within the learning environment is not possible, but the curriculum integration ratio is a way to characterise the type of learning environment in curriculum. The curriculum integration ratio is a useful variable to express the level of integration in a curriculum ("discipline" focus versus "real world" focus). Student achievement is higher in less integrated 1st year curricula. The other variables in the instruction group are related to time. Planned contact time, the number of hours on the timetable, does not show a relationship with achievement, but obligatory time has a positive effect, because students are actively involved in learning. For the examination characteristic, the number of final grades is positively related to achievement. More opportunities to obtain credits, through curricula with courses carrying smaller study load, promote achievement. The number of conditional exam activities also has a positive effect on achievement, but the interpretation of the variable is ambiguous. In the group of organisational characteristics, the number of parallel activities and the way exams are organised, in terms of the weeks between exams and re-sits, do not predict achievement. Student's perception of the curriculum was derived from National Student Survey data. Curricula on which students report that they participate in all scheduled activities show a higher achievement, for the other National Student Survey questions no effects are found. When the present results are compared with other research done on curriculum organisation, it is concluded that what is required in the science and technical higher professional education differs from the requirements in medical schools and other programmes in academic universities. The results of the present study can probably not be generalised beyond higher professional education and because of the discipline differences may only be applicable to science and technical higher professional education.

A general mismatch seems to exist between the largest group of students from SGSE (HAVO) and the organisational model in the 1st year of higher professional education. The model does not match with way the SGSE (HAVO) students take up their studies and the changeover is too abrupt. It is recommended to build curriculum models, that accommodate a smooth transfer of students into higher professional education. The students with SGSE (HAVO) background will not suddenly have a different approach to their studies, when they start in higher education after the summer holidays. A curriculum model with, at the start, a larger number of final grades (courses with less study load), sufficient obligatory time that really matters to the students and less integration will promote achievement, while students can adjust themselves to their new study life in higher professional education. It is recommended to optimise the use of active obligatory contact time, by making sure that students perceive these hours as essential to their learning and enhance their feeling of belonging and being engaged. This study did not specifically investigate the factors belonging and engagement, but they are likely linked to obligatory contact hours in the black box “student effort” of the research model (see Figure 6).

The smooth transfer to higher professional education for SGSE (HAVO) students, was one of the reasons for making curriculum adjustments at SGSE (HAVO). Students who studied in the new “concept & context” curriculum (Van Asselt, 2014) enrolled in higher professional education in 2015 (new approach for physics, biology and chemistry) and are expected to enrol in 2017 (new approach on mathematics). It is too early to observe whether these students are more successful, but it is recommended to continue monitoring the SGSE (HAVO) group closely as their approach to study may gradually change. The use of a multilevel model to analyse the curriculum characteristics proves to be very useful. The results provide a new in-sight in the functioning of the in-house curricula. The largest group of students come from SGSE (HAVO). Within the data set, the profile at secondary education for all students is known (Nature & Health (NG) or Nature & Technology (NT)). This information could not only be used to improve the ability scale in the multilevel model, but also for monitoring the transfer into higher education for the specific groups of SGSE (HAVO) students.

In this study achievement was measured in terms of credits obtained in the 1st and 2nd year of the programme. Van der Hulst and Jansen (2002) suggested to use the Grade Point Average (GPA) as well as credits obtained per year as outcome measures. The GPA can be seen as a measure of the quality of the student achievement. The focus of the present research was on the first two years of programmes in higher professional education. An interesting extension of this research would be to investigate how well students perform in the 3rd and 4th year of their studies. This would give information on the role curriculum variables play in relation to the preparation for large multidisciplinary project, the internship and the graduation project. All these activities carry 24 to 30 EC and the grades could be used as an outcome measures. It is recommended to investigate whether curriculum characteristics in 1st and 2nd year are predictors of achievement in the later years.

In the design of curricula the perspective of the stakeholders is of paramount importance. In the curricular spider web of Van den Akker (2003) (see Figure 5), the rational is in the centre and in the process of curriculum design the designer has to find a balance between the often conflicting view of the various stakeholders. The Conceive, Design, Implement and Operate (CDIO) methodology of curriculum design also has a strong outward focus (Biggs & Tang, 2007). Talking to the outside world starts with knowing who the stakeholders are. An overview is given in Appendix M: Stakeholders in higher professional education. The stakeholders influence what the programmes are about, but how the programmes are organised is responsibility of the institutions. The institutions can turn the organisational knobs to influence the curriculum characteristics. Using a data based approach to determine which knobs to turn, may result in unexpected answers. However taking informed decisions based on data is a major ingredient for making successful programmes in higher professional education.

References

Bachelor of Engineering (2016), *Bacheloropleidingen Engineering een competentiegerichte profielbeschrijving.* Retrieved from http://www.vereniginghogescholen.nl/system/profiles/documents/000/000/033/original/domeinprofiel.bachelor_of_engineering.2016.pdf?1463577995

Bachelor of Applied Science (2012), *Bachelor of Engineering een competentiegerichte profielbeschrijving.* Retrieve from: http://www.vereniginghogescholen.nl/system/profiles/documents/000/000/109/original/bachelor_20of_20applied_20science_competentie_20profiel.pdf?1437563950

Becher, T. (1994).The significance of disciplinary differences. *Studies in Higher Education,* Jun94, Vol. 19 Issue 2, p151, 11p,

Biggs, J.B. (1987). *Student Approaches to Learning and Studying*. Hawthorn, Victoria: Australian Council for Educational Research.

Biggs, J., & Tang, C. (2007). Teaching for Quality Learning at University. Berkshire: Open University Press

Bologna Follow-Up Group (2005). *Framework for Qualifications of the European Higher Education Area*. Kopenhagen, p. 9. Retrieved from http://ecahe.eu/w/index.php/Dublin_Descriptors

Carroll, J. B. (1963). A model of school learning. *Teachers College Record, 64,* 723–733.

CBS (2017). Stateline database. Accessed through: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=37220&D1=95%2c101-108%2c141-148&D2=0&D3=110-115&HDR=T%2cG1&STB=G2&P=P&VW=T

Cohen-Schotanus, J. (2016). De invloed van het toets programma op studiedoorstroom en rendement. In van Berkel, H., Jansen, E., Bax, A. (Ed). *Studiesucces bevorderen: het kan en is niet moeilijk.* pp 65-78. Amsterdam, Nederland: Boom uitgevers.

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology, 49,* 182–185.

Doolen, T.L. (2014). The Impact of a Cohort Model Learning Community on First-Year Engineering Student Success. *American Journal of Engineering Education* 5(1):27 20140101 21532516

Edström, K. (2014). Curriculum and course development with CDIO, PowerPoint. Retrieved from http://lewis.upc.es/~ricksellens/final/303/303_Paper.pdf

Edström, K. & Kolmos, A. (2014) PBL and CDIO: complementary models for engineering education development, *European Journal of Engineering Education,* 39:5, 539-555

European Commission (2008). *The European qualifications framework for lifelong learning (EQF).* Luxembourg: Office for Official Publications of the European Communities. Retrieved from https://ec.europa.eu/ploteus/en/content/descriptors-page

Guay, F., Ratelle, C. F., & Chanal, J. (2008). Optimal learning in optimal contexts: The role of self-determination in education. *Canadian Psychology, 49,* 233–240.

HBO-raad-OCW (2011). *Hoofdlijnenakkoord.* Retrieved from http://www.vereniginghogescholen.nl/themas/prestatieafspraken

Hoeben, W. Th. J. G. (1994). Curriculum Evaluation and Productivity. *Studies in Educational Evaluation, 20,* 477-502.

Huisman, J., Witte, J., & File J.M. (2007). *The extent and impact of higher education curricular reform across Europe.* Enschede, The Netherlands: Center for Higher Education Policy Studies.

ISCED-F (2013), *International Standard Classification of Education: Fields of Education and Training 2013.* Retrieved from http://ec.europa.eu/education/resources/international-standard-classification-education-fields_en

Jansen, E. P. W. A. (1996). *Curriculumorganisatie en studievoortgang* [Curriculum organisation and study progress]. Dissertation, GION, Groningen.

Jansen, E. P. W. A. (2004). The influence of the curriculum organization on study progress in higher education. *Higher Education*, 47, 411–435.

Jansen E. (2016). De organisatie van het curriculum en inrichting van de leeromgeving. In van Berkel, H., Jansen, E., Bax, A. (Ed). *Studiesucces bevorderen: het kan en is niet moeilijk.* pp 103-112. Amsterdam, Nederland: Boom uitgevers.

Field, A. (2004). *Discovering statistics using IBM SPSS Statistics.* London: SAGE,

Kan, A. R. (2014). Advies Rapport: flexibel hoger onderwijs voor volwassenen [Advice: Flexible higher education for adults]. Retrieved from https://www.rijksoverheid.nl/documenten/rapporten/2014/03/12/flexibel-hoger-onderwijs-voor-volwassenen

Kamphorst, J. C. (2013). *One size fits all? Differential effectiveness in higher vocational education.* Dissertation. Groningen

Kappe, F.R. (2011). *Determinants of success: a longitudinal study into higher professional education*. Amsterdam Vrije Universiteit

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry based teaching. *Educational Psychologist, 41*(2), 75–86.

Knight, P. T. (2001). Complexity and Curriculum: a process approach to curriculum-making. *Teaching in Higher Education*, 6:3, 369-381.

Kolmos, A., Fink, F.K. & Krogh, L. (eds.) (2004). *The Aalborg model: Progress, diversity and challenges*. Aalborg University Press. Chapter 1.Retrieved from http://people.plan.aau.dk/~ak/PBL/kap2-introductionTHE%20AALBORG%20MODEL.pdf

Kolmos, A., Holgaard, J.E., & Dahl, B. (2013). *Reconstructing the Aalborg Model for PBL*. The 4th International Research Symposium on Problem-Based Learning (IRSPBL) 2013. Retrieved from http://tree.utm.my/wp-content/uploads/2013/11/Reconstructing-the-Aalborg-Model-for-PBL-.pdf

Mantri, A. (2014) Working towards a scalable model of problem-based learning instruction in undergraduate engineering education, *European Journal of Engineering Education*, 39:3, 282-299,

Onderwijsraad (2015). De helft van Nederland hoogopgeleid, retrieved from https://www.onderwijsraad.nl/publicaties/2005/de-helft-van-nederland-hoogopgeleid/item568

Perdigones, A., Benedicto, S., Sánchez-Espinosa, E., Gallego, E., & García, J. L. (2014) How many hours of instruction are needed for students to become competent in engineering subjects?, *European Journal of Engineering Education*, 39:3, 300-308.

Reynolds, A. J., & Walberg, H.J. (1992). A structural model of science achievement and attitude: An extension to high school. *Journal of Educational Psychology, 84* (3), 371-382.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82* (1), 33-40.

Romiszowski, A. (1999), The development of physical skills: Instruction in the psychomotor domain. In C.M. Reigeluth (Ed.*), Instructional design theories and models. Volume II* (pp. 457-481). Mahwah, N.J.: Lawrence Erlbaum.

Schmidt, H. G., Cohen-Schotanus, J., van der Molen, H. T., Splinter, T. A. W., Bulte, J., Holdrinet, R., & Van Rossum, H. J. M. (2010). Learning more by being taught less: a “time-for-self-study” theory explaining curricular effects on graduation rate and study duration. *Higher Education,* 60, 287–300.

Tinto, V. (1975). Dropout from higher education: a theoretical synthesis of recent research. *Review of Educational Research, 45* (1), 89 -125.

Tinto, V. (1987). *Leaving College: rethinking causes and cures of student attrition*. Chicago: The university of Chicago.

Tinto, V. (1997). Classrooms as communities—Exploring the educational character of student persistence. *Journal of Higher Education, 68(6),* 599–623.

Tyler, R.W. (1949). Basic principles of curriculum and instruction. The University of Chicago Press. Chicago.

van Asselt, R. (2014). *Overzicht van de veranderingen in de vernieuwde havo-programma’s Natuurkunde, Wiskunde, Scheikunde, Biologie en NLT.* Retrieved from https://www.nvvw.nl/

van Asselt, R. (2016). *Mogelijke verklaringen van de dalingen van de studiesuccessen van mbo’ers en havisten na 5 jaar voltijd hbo studie.* Retrieved from https://www.nvvw.nl/17118

van den Akker, J. (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.

van den Akker, J. (2006). Curriculum development re-invented. In J. Letschert (Ed.), *Curriculum development re-invented* (pp. 16-30). Enschede: SLO. Retrieved from http://www.slo.nl/downloads/Currdevelopment__re-invented.pdf/

van der Drift, K. D. J., & Vos, P. (1987). *Anatomie van een leeromgeving, een onderwijseconomische analyse of universitair onderwijs (Anatomy of a learning environment, an economical analysis of university education).* Lisse: Swets & Zeitlinger.

van der Hulst, M. and Jansen, E. (2002). ‘Effects of curriculum organisation on study progress in engineering studies’, *Higher Education* 43, 489–506.

Vanfretti, L. & Farrokhabadi, M. (2015). Consensus-based course design and implementation of constructive alignment theory in a power system analysis course, *European Journal of Engineering Education,* 40:2, 206-221.

VHS (2017). Instroomcijfers database. Accessed though: http://cijfers.vereniginghogescholen.nl

Weert, de E., & Boezerooy, P. (2007) *Higher education in the Netherlands*. Retrieved from http://www.utwente.nl/cheps/publications/

Appendix A: European Qualifications Framework (EQF)

Descriptors defining levels in the European Qualifications Framework (EQF)

Each of the 8 levels is defined by a set of descriptors indicating the **learning outcomes** relevant to qualifications at that level in any system of qualifications

EQF Level	Knowledge	Skills	Competence
	In the context of EQF, knowledge is described as *theoretical and/or factual*.	In the context of EQF, skills are described as *cognitive* (involving the use of logical, intuitive and creative thinking), *and practical* (involving manual dexterity and the use of methods, materials, tools and instruments)	In the context of EQF, competence is described in terms of *responsibility and autonomy*.
Level 1	Basic general knowledge	Basic skills required to carry out simple tasks	Work or study under direct supervision in a structured context
Level 2	Basic factual knowledge of a field of work or study	Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools	Work or study under supervision with some autonomy
Level 3	Knowledge of facts, principles, processes and general concepts, in a field of work or study	A range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information	Take responsibility for completion of tasks in work or study; adapt own behaviour to circumstances in solving problems
Level 4	Factual and theoretical knowledge in broad contexts within a field of work or study	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study	Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change; supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities
Level 5[1]	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others
Level 6[2]	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Level 7[3]	Highly specialised knowledge, some of	Specialised problem-solving skills required in research	Manage and transform work or study contexts that are complex, unpredictable

EQF Level	Knowledge	Skills	Competence
	In the context of EQF, knowledge is described as *theoretical and/or factual.*	In the context of EQF, skills are described as *cognitive* (involving the use of logical, intuitive and creative thinking), *and practical* (involving manual dexterity and the use of methods, materials, tools and instruments)	In the context of EQF, competence is described in terms of *responsibility and autonomy.*
	which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research Critical awareness of knowledge issues in a field and at the interface between different fields	and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams
Level 8[4]	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	The most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research

Compatibility with the Framework for Qualifications of the European Higher Education Area

The Framework for Qualifications of the European Higher Education Area provides descriptors for cycles. Each cycle descriptor offers a generic statement of typical expectations of achievements and abilities associated with qualifications that represent the end of that cycle.

1. The descriptor for the higher education short cycle (within or linked to the first cycle), developed by the Joint Quality Initiative as part of the Bologna process, corresponds to the learning outcomes for EQF level 5.
2. The descriptor for the first cycle in the Framework for Qualifications of the European Higher Education Area corresponds to the learning outcomes for EQF level 6.
3. The descriptor for the second cycle in the Framework for Qualifications of the European Higher Education Area corresponds to the learning outcomes for EQF level 7.
4. The descriptor for the third cycle in the Framework for Qualifications of the European Higher Education Area corresponds to the learning outcomes for EQF level 8.

Downloaded from: https://ec.europa.eu/ploteus/en/content/descriptors-page

Appendix B: Overview of effects in multilevel studies

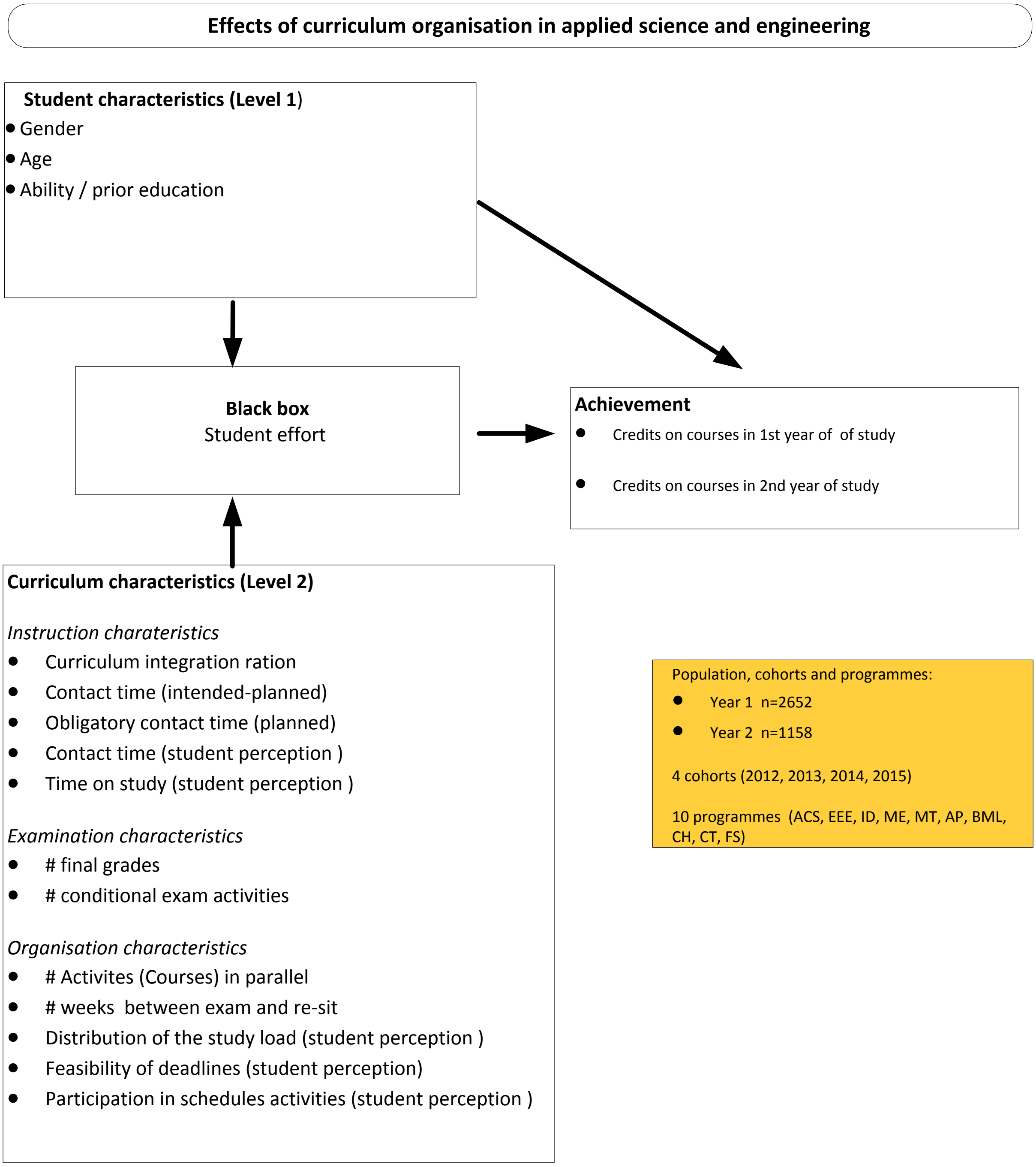
An overview of effects found in Jansen (1996, 2004), Van der Hulst and Jansen (2002), Schmidt et al. (2010).

	Jansen (1996)	**Jansen (1996)**	**Jansen (2004)**	**van der Hulst and Jansen (2002)**	**Schmidt et al. (2010).**
Outcome measure	**Pass 1st year exam within a year**	**Pass 1st year within 2 years**	**Pass 1st year exam within a year**	**Credits obtained 1st year of study**	**Study duration and graduation rate**
Sample size students	6037	6037	5151	1578	
Sample size curriculum	5 cohorts 5 departments	5 cohorts 5 departments	5 cohorts 5 departments	4 cohorts 3 departments	10 cohort 8 schools
Type of programmes	Various	Various	Various	Engineering	Medical school
Student group prior education	PUE-VWO + HPE-HBO	PUE-VWO + HPE-HBO	PUE-VWO	PUE-VWO	PUE-VWO
Students char. ↓					
Gender	+ Female	+ Female	+ Female	+ Female	
Age	- younger	- younger	ns	- younger	
Ability	+ higher grades	+ higher grades	+ higher grades	+ higher grades	
Curriculum char. ↓					
Instruction					
Hrs. lectures	+ more	+ more	+ more	ns	- less
Hrs tutorials	ns	- less	- less	ns	ns
Hrs. practicals					ns
Number of courses with additional practice	+ more	ns	+ more		
Feedback moments	ns	ns	ns		
Time for self study					+ more
Examination					
Exam regulation (compensation)	ns	ns			
Number of theoretical courses (coherence)				- fewer	
Number of exams				ns	
Number of final grades				Fewer grades & compensation	
Organisation					
Instruction weeks				ns	
Spread of exams	ns	+	ns		
Preparation week before exam				+	
2 exams in one week	ns	- less	ns		
Spread of re-sits	ns	-	ns		
Combing regular exams and re-sits	ns	-	ns		
Courses in parallel	- fewer	- more	- fewer	- fewer	

Note: Empty fields in the table: not include in the research

ns: not significant

Appendix C: Model for multilevel analysis



Appendix D: Programme names, Dutch names and codes

Domain	Programme – English name	Code (English)	Programme – Dutch name	Code (Dutch) BISON*)	Dutch government registration CROHO
ICT	Applied Computer Science	ACS	Technische Informatica	TI	34475
Engineering	Electrical and Electronics Engineering	EEE	Elektrotechniek	ELT	34267
	Industrial Design	ID	Industriële product ontwikkeling	IPO	34389
	Mechanical Engineering	ME	Werktuigbouwkunde	WB	34280
	Mechatronic Engineering	MT	Mechatronica	MT	30026
Applied Science	Applied Physics	AP	Technische Natuurkunde	TN	34268
	Bio-medical laboratory	BML	Biologie en Medisch Laboratoriumonderzoek	BML	34397
	Chemistry	CH	Chemie	C	34396
	Chemical Technology	CT	Chemische Technologie	CT	34275
	Forensic Science	FS	Forensisch Onderzoek	FO	34112

*)BISON: SAXION UAS student's results database

Appendix E: National Student Survey Questions

Nattional student survey questions used for the student's perception in multi level analysis

11. Study load

V25. The following questions are about the study load.

Please indicate how satisfied you are about: <1 to 5, 1 = very dissatisfied, 5 = very satisfied, 6 = Not applicable> 5

a The distribution of the study load over the academic year

b The feasibility of deadlines

12. Contact hours <not for distant education>

V26. The following questions are about contact hours. This is the number of hours on the clock per week in which you have scheduled contact with a teacher (lecturer, tutor, etc.). Internships/work placements, workplace learning, theses and graduate research projects do not count as contact hours.

Indicate the answer that applies to you with regard to the contact hours in your study programme.

a. The following number of contact hours are available to me in this teaching period:

- fewer than 6 hours per week
- 6 to 12 hours per week
- 12 to 18 hours per week
- 18 to 24 hours per week
- 24 to 30 hours per week
- 30 or more hours per week
- Not applicable

Variable is transformed to scale of 3 hours - 33 hours (Contact hrs = Contact_01 x 6 -3)

c. I follow the scheduled teaching activities:

o never, o rarely, o sometimes, o nearly always, o always

Hours per week spend on study

SAXION question, not part of the common set of questions for the whole of the Netherlands, question was no longer used in 2016 onwards.

NL: Hoeveel uur besteed je gemiddeld per week aan je studie (o.a. colleges voorbereiden en volgen, projecten, zelfstudie, toetsvoorbereiding, stage, werkplekleren, etc.)?

EN: How many hours do you on average spend on your studies in a week (e.g. lectures, preparing and taking part, project time, self-study, preparing for exams, internship, learning on the job, etc.) ? Open question provide a number

Appendix F: Characterisation of teaching and learning environment

	Course teaching & learning environment	
Variable	**On teaching & learning activities[1]:**	**On assessment tasks[1]:**
General Skills	The general skills deal with planning, language, communication, preparation for the "world of work", study skills, reflection, etc. Can approached as basis skills training or an integrated part of project work	Common way for assessment are skills exams (basis skills) and portfolio (meta cognitive skills)
Discipline Skills	Course focus on skills of a discipline. Typical examples: programming skills, communication / professional skills, measurement skills, workmanship skills , etc. Students work individual or in teams (max 2 students)	A large part (>50%) of the grade is from course work. Could be graded with a final individual oral assessment. May have individual (written or digital) examination to assess individual performance
Know-ledge	Course with lectures and work session dealing with the "knowledge of the discipline(s)", such as Mathematics, Control theory, Organic Chemistry, Circuit theory, etc. Course not necessarily follow the discipline logic and could also combine knowledge of related disciplines.	Focus is on **F**acts/procedures, **C**oncepts/principles and **R**eproductive skills and not on **P**roductive skills (Romiszowski, 1999) Limited assessment of course work (less than 20% of the grade from course work), or formative assessment only Usually with 1 final exam (written or digital)
Knowledge & Skills (Applied)	Focus is on application of knowledge and skills on tasks from the "world of work", Authentic task, but often a partial task.	A larger part (>30%) of the grade obtained through application of knowledge. Besides **R**eproductive skills also **P**roductive skills (Romiszowski, 1999) are expected of students. The examination can for instance be done by a written (project) exam.
Projects – Limited	Guided (steps and assignments given) with some aspects of a project approach. And limited freedom for students. Could also be a form of teamwork (>2 student)	Some aspects of project assessment combined with and skills of knowledge examination
Projects – Full	Limited guidance on process steps only, student teams are self-organising. Large degree of freedom on design and research choices. Large projects (more than 2 days a week or fulltime) with . sufficient participants in groups (≥4) Could be project based, as well as problem based learning	Full project assessment, with various ways of formative feedback Full integration. A separate "written project exam" is not possible in a full project.

[1] Information collected through interviews with curriculum owners and study of programme documentation

Appendix G: Example of course characterisation

						EC's on							Example	
	code	Teaching & learning activities (TLA)	Assessment Tasks (AT)	remark	Class size	GS	DS	K	KSA	PrL	PrF	Programme	Course	
					Observed									
General Skills (Basis)	SG	Training session	skill tests	organisational glue		6							SLB LS1 / SLB LS2	
				a bit of every thing		3							PPO1 / SOCO1	
Discipline Skills	SD	Practicum	logbook lab	pure skills	?							LS	vaardigheden LS (lab werk)	
		Practicum	portfolio with sketches									IPO	handtekenen IPO	
		Practicum	product demo	1 of 2 students	12		3					TI/ELT	hardware lab TI/ELT	↑
		Practicum	product	individual	60							IPO	Digital visualiseren	
		Practicum	Set assignments											
		Lecture; Practical	4 assignments + written exam				2	1				TI/ELT	Programming 1	more discipline focus
Knowledge	K	Lecture	1 written exam	Pure theory + written test	24			3				WB/IPO	Wiskunde 1	
		Lecture; Tutorial	1 written exam	Flipped / trational / worksessions	35			3				MT/ELT/TI	Circuits DC - ELT / MT	
limited coursework in final grade		Lecture	1 Digital exam	The teacher's choice	60			3				FO	FO tools	
			continous assement											
		Lecture; Presentation	written exam + group presentation					3				ELT	Drives 2	
Knowledge & Skills (Applied)	KSA	Assignment	Report	2 students / 2 x feedback	30			2	1			WB	Theoretische Werktuigbouwkunde 2 (reken opdracht)	
Authentic tasks (Tasks from "world of work")		Tutorial; Practical	week tasks		12		1.5	1.5				TI/ELT	Digital 1, Digital 2	
Project-limited	PrL	Project; assignments	Set of assignments	Set of assignments; closed	15 ?					3		CT	Project CT year 2	
		Project; assignments	Single design goal		60					6		ELT	Project Sim & Real	
Process steps and deadline no freedom														more real life focus
Project-full	PrF	Project	assessment	Half year project (2nd year)	40						9	ELT	Project automation	↓
Project goals + design choices free and open		Project	assessment	1 assement per quarter + open goal + company project	50						6	IPO	Project 5 & Project 6	
General Skills	SG	Study coaching	portfolio with assignements	organisational glue									SLB LS1 / SLB LS2	
				a bit of every thing									PPO2	

Appendix H: Curriculum missing data

Overviews of missing curricula data

List of missing data for curriculum instruction questions

Table 33

List of invalid curricula for year 1 & 2: Instruction variables (except NSS(NSE))

Instruction	Curriculum ID's								
Contact time (planned)	34397-2012-1	34396-2012-1	34275-2012-1	34112-2012-1	34475-2012-1	34475-2013-1		34268-2013-2	
Obligatory contact time (planned)	34397-2012-1	34396-2012-1	34275-2012-1	34112-2012-1	34475-2012-1	34475-2013-1		34268-2013-2	34267-2013-2

Missing: 6 year 1 curricula. Missing 1 or 2 year 2 curricula (use 28)

Table 34

List of invalid curricula for year 1 & 2: Organisation variables (except NSS(NSE))

Organisation	Curriculum ID's			
Parallel activities	34475-2012-1	34112-2012-1	34112-2013-1	
Weeks between exam and re-sit	34475-2012-1			34475-2013-1

34112-2013-1 is unique

Table 35

List of invalid curricula for year 1 & 2: NSS (NSE) questions

Programme code	Programme year	Cohort year	ID cur	ID cur	ID cur
BML	1	2012	34397-2012-1		
CH	1	2012	34396-2012-1		
CT	1	2012	34275-2012-1		
ELT	1	2012	34267-2012-1		
FO	1	2012	34112-2012-1		
IPO	1	2012	34389-2012-1		
MT	1	2012	30026-2012-1		
TI	1	2012, 2013, 2014	34475-2012-1	34475-2013-1	34475-2014-1
TI	2	2013, 2014	34475-2013-2	34475-2014-2	
TN	1	2012	34268-2012-1		
WB	1	2012	34280-2012-1		

For year 1: These 12 include 6 for contact time.

Year 2: curricula for contact time and NSS do not overlap unique for year 2 missing:

34268-2013-2	34267-2013-2	34475-2013-2	34475-2014-2

Group 26 curricula used

Appendix I: Student progress data processing

Student records removed from dataset

Total student sample: n=2823 in the database

Removed:

1. Students from AD programmes
2. Students older of 27 years and above (to select evening school)
3. Students who received credits through exemptions and did not take part in regular curriculum

	Variable used	selection	n removed	
AD programme students	OPL_CODE_JR1	80019	8	AD mechanical
		80022	16	AD TI
Special track students (evening, Antilles,)	AGE	Age 16 – 26 only	83	
Short degree and other exempted students e.g. from UT.	DIPLOMAJAAR _AFST	Not 2012, 2013, 2014, 2015	33	
		total	140	

Remaining relevant student sample: n=**2683**

Making an ability scale based on prior education

See Table 36. The influence of either Foreign diploma and Unknown is not very large. Ability scale A was used within the population with known Dutch previous study. Ability scale F was used for the whole population

Table 36

Use of the prior education variable as an ability scale?

Previous study	**Value**	**Ability A**	**Ability B**	**Ability C**	**Ability D**	**Ability E**	**Ability F**
		NL	Test1	Test2	Test3	Test4	Test5
SSVE2(MBO) other domain	0	0	0	0	0	0	0
SSVE1(MBO) same domain	1	1	1	1	1	1	1
SGSE (HAVO)	2	2	2	2	2	2	2
PUE (VWO)	3	3	3	3	3	3	3
Foreign diploma	4	-1	2.5	3.5	3.5	3.1	3.1
Unknown	5	-1	-1	-1	2.1	3.2	2.1
Chi^2		24002,98	Not tested	Not tested	23939,95	23944,80	23938,39
df new					6	6	6
Change in Chi^2							75,99

Without Ability scale: -2LL = 24014,32, df =5 highly significant change of Chi^2

Appendix J: Correlation tables year 1

Correlations: Kendall's tau_b

Correlation Coefficient		C_CIR	C_CTP	C_CTO	C_CT_SP	C_ToS_SP	C_NoFG	C_NoCEA	C_DoSL_SP	C_FoDL_SP	C_PoSA_SP	C_PA	C_W_E_R
Curriculum Integration ratio (%)	C_CIR	1,000	,064**	-,525**	-,379**	-,033*	-,777**	-,733**	-,166**	,129**	-,349**	-,177**	-,219**
Contact time - planned (hrs)	C_CTP		1,000	,291**	,100**	-,108**	,063**	-0,001	,272**	0,023	-,088**	,283**	-,034*
Obligatory contact time - planned (hrs)	C_CTO			1,000	,489**	-0,013	,487**	,428**	,206**	-,259**	,315**	,191**	,268**
Time on study - student perception (hrs)	C_CT_SP				1,000	-,093**	,250**	,220**	,246**	-,088**	,260**	0,019	,057**
Contact time - student perception (hrs)	C_ToS_SP					1,000	-,113**	-,117**	-,463**	-,157**	,102**	-,191**	,050**
Final grades (#)	C_NoFG						1,000	,842**	,187**	-,214**	,292**	,101**	,139**
Conditional exam activities (#)	C_NoCEA							1,000	,149**	-,226**	,277**	,045*	,170**
Distribution of studyload - student perc.(scale*)	C_DoSL_SP								1,000	,295**	-,193**	,440**	,199**
Feasibility of dead-lines - student perc.(scale*)	C_FoDL_SP									1,000	-,374**	,220**	,102**
Participation scheduled activities - student perc. (scale*)	C_PoSA_SP										1,000	-,230**	-0,018
Parallel activities (#)	C_PA											1,000	,512**
Weeks between exam and re-sit (#)	C_W_E_R												1,000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

N= 1975

Instruction variables correlation year 1

Kendall's tau_b										
Correlations		EC_IN_YEAR_1	Age - 16	GENDER	ABILITY_F	C_CIR	C_CTP	C_CTO	C_CT_SP	C_ToS_SP
	EC_IN_YEAR_1	1,000	-,042*	-,058**	,130**	-,084**	-0,022	,067**	,045**	-0,008
	Age - 16		1,000	,104**	-,088**	-,113**	,049**	,083**	0,027	-0,026
	GENDER			1,000	-,081**	-,360**	,089**	,321**	,181**	-,037*
Ability F scale	ABILITY_F				1,000	,052**	0,019	-,095**	-,044*	-,038*
Curriculum Integration ratio (%)	C_CIR					1,000	,043**	-,512**	-,375**	-,043**
Contact time - planned (hrs)	C_CTP						1,000	,332**	,148**	-,062**
Obligatory contact time - planned (hrs)	C_CTO							1,000	,517**	0,028
Time on study - student perception (hrs)	C_CT_SP								1,000	-,048**
Contact time - student perception (hrs)	C_ToS_SP									1,000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

n = 2031

Examination variables correlation year 1

Kendall's tau_b								
Correlation Coefficients		EC_IN_YEAR_1	Age - 16	GENDER	ABILITY_F	C_CIR	C_NoFG	C_NoCEA
	EC_IN_YEAR_1	1,000	-,056**	-,074**	,123**	-,045**	,062**	,067**
	Age - 16		1,000	,106**	-,104**	-,114**	,107**	,104**
	GENDER			1,000	-,088**	-,334**	,354**	,372**
Ability scale F	ABILITY_F				1,000	,047**	-,079**	-,083**
Curriculum Integration ratio (%)	C_CIR					1,000	-,685**	-,615**
Final grades (#)	C_NoFG						1,000	,794**
Conditional exam activities (#)	C_NoCEA							1,000
**. Correlation is significant at the 0.01 level (2-tailed).								
c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples								
n =2683								

Organisation variables correlation year 1

Kendall's tau_b											
Correlations		EC_IN_YEAR_1	Age - 16	GENDER	ABILITY_F	C_CIR	C_PA	C_W_E_R	C_DoSL_SP	C_FoDL_SP	C_PoSA_SP
	EC_IN_YEAR_1	1,000	-,040*	-,048*	,120**	-,087**	-0,033	0,008	0,017	-0,024	,066**
	Age - 16		1,000	,102**	-,089**	-,113**	,115**	,070**	,047**	0,018	-0,006
	GENDER			1,000	-,073**	-,363**	,157**	,149**	,135**	-,103**	,138**
Ability scale F	ABILITY_F				1,000	,051**	0,024	-0,035	,046**	,084**	-,072**
Curriculum Integration ratio (%)	C_CIR					1,000	-,177**	-,219**	-,166**	,129**	-,349**
Parallel activities (#)	C_PA						1,000	,512**	,440**	,220**	-,230**
Weeks between exam and re-sit (#)	C_W_E_R							1,000	,199**	,102**	-0,018
Distribution of studyload - student perc.(scale*)	C_DoSL_SP								1,000	,295**	-,193**
Feasibility of dead-lines - student perc.(scale*)	C_FoDL_SP									1,000	-,374**
Participation scheduled activities - student perc.	C_PoSA_SP										1,000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

n = 1975

Appendix K: Correlation tables year 2

Kendall's tau_b													
Correlation Coefficient		C_CIR	C_CTp	C_CTo	C_ToS_SP	C_CT_SP	C_NoFG	C_NoCEA	C_PA	C_W_E_R	C_DoSL_SP	C_FoDL_SP	C_PoSA_SP
Curriculum Integration ratio (%)	C_CIR	1,000	-,214**	,164**	0,007	,122**	-0,001	,367**	-,480**	-,121**	-,173**	-,131**	,442**
Contact time - planned (hrs)	C_CTp		1,000	,301**	,165**	0,042	-,074**	-,437**	,524**	-,313**	,207**	,294**	-,222**
Obligatory contact time - planned (hrs)	C_CTo			1,000	,375**	,189**	0,029	-0,034	,200**	-0,027	,156**	,157**	,180**
Time on study - student perception (hrs)	C_ToS_SP				1,000	,072**	,067**	-0,046	,201**	-,236**	,057**	-0,004	0,010
Contact time - student perception (hrs)	C_CT_SP					1,000	-,098**	,061**	-,064**	,119**	,269**	,083**	,276**
Final grades (#)	C_NoFG						1,000	,483**	-0,028	,286**	,157**	-,096**	-,148**
Conditional exam activities (#)	C_NoCEA							1,000	-,338**	,351**	-,111**	-,407**	,159**
Parallel activities (#)	C_PA								1,000	-,108**	,182**	,180**	-,263**
Weeks between exam and re-sit (#)	C_W_E_R									1,000	,203**	-0,001	-0,015
Distribution of studyload - student perc.(scale*)	C_DoSL_SP										1,000	,446**	-,173**
Feasibility of dead-lines - student perc.(scale*)	C_FoDL_SP											1,000	-,087**
Participation scheduled activities - student perc. (scale*)	C_PoSA_SP												1,000

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

n= 1040

Instruction variables correlation year 2

Kendall's tau_b										
Correlation Coefficient		EC_IN_YEAR_2	AGE - 17	GENDER	ABILITY_F	C_CIR	C_CTp	C_CTo	C_ToS_SP	C_CT_SP
	EC_IN_YEAR_2	1,000	-0,040	-,100**	-0,002	-,072**	-0,037	-0,022	-,051*	-0,018
	AGE - 17		1,000	,107**	-0,046	,113**	-0,031	0,007	0,037	0,017
	GENDER			1,000	-,122**	,368**	-,312**	-,100**	-,085**	,135**
Ability scale F	ABILITY_F				1,000	-,089**	,071**	-,089**	0,005	-,114**
Curriculum Integration ratio (%)	C_CIR					1,000	-,214**	,164**	0,007	,122**
Contact time - planned (hrs)	C_CTp						1,000	,301**	,165**	0,042
Obligatory contact time - planned (hrs)	C_CTo							1,000	,375**	,189**
Time on study - student perception (hrs)	C_ToS_SP								1,000	,072**
Contact time - student perception (hrs)	C_CT_SP									1,000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

n= 1040

Examination variables correlation year 2

Kendall's tau_b								
Correlation Coefficient		EC_IN_YEAR_2	AGE_Y2_minus_17	GENDER	ABILITY_F	C_CIR	C_NoFG	C_NoCEA
	EC_IN_YEAR_2	1,000	-0,040	-,103**	0,006	-,066**	,064**	,068**
	AGE - 17		1,000	,120**	-,060*	,111**	0,040	,057*
	GENDER			1,000	-,113**	,349**	-,114**	,302**
Ability scale F	ABILITY_F				1,000	-,087**	,108**	-,067**
Curriculum Integration ratio (%)	C_CIR					1,000	-,135**	,355**
Final grades (#)	C_NoFG						1,000	,368**
Conditional exam activities (#)	C_NoCEA							1,000
*. Correlation is significant at the 0.05 level (2-tailed).								
**. Correlation is significant at the 0.01 level (2-tailed).								
c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples								
n= 1145								

Organisation variables correlation year 2

Kendall's tau_b											
Correlation Coefficient		EC_IN_YEAR_2	AGE - 17	GENDER	ABILITY_F	C_CIR	C_PA	C_W_E_R	C_DoSL_SP	C_FoDL_SP	C_PoSA_SP
	EC_IN_YEAR_2	1,000	-,046*	-,103**	0,012	-,062**	-0,002	,147**	-0,005	-,056**	-0,025
	AGE - 17		1,000	,118**	-,052*	,109**	-,050*	-,066**	0,006	0,009	-0,010
	GENDER			1,000	-,112**	,339**	-,293**	-0,038	-,059*	-,085**	,165**
Ability scale F	ABILITY_F				1,000	-,082**	0,005	-,053*	-0,032	0,010	-,105**
Curriculum Integration ratio (%)	C_CIR					1,000	-,503**	-,079**	-,204**	-,140**	,447**
Parallel activities (#)	C_PA						1,000	-,134**	,213**	,171**	-,284**
Weeks between exam and re-sit (#)	C_W_E_R							1,000	,129**	-,070**	,057**
Distribution of studyload - student perc.(scale*)	C_DoSL_SP								1,000	,452**	-,221**
Feasibility of dead-lines - student perc.(scale*)	C_FoDL_SP									1,000	-,143**
Participation scheduled activities - student perc. (scale*)	C_PoSA_SP										1,000

*. Correlation is significant at the 0.05 level (2-tailed).

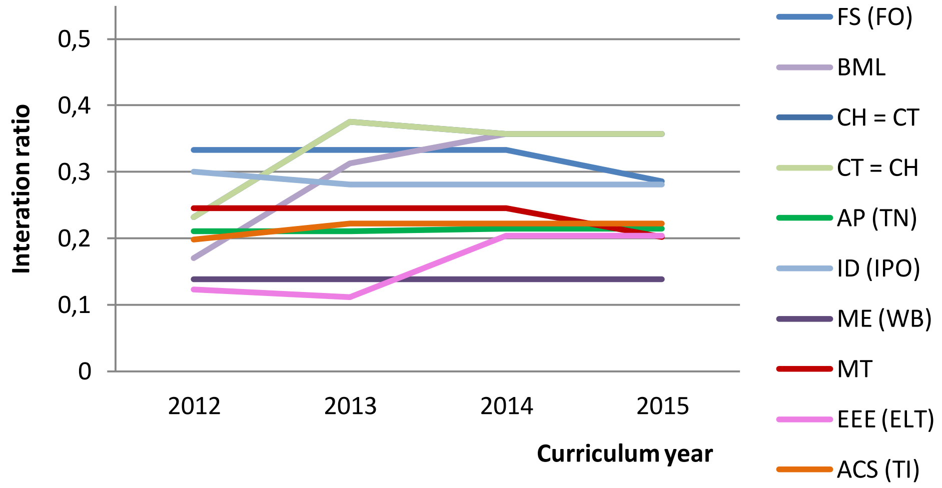
**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

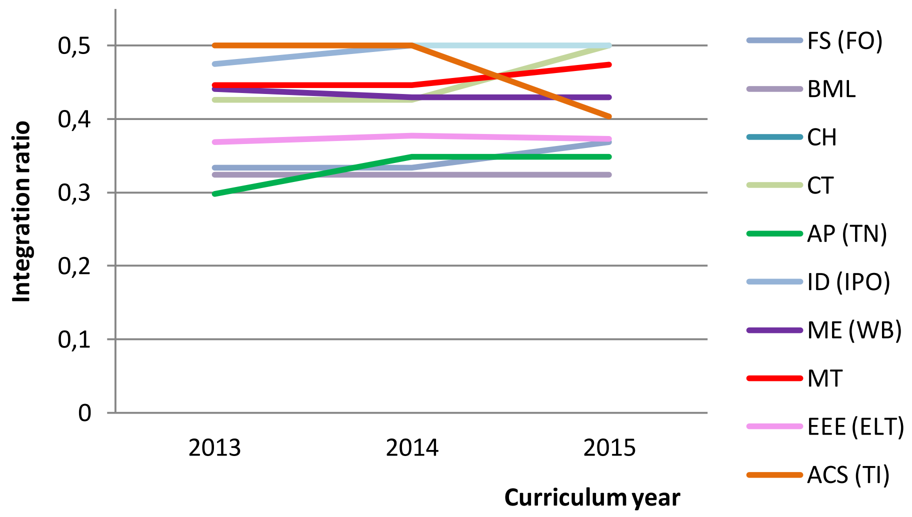
n= 1102

Appendix L: Curriculum variables versus time

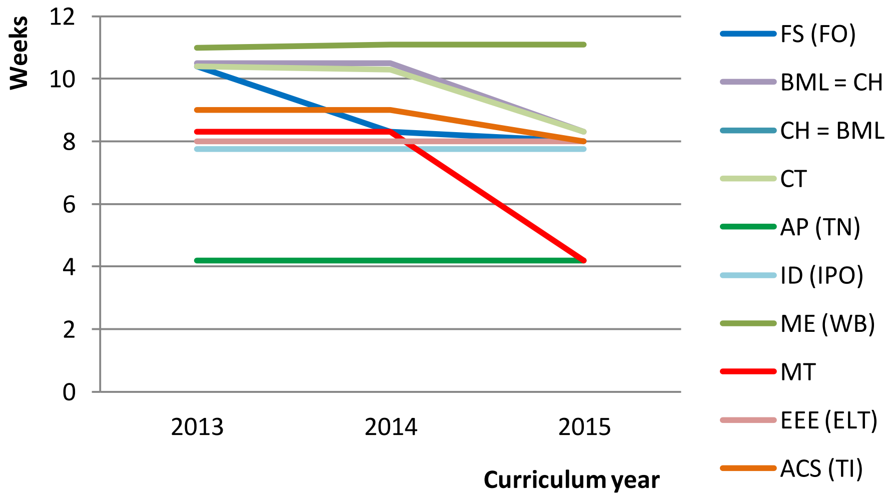
Graph of curriculum integration ratio variable in year 1



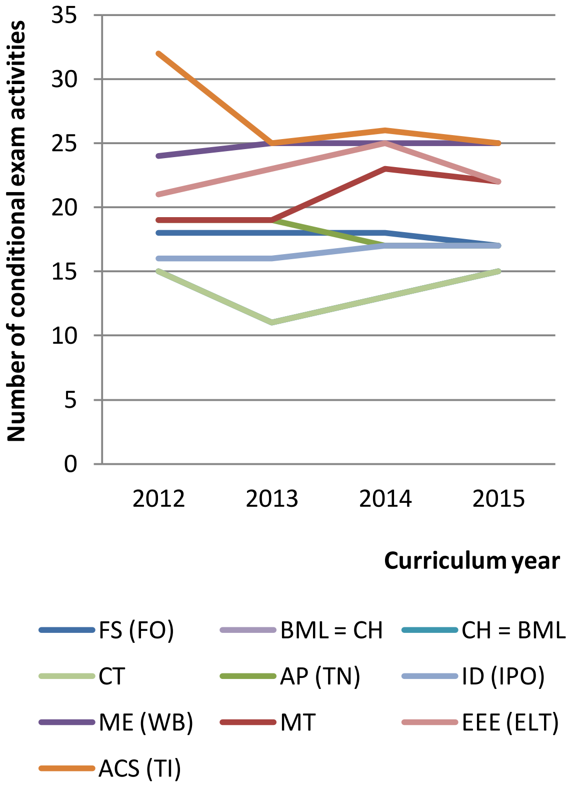
Graph of curriculum integration ratio variable in year 2



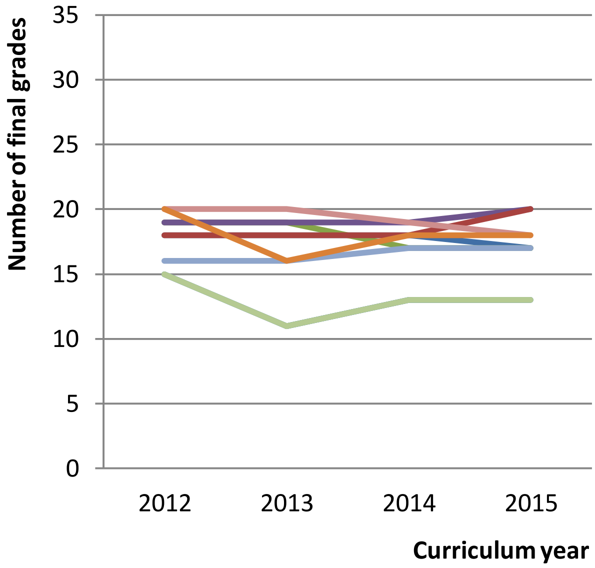
Weeks between exam and re-sit in year 2.



Number of conditional exam activities year 1



Number of final grades in year 1



Appendix M: Stakeholders in higher professional education